



Hypertension Prevalence, Awareness, Treatment, and Control in National Surveys from England, the USA, and Canada, and Correlation with Stroke and Ischemic Heart Disease Mortality



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Hypertension Prevalence, Awareness, Treatment, and Control in National Surveys from England, the USA, and Canada, and Correlation with Stroke and Ischemic Heart Disease Mortality

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Article Summary

- 1) Article focus
 - Comparison of hypertension prevalence, awareness, treatment, and control in 3 National studies, England, USA, and Canada
 - Correlation with stroke and ischemic heart disease mortality
- 2) Key messages
 - Important variation by country
 - Strong relationship between hypertension indicators and stroke mortality
 - Gaps in the management of hypertension
- 3) Strengths and limitations
 - Strengths
 - National population data
 - Detailed data on hypertension characteristics
 - Strong correlation with meaningful outcome, mortality
 - Limitations
 - Data from England from 2006, but provide an important basis for measuring progress (current data not yet available)
 - Limited to 3 countries
 - Ecological correlation with mortality that excludes looking at confounders

ABSTRACT

Objective Comparison of recent national survey data on prevalence, awareness, treatment and control of hypertension in England, the USA and Canada, and correlation of these parameters with each country stroke and ischemic heart disease (IHD) mortality.

Methods Non-institutionalized population surveys from England (2006), the USA (2007-2010) and Canada (2007-2009) using standardized protocols and devices. Analysis included individuals age 20-79 years. Stroke and IHD mortality rates were plotted against country specific prevalence data.

Results Mean systolic blood pressure (SBP) was higher in England than in the USA and Canada in all age-gender groups. Mean diastolic blood pressure (DBP) was similar in the three countries before age 50 and then fell more rapidly in the USA and was the lowest in the USA. Only 34% had a BP under 140/90 mmHg in England, compared with 50% in the USA and 66% in Canada. Pre-hypertension and stage 1 and 2 hypertension prevalence figures were the highest in England. Hypertension prevalence (≥ 140 mmHg SBP and/or ≥ 90 mmHg DBP) was lower in Canada (19.5%) than in the USA (29%) and England (30%). Hypertension awareness was higher in both the USA (81%) and Canada (83%), than in England (65%). England also had lower levels of hypertension treatment (51%; USA 74%; Canada 80%) and control ($< 140/90$ mmHg; 27%; USA 53%; Canada 66%). Canada had the lowest Stroke and IHD mortality rates, England the highest, and rates were inversely related to the mean SBP in each country and strongly related to blood pressure indicators, the strongest relationship being between low hypertension awareness and stroke mortality.

Conclusion While current prevention efforts in England should result in future improved figures, these data still show important gaps in the management of hypertension in these countries with consequences on stroke and IHD mortality.

Introduction

Increased blood pressure is the leading risk factor for premature death, stroke, and heart disease worldwide.¹ In the year 2000, the world was estimated to have close to 1 billion people with hypertension and predicted an increase to 1.56 billion by 2025.² The global economic burden of increased blood pressure was estimated to consume 370 billion US \$ worldwide and 10 % of health care expenditures.³ Usual blood pressure is strongly and directly related to vascular and overall mortality without evidence of a threshold down to at least 115/75mmHg⁴ with small changes in blood pressure resulting in substantial changes in vascular disease.⁵

Based on clinical and population research, increased blood pressure, hypertension and hypertension related complications are largely preventable. Lifestyle changes can lower blood pressure and prevent hypertension while antihypertensive drug therapy can effectively reduce the cardiovascular events attributed to hypertension.¹⁻⁶ Nevertheless, most people with hypertension worldwide are not effectively treated and controlled to recommended blood pressure targets.⁷ There are few national programs to serve as models for prevention and control of hypertension and few countries have embarked on national hypertension prevention and control programs. The United States (USA) blood pressure education program was established in 1972⁸, while Canada (2000) and England (2004) have more recent initiatives.^{9,10} This manuscript compares recent data on prevalence, awareness, treatment and control of hypertension in England, the USA and Canada and correlates these hypertension-related parameters in the three countries to mortality from stroke and ischemic heart disease (IHD).

Methods

Survey methods used in England, the USA, and Canada are summarized in Table 1. Detailed methodology for each survey is available elsewhere.¹¹⁻¹³ Briefly, each survey is a representative sample of each country's non-institutionalized population and uses standardized protocols and

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2
3 devices. While the England (2006) and Canada (2007-2009) surveys used automatic oscillometric
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5 devices, the USA (2007-2010) survey used mercury wall sphygmomanometer models. The number
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7 of blood pressure measurements available for analysis varied by count of blood pressure measures
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9 and survey protocols (Table 1).

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11 In these analyses, hypertension was defined as a mean systolic blood pressure (SBP) ≥ 140 mmHg
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13 or a mean diastolic blood pressure (DBP) ≥ 90 mmHg or a respondent self-report of medication to
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15 lower blood pressure. Pre-hypertension (SBP 120-139 mmHg or DBP 80-89 mmHg), stage 1 (SBP
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17 140-159 mmHg or DBP 90-99 mmHg), and stage 2 (SBP ≥ 160 mmHg or DBP ≥ 100 mmHg)
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19 hypertension were defined according to the Seventh Report of the Joint National Committee on the
20
21 Prevention, Detection, Evaluation and Treatment of High Blood Pressure (JNC 7) definitions.⁶
22
23 Prevalence, awareness, treatment, control and awareness of hypertension were defined using
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25 commonly recognized standards. Prevalence was defined as SBP ≥ 140 or DBP ≥ 90 or currently
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27 taking medication to lower their blood pressure. Awareness was defined by self-report and
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29 included having been diagnosed as hypertensive by a doctor or nurse, excluding women diagnosed
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31 during pregnancy (England), medication to lower blood pressure in the past month or reported
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33 high blood pressure (Canada), or having been diagnosed as hypertensive by a doctor or nurse,
34
35 excluding women diagnosed during pregnancy (USA). Treatment was defined as taking medication
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37 to lower blood pressure, as recorded by the nurse (England), or a self-report of taking medication
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39 to lower blood pressure (Canada, USA). Treated and controlled was defined as taking medication to
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41 lower blood pressure and SBP < 140 mmHg and DBP < 90 mmHg; treated and uncontrolled a SBP
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43 ≥ 140 mmHg or DBP ≥ 90 mmHg while on medication to lower blood pressure. Aware, yet not
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45 treated, was defined by self-report and included having been diagnosed as hypertensive by a doctor
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47 or nurse (England) / health care provider (Canada, USA), and not taking medication to lower blood
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49 pressure.
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3 Survey data were not age and sex standardized. They represent the current country-specific figures,
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5 and therefore correspond more precisely to each country's crude mortality rates for stroke and
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7 IHD. All prevalence figures are weighted using survey weights to represent each country's
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9 population. Standard errors were computed taking into account each country's sampling
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11 methodology.¹¹⁻¹³ To be comparable across the three surveys, the analysis was restricted to
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13 individuals age 20-79 years and excluded pregnant women. The Canadian Health Measures Survey
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15 (CHMS) data analysis was performed using SAS® Enterprise Guide (Version 4.1, SAS Institute Inc.,
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17 Cary, NC, 2006). The Health Survey for England (HSE) data analysis was performed using SPSS 19.
18
19 The National Health and Nutrition Examination Survey (NHANES) data analysis was performed
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21 using SAS version 9.2 and SAS-Callable SUDAAN version 10 (RTI International)], to account for the
22
23 complex sampling design.
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27 The latest WHO country specific mortality data available were from 2008 for Canada and the USA¹⁴
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29 and we used 2006 data for England.¹⁵ Crude mortality rates per 100,000 were obtained for men and
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31 women for stroke and ischemic heart disease (IHD) and plotted against country specific prevalence
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33 data for hypertension awareness, treatment, and control.
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38 **Results**

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40 The distribution of SBP and DBP by sex, age, and country shows an increase in SBP with age and an
41
42 increase, plateau and decrease of DBP with aging (Figure 1; Appendix 1 Table). SBP is higher in
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44 men than women in the younger age groups and becomes higher in women than men after age 60
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46 years in Canada and age 70 years in England and USA. Mean SBP is overall higher in England than in
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48 the USA and Canada in all age-gender groups. DBP is similar in the 3 countries before age 50 and
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50 then falls more rapidly in the USA and is overall lower in men and women from the USA.
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54 The distribution of measured blood pressure (including treated individuals), by level, in Table 2
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56 reflects the findings in Figure 1. Only 34% of adults aged 20-79 years would be classified as having
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3 a normal blood pressure (<120/80 mmHg) in England, compared with 50% in the USA and 66% in
4
5 Canada. Pre-hypertension and stage 1 and 2 hypertension prevalence figures are also much higher
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7 in England than in the USA and Canada.
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10 The prevalence of hypertension, and awareness, treatment, and control levels among those with
11
12 hypertension are shown in Table 3. The prevalence of hypertension is lowest in Canada (19.5%)
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14 and higher in the USA (29%) and England (30%). Hypertension awareness is close to 80% in both
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16 the USA (81%) and Canada (83%) and lower in England (65%). England also has lower levels of
17
18 hypertension treatment (England 51%; USA 74%; Canada 80%) and control (England 27%; USA
19
20 53%; Canada 66%). These patterns are similar in the different age and sex sub groups (Table 3).
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22 Among individuals treated for hypertension (i.e., taking medication to lower blood pressure), the
23
24 proportion being controlled is lowest in England (53%), while 71% in the USA and 82% in Canada
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26 are controlled.
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30 The mean SBP and DBP are provided in Appendix 2 by the different prevalence categories of Table
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32 3. The data are consistent with those in the previous tables showing the highest SBP mean in
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34 England in all categories. For DBP, England has also higher means than the USA and Canada among
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36 all hypertensives and aware and treated categories.
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39 At the time when these surveys were conducted, Canada had the lowest stroke and IHD mortality
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41 rates while England had the highest. Rates of both outcomes were inversely related to the mean
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43 SBP in each country (Figure 2). We found a strong relationship between the selected blood
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45 pressure indicators and stroke and IHD mortality, the strongest relationship being between
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47 hypertension awareness and stroke mortality, especially in women (Figure 3). Stroke rates were
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49 higher in women than men for any level of each of the BP indicators and the opposite was true for
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51 IHD (Figure 2-3).
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56 Discussion

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3 Although all 3 countries evaluated have had substantive improvement in most hypertension
4 treatment indicators over the past two decades¹⁶⁻²⁰, this study found marked differences in
5 hypertension prevalence, awareness, treatment and control rates in England, the USA, and Canada.
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10 Canada has the lowest prevalence of hypertension at 19% followed by England and United States at
11 about 30% each. A previous study based on earlier cycles of these surveys also found little
12 difference in the prevalence of hypertension between England and the USA.²¹ The main
13 determinants of hypertension are known. These include poor dietary habits, excess sodium intake,
14 physical inactivity, obesity, excess alcohol consumption, as well as age, gender, race and
15 sociodemographic factors. The national differences in prevalence are likely related to differences in
16 the interaction between these determinants as well as differences in the clinical systems,
17 community programs, and environmental and policy supports for hypertension prevention and
18 management. Compared to the USA, Canada has a lower rate of obesity but to our knowledge there
19 has never been a comprehensive comparison of the determinants of blood pressure using
20 appropriately adjusted data in these countries. A comprehensive comparison of the determinants of
21 hypertension and the policies that fail to address adverse differences in the modifiable
22 determinants would be an important next step.
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39 Our study has also found important differences in the awareness, treatment and control of
40 hypertension in the three countries. England, the USA, and Canada all have developed differing
41 approaches to improve hypertension treatment and control. In the USA, several diverse
42 approaches have been taken.^{6, 8, 22} Historically the USA has had one of the world's highest rates of
43 hypertension awareness, treatment and control and has also seen improvements in these indicators
44 with intensified efforts;¹⁸ however, despite broad clinical and community efforts, over half of adults
45 with hypertension are uncontrolled based on current guidelines.¹⁹ Recent national activities and
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3 Importantly, we also found national-level differences in mortality rates from stroke and IHD, which
4 paralleled the differences in hypertension awareness, treatment, and control between these 3
5 countries. Both stroke and IHD mortality were strongly inversely correlated with mean SBP in each
6 country.
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11 Efforts in England have included episodic national hypertension recommendations developed by
12 the British Hypertension Society (B.H.S - a non-governmental organization of specialists and
13 researchers) with the recommendations more recently being developed by a governmental
14 organization in collaboration with the BHS.²⁸ Implementation programs have included an extensive
15 public program to educate people on the risks of salt for hypertension²⁹ and also to an extensive
16 government program to pay General Practitioners bonus payments for achieving benchmarks for
17 hypertension care³⁰ – although the efficacy of payment for performance for improving hypertension
18 control has been questioned.³¹
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30 In 2000, Canada launched an annually updated hypertension recommendations program (Canadian
31 Hypertension Education Program (CHEP)).⁹ In 2006, the program was assisted by an extensive
32 initiative to inform the public about hypertension and the health risks and opportunities to reduce
33 dietary salt.³² The introduction of CHEP in Canada is temporally related to improvements in
34 management patterns and has been also temporally associated with reduced CVD in Canada.³³
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41 It is difficult to assess how much the different national approaches to hypertension detection and
42 management impact on the differences observed in our study. British Guidelines in place in
43 2006^{10,37} and since²⁸ do not recommend the routine use of antihypertensive treatment for those
44 with a systolic BP >140 mmHg and/or diastolic BP > 90 mmHg, rather only if such people have an
45 estimated 10 year CV risk of > 20%. Consequently treatment rates and control rates might be
46 expected to be lower in England than in the USA & Canada. Furthermore, in England, the National
47 Institute for Health and Clinical Excellence's Quality and Outcomes Framework, which includes
48 measures used in the calculation of provider reimbursement, included a higher blood pressure
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3 target (<150/90) during the period of data used for these analyses. This will be lowered (to
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5 <140/90) in 2013/2014 to align with national guidelines. In addition to the new National Institute
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7 for Health and Clinical Excellence (NICE) guidelines²⁸, the national salt reduction program in
8
9 England would be expected to result in further reductions in the prevalence of hypertension and
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11 improvement in hypertension treatment indicators in the recent and future years as Canadian and
12
13 Finnish data suggest.^{34,35}

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16 There are several potential limitations to our current analyses. In addition to low response rates
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18 and hence small numbers in some strata, each country uses different methodology to assess blood
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20 pressure and relatively small differences in blood pressure can impact hypertension indicators. In
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22 particular Canada has adopted the use of a fully automated blood pressure device that operates in
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24 the absence of an observer and averages the last 5 of six blood pressure readings. The Canadian
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26 method reduces the influence of the observer (white coat effect) on blood pressure and results in a
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28 slightly lower average blood pressure than a single auscultatory blood pressure reading.
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32 Nevertheless using an algorithm to adjust the data in the Canadian survey to represent single
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34 manual reading results in little change in the major hypertension indicators as the difference in
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36 methods at the therapeutic cut point of 140/90 mmHg is small.³⁶ The close relationship between
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38 stroke mortality and hypertension prevalence and hypertension indicators suggest that blood
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40 pressure and hypertension differences seen in this study are real and biologically important.
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44 We did not use age- or gender-adjusted data from the different countries. The lack of adjustment
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46 was intended so that hypertension risk factors could be directly compared to stroke mortality for
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48 each country. In addition, in a separate analysis, comparison of age-adjusted data to a common
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50 standard population showed very little difference with the current figures. We were not able to
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52 obtain more recent common mortality data than 2008 for all countries. There is some overlap
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54 between the timing of the US and Canadian surveys, but the English survey was conducted more
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56 than one year earlier. Management of hypertension in England is likely to have improved since
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3 2006. Increased blood pressure and hypertension represent major global threats to population
4 health, with stroke and IHD being the most closely related adverse outcomes.⁴ Interventions to
5 lower average population blood pressure and interventions to identify and control blood pressure
6 in those with hypertension are critical to prevent blood pressure related complications.²⁻⁶
7
8 Nevertheless, hypertension control rates are low even in developed countries and most countries
9 do not have formal programs to control hypertension.³⁸ Further, population surveys indicate that
10 approximately 29% of men and 25% of women have uncontrolled hypertension with increasing
11 numbers of hypertension cases globally due to population growth and ageing.³⁹ Hence, countries
12 worldwide should consider introducing and evaluating coordinated programs to improve the
13 prevention, detection, awareness, treatment, and control of hypertension, and our data suggest that
14 the more assertive approach apparent in North America is associated with large benefits in terms of
15 reduced cardiovascular mortality.
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Table 1. Survey methods, by country.

<i>Country</i>	<i>Years of Survey</i>	<i>Sample Frame</i>	<i>n</i>	<i>Age Range</i>	<i>Response Rate</i>
England	2006	Multistage, postal code address	6,873	20-79	68% household response rate, 88% individual response rate in co-operating households and 66% with nurse visit (examination response rate).
Canada	2007-2009	Multistage	3,485	20-79	Household response rate = 70% Individual response rate to the household questionnaire = 88% Examination response rate = 85%
US	2007-2010	Multistage	10,003	20-79	Interview response rate = 79% Examination response rate = 76% 93% of those examined had ≥2 blood pressure measurements
<i>Country</i>	<i>Blood Pressure Device</i>	<i>Technician</i>	<i>N of Blood Pressure Measures</i>	<i>Study Protocol Used</i>	
England	Omron HEM 907	Nurse	3	Mean of second and third measures taken 1 minute apart after 5 minutes rest	
Canada	Bp TRU™ BP-300*	Health measures specialists	6	Average of last 5 of 6 measures taken one minute apart after a 5 minute rest period	
US	Calibrated® V-Lok® cuff, Latex Inflation Bulb, Air-Flo® Control Valve. Baumanometer® calibrated mercury wall model.	Physician	3	Mean of second and third measurement taken 30 seconds apart after resting quietly in a sitting position for 5 minutes†	

*Bp TRU™ BP-100 used during home visits for respondents who were unable or unwilling to go at the mobile clinic.

† US NHANES survey protocol: After resting quietly in a sitting position for 5 minutes, three consecutive blood pressure readings were obtained. If a blood pressure measurement was interrupted or incomplete, a fourth attempt could be made.

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All valid blood pressure readings excluding pregnant.

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Figure 1. Distribution of Systolic and Diastolic Blood Pressure by Country, Age and Sex.

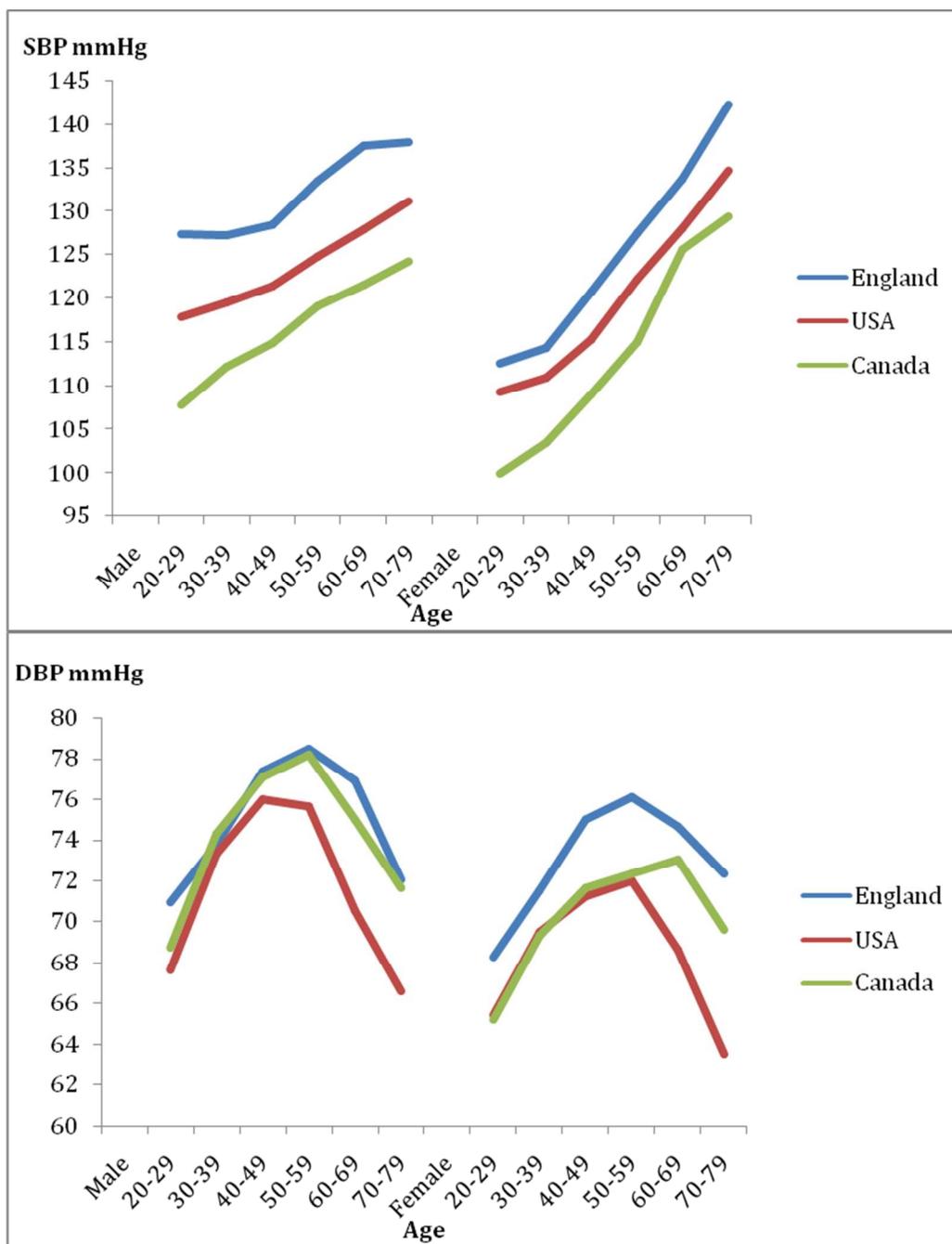


Table 2. Distribution of Measured Blood Pressure by Level, Sex, Age, and Country.

	Total	Normal			Pre-Hypertension			Stage 1			Stage 2		
		n	%	se	n	%	se	n	%	se	n	%	se
<i>ENGLAND</i>													
All	7,382	2,528	34.2	0.7	3,242	43.9	0.7	1,235	16.7	0.5	376	5.1	0.3
Sex													
Males	3,555	761	21.4	0.8	1,903	53.5	0.9	709	19.9	0.7	182	5.1	0.4
Females	3,826	1,767	46.2	0.9	1,339	35	0.9	526	13.7	0.6	195	5.1	0.4
Age													
20-39	2,618	1,273	48.6	1.2	1,115	42.6	1.1	210	8	0.6	20	0.8	0.2
40-59	2,962	966	32.6	0.9	1,360	45.9	0.9	482	16.3	0.7	155	5.2	0.4
60-79	1,801	289	16.1	1	767	42.6	1.5	543	30.2	1.3	201	11.2	0.9
<i>CANADA</i>													
All	3,485	2,214	66.1	1.7	955	27.2	1.4	259	5.4	0.3	57	1.3 ^E	0.2 ^E
Sex													
Males	1,649	951	60.6	2.4	538	32.9	2.2	140	5.9	0.5	20	0.7 ^E	0.2 ^E
Females	1,836	1,263	71.6	1.4	417	21.6	1.1	119	4.8	0.6	37	2.0 ^E	0.5 ^E
Age													
20-39	1,159	992	84.0	1.9	155	15.2	1.8	F	F	F	F	F	F
40-59	1,231	785	63.4	3.3	351	30.2	2.8	81	5.3	0.7	14	1.1 ^E	0.3 ^E
60-79	1,095	437	39.4	2.0	449	42.9	2.2	168	13.8	1.1	41	3.9 ^E	1.0 ^E
<i>USA</i>													
All	10,003	4,663	50.3	0.8	3,615	36.0	0.7	1,296	11.0	0.4	429	2.7	0.2
Sex													
Males	5,033	1,998	42.2	1.0	2,109	42.7	1.0	713	12.2	0.6	213	2.8	0.3
Females	4,970	2,665	58.3	1.0	1,506	29.3	0.8	583	9.7	0.5	216	2.7	0.2
Age													
20-39	3,394	2,210	65.2	1.1	1,007	29.7	1.1	148	4.4	0.4	29	0.7	0.1
40-59	3,586	1,608	46.5	1.3	1,371	39.1	1.1	473	11.9	0.7	134	2.6	0.3
60-79	3,023	845	30.8	1.3	1,237	41.3	1.2	675	21.2	1.1	266	6.7	0.5

^E Interpret with caution (coefficient of variation 16.6% to 33.3%)

^F Too unreliable to be reported (coefficient of variation greater than 33.3%)

Normal: Systolic<120 and diastolic<80. Pre-Hypertension: 120≤Systolic<140 or 80≤diastolic<90. Stage 1: 140≤Systolic<160 or 90≤diastolic<100. Stage 2: Systolic≥160 or diastolic≥100. Regardless of medication use

Table 3. Hypertension Prevalence and Percentage with Hypertension, Aware, Treated, Controlled, by sex, age group, and country.

	Prevalence		Aware		Treated		Treated & Controlled		Treated & not controlled		Aware, not treated	
	%	SE	%	SE	%	SE	%	SE	%	SE	%	SE
ENGLAND	30.0	0.7	65.3	1.2	51.3	1.2	27.3	1.1	23.9	0.9	14.1	0.8
All												
Sex												
Male	32.9	0.9	60.6	1.5	45.1	1.6	23.9	1.4	21.2	1.2	15.5	1.1
Female	27.3	0.8	70.7	1.5	58.2	1.6	31.1	1.6	27	1.4	12.5	1.1
Age												
20-39	9.3	0.7	35	3.1	10.6	2.1	5	1.4	5.6	1.7	24.4	2.9
40-59	27.9	0.8	59.3	1.7	40.8	1.8	23.1	1.5	17.7	1.2	18.5	1.3
60-80	63.7	1.3	76.1	1.6	67.4	1.7	35.1	1.8	32.3	1.6	8.7	0.9
CANADA												
All	19.5	0.6	83.4	1.8	79.9	2.0	65.8	2.0	14.0	2.0	3.5 ^E	0.9 ^E
Sex												
Male	19.7	1.1	80.4	2.2	76.5	2.1	66.8	3.0	9.7 ^E	2.0 ^E	3.9 ^E	0.9 ^E
Female	19.3	0.6	86.5	2.0	83.3	2.4	64.9	2.8	18.4 ^E	3.2 ^E	F	F
Age												
20-39	2.0 ^E	0.6 ^E	64.4	9.8	58.4 ^E	10.3 ^E	56.8 ^E	10.6 ^E	F	F	F	F
40-59	18.4	1.5	80.4	2.7	73.4	3.7	65.4	3.8	8.0 ^E	1.8 ^E	7.0 ^E	2.3 ^E
60-79	53.2	2.4	86.7	1.8	85.7	2.1	66.8	1.8	19.0	2.6	F	F
USA												
All	29.1	0.8	81.1	1.0	74.0	1.1	52.8	1.0	21.2	0.7	7.0	0.7
Sex												
Male	29.4	1	77.7	1.4	69.1	1.5	48.7	1.6	20.3	1.1	8.6	1
Female	28.8	0.9	84.6	1.2	79.1	1.4	57	1.5	22.1	1	5.5	0.7
Age												
20-39	7.7	0.6	61.1	4.6	47.2	4.0	35.0	3.6	12.2	2.4	13.9	2.5
40-59	31.1	1.2	82.4	1.4	73.1	1.8	53.5	1.7	19.6	1.3	9.4	1.0
60-79	63.6	1.3	84.2	1.3	80.9	1.4	56.1	1.5	24.8	0.9	3.3	0.6

^E Interpret with caution (coefficient of variation 16.6% to 33.3%)

^F Too unreliable to be reported (coefficient of variation greater than 33.3%)

Hypertension: Systolic pressure ≥ 140 or diastolic pressure ≥ 90 or currently taking blood pressure lowering medication

Awareness, treatment and control were assessed among those with hypertension.

1 Aware: Self-report of having been diagnosed as hypertensive by a doctor or nurse, excluding women diagnosed during
2 pregnancy (ENGLAND); Self-reported BP medication use in the past month or self-reported high blood pressure (Canada);
3 Self-report of having been diagnosed as hypertensive by a doctor or nurse, excluding women diagnosed during pregnancy
4 (USA)

5 Treated: Taking medication to lower blood pressure recorded by the nurse (ENGLAND); Taking medication to lower blood
6 pressure, self-report (Canada, USA);

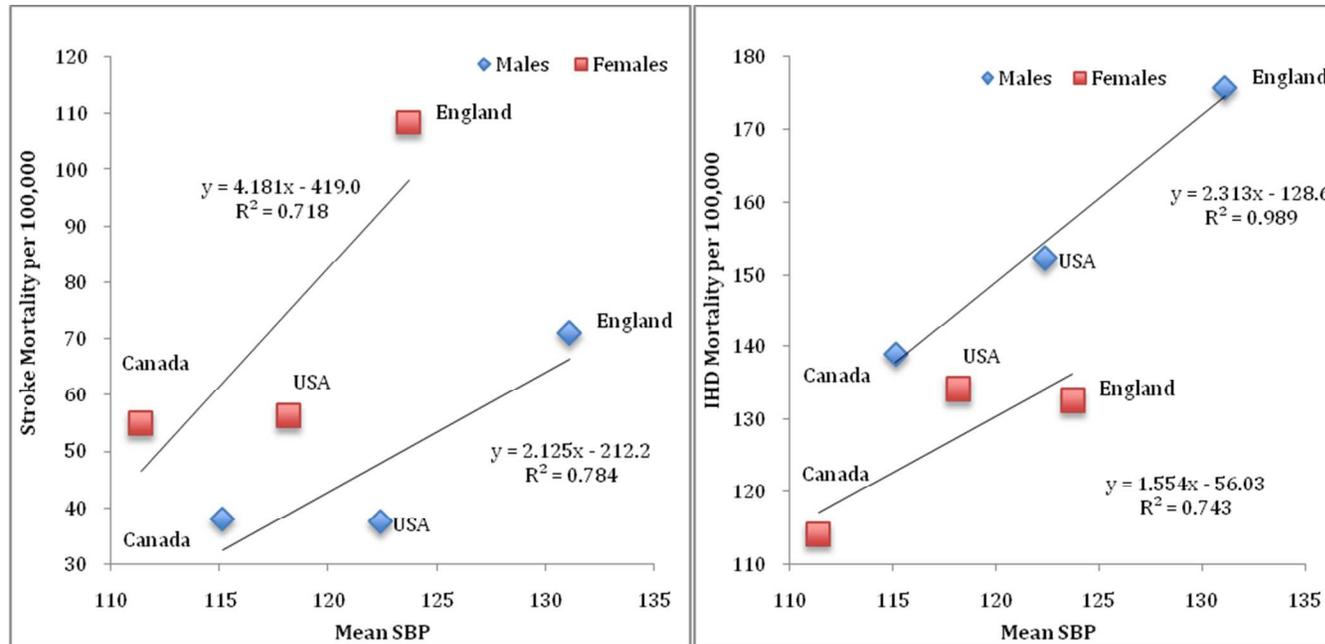
7 Treated and controlled: Taking medication to lower blood pressure and DBP <90 mm Hg and SBP <140 mm Hg

8 Treated and uncontrolled: Taking medication to lower blood pressure and DBP ≥90 mm Hg or SBP ≥140 mm Hg

9 Aware, not treated: Self-reported of having been diagnosed as hypertensive by a doctor or nurse, no taking medication to
10 lower blood pressure (ENGLAND); Self-reported of having been told by health care provider that they have high blood
11 pressure, not taking medication to lower blood pressure (Canada); Self-reported of having been told by health care
12 provider that they have high blood pressure, not taking medication to lower blood pressure (USA)

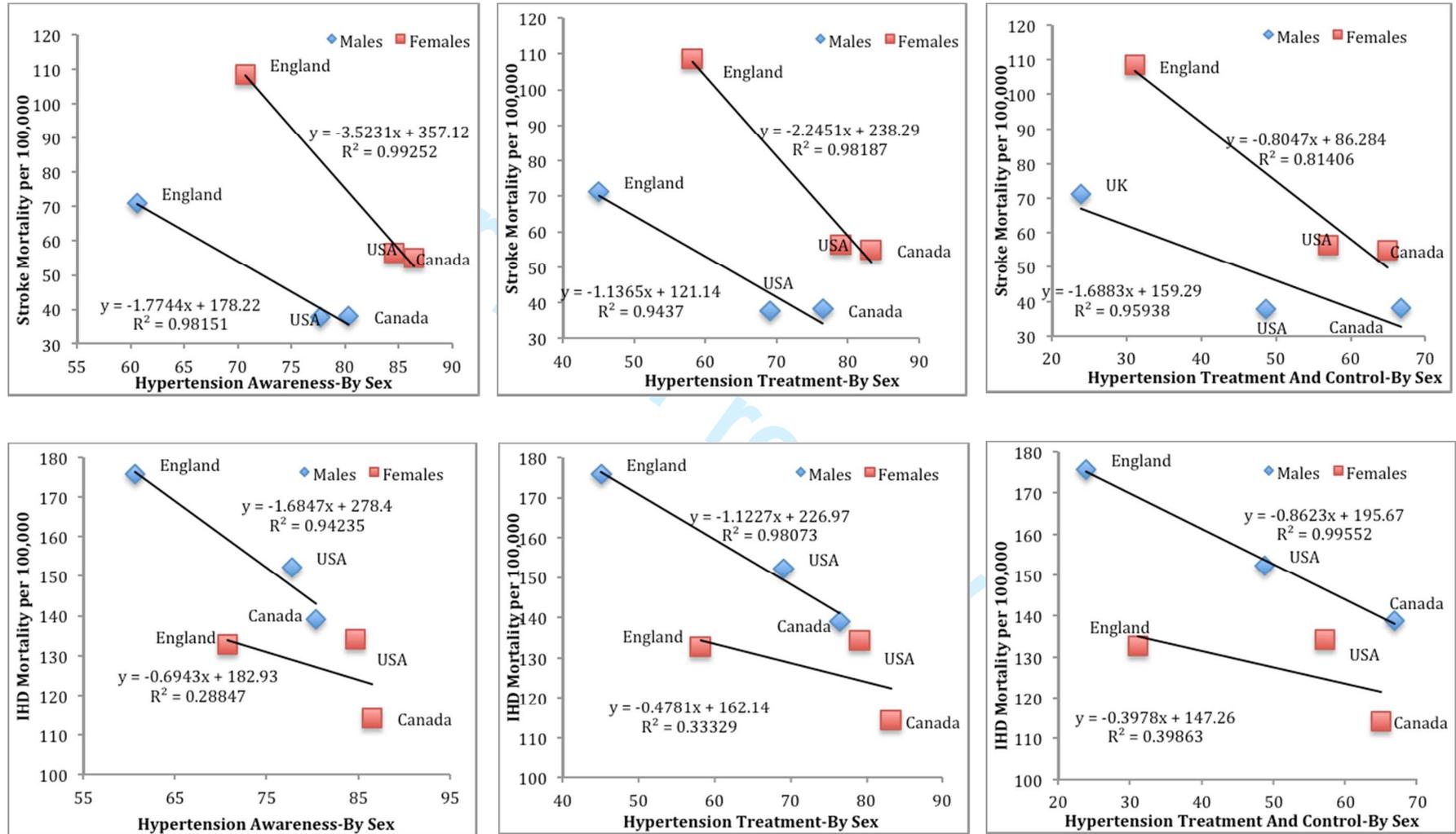
13 Unaware: No self report of having been diagnosed as hypertensive by a doctor or nurse (ENGLAND); No self report of
14 having been told that they have high blood pressure and no self report of BP medication use in the past month (Canada);
15 No self report of having been told that they have high blood pressure (USA)
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Figure 2. Stroke and Ischemic Heart Disease (IHD) Mortality* by Country Mean SBP



*2008 mortality rate per 100,000 (WHO) for USA and Canada; 2006 Statistics for England and Wales.

Figure 3. Stroke and IHD mortality by Country Prevalence of Hypertension Awareness, Treatment and Control



*2008 mortality rate per 100,000 (WHO) for USA and Canada; 2006 Statistics for England and Wales.

Appendix 1. Distribution of Systolic and Diastolic Blood Pressure by Sex, Age, and Country.

	England					CANADA					USA				
	n	SBP	se	DBP	se	n	SBP	se	DBP	se	n	SBP	se	DBP	se
Males															
20-24	153	126.7	0.8	69.2	0.8	127	106.6	0.7	67.5	0.8	436	117.0	0.6	66.3	0.9
25-29	196	127.9	0.8	72.5	0.8	98	108.9	1.0	70.1	0.8	413	118.6	0.8	68.9	0.6
30-34	275	127.5	0.7	73.5	0.6	134	112.2	0.9	73.8	0.7	410	118.4	0.6	71.6	0.5
35-39	320	126.8	0.7	74.1	0.6	165	112.1	0.8	74.7	0.6	468	120.3	0.6	74.7	0.6
40-44	389	126.5	0.6	75.7	0.5	190	113.5	0.8	76.5	0.6	442	120.7	0.8	76.1	0.7
45-49	335	130.9	0.9	79.5	0.7	173	115.9	0.9	77.7	0.6	448	121.8	0.9	75.9	0.8
50-54	316	132.2	0.9	78.4	0.6	134	117.9	1.0	78.8	0.6	510	124.4	0.9	75.9	0.7
55-59	384	134.6	0.8	78.6	0.6	85	120.6	1.6	77.4	0.9	383	125.1	0.9	75.2	0.7
60-64	326	137.0	0.9	77.5	0.6	201	120.5	1.0	76.2	0.6	517	128.3	1.0	72.4	0.9
65-69	141	138.2	2.1	76.1	1.1	141	122.7	1.3	73.6	0.7	381	127.0	1.4	67.9	1.1
70-74	124	137.3	1.7	72.1	1.0	107	125.2	1.6	72.8	1.0	345	130.0	1.3	67.1	0.7
75-79	84	138.9	1.9	71.9	1.1	94	123.2	1.6	70.3	0.9	280	132.3	1.6	66.0	1.0
All males	3,043	131.1	0.3	75.3	0.2	1649	115.1	0.3	74.5	0.2	5033	122.4	0.3	72.3	0.4
Females															
20-24	215	112.2	0.6	67.4	0.5	100	101.7	0.9	66.6	0.8	423	108.6	0.6	64.4	0.6
25-29	252	112.9	0.6	69.2	0.6	142	98.2	0.7	63.9	0.7	388	109.7	0.5	66.3	0.7
30-34	348	113.0	0.6	70.6	0.5	172	103.3	0.8	69.0	0.6	404	109.5	0.7	67.6	0.7
35-39	462	115.4	0.6	72.3	0.5	221	103.4	0.8	69.6	0.6	452	112.0	0.7	71.0	0.5
40-44	492	118.9	0.7	74.2	0.5	192	105.6	0.8	69.6	0.6	488	113.1	0.8	70.5	0.7
45-49	414	123.1	0.9	76.0	0.6	204	111.5	1.0	73.0	0.7	486	117.3	1.0	71.9	0.8
50-54	383	125.6	1.0	76.3	0.6	133	115.3	1.2	73.2	0.7	452	120.0	0.7	72.4	0.6
55-59	451	129.1	0.9	75.9	0.5	120	114.7	1.4	71.3	0.8	377	124.5	1.3	71.5	0.8
60-64	403	131.9	0.9	75.3	0.5	193	123.0	1.3	72.4	0.6	536	127.3	1.0	70.1	0.8
65-69	183	135.7	1.4	73.9	0.8	146	129.3	1.5	73.9	0.8	343	128.9	1.5	66.4	1.2
70-74	121	140.3	1.8	73.4	0.8	114	125.8	1.4	69.3	0.9	365	134.0	1.2	64.7	0.8
75-79	106	144.1	2.0	71.3	1.1	99	134.2	2.2	70.0	1.0	256	135.7	1.2	61.8	1.2
All females	3,830	123.7	0.4	73.1	0.2	1836	111.4	0.4	70.2	0.2	4970	118.1	0.4	69.0	0.4

Appendix 2. Mean Systolic (SBP) and Diastolic (DBP) Blood Pressure (mm Hg) among Hypertensive Individuals, by Awareness, Treatment and Control, and by Country.

		ENGLAND		CANADA		USA	
		SBP	DBP	SBP	DBP	SBP	DBP
Non hypertensive	mean	119.9	71.2	109.3	71.1	114.8	69.3
	se	0.2	0.1	0.2	0.2	0.2	0.4
All, Hypertensive	mean	144.3	81.0	129.5	77.3	133.7	74.0
	se	0.5	0.3	0.6	0.4	0.4	0.5
All, Aware	mean	141.7	78.5	126.1	75.2	130.8	72.3
	se	0.6	0.4	0.6	0.4	0.4	0.5
All, Treated	mean	138.8	75.9	125.2	74.4	129.0	71.1
	se	0.7	0.4	0.6	0.4	0.4	0.5
Treated and Controlled	mean	125.4	71.2	119.7	72.8	120.2	68.3
	se	0.5	0.4	0.5	0.4	0.3	0.5
Treated and not controlled	mean	154.1	81.2	151.1	81.9	151.0	78.0
	se	0.8	0.6	1.3	0.9	0.6	0.7
Aware, not treated	mean	151.5	88.1	147.2 ^E	93.8 ^E	149.3	85.1
	se	0.8	0.6	2.5 ^E	2.0 ^E	1.2	1.1
Unaware	mean	149.3	85.5	146.7	87.6	146.1	81.5
	se	0.5	0.5	1.0	0.7	0.6	1.3

^E Interpret with caution (coefficient of variation 16.6% to 33.3%)

Hypertension: Systolic pressure ≥ 140 or diastolic pressure ≥ 90 or currently taking blood pressure lowering medication

Aware: Self-report of having been diagnosed as hypertensive by a doctor or nurse, excluding women diagnosed during pregnancy (England); Self-reported blood pressure medication use in the past month or self-reported high blood pressure (Canada); Self-report of having been diagnosed as hypertensive by a doctor or nurse, excluding women diagnosed during pregnancy (USA)

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5 Treated: Taking medication to lower blood pressure recorded by the nurse (England); Taking medication to lower blood
6 pressure, self-report (Canada, USA);
7 Treated and controlled: Taking medication to lower blood pressure and DBP <90 mm Hg and SBP <140 mm Hg
8 Treated and uncontrolled: Taking medication to lower blood pressure and DBP ≥90 mm Hg or SBP ≥140 mm Hg
9 Aware, not treated: Self-reported of having been diagnosed as hypertensive by a doctor or nurse, no taking medication to
10 lower blood pressure (England); Self-reported of having been told by health care provider that they have high blood
11 pressure, not taking medication to lower blood pressure (Canada); Self-reported of having been told by health care
12 provider that they have high blood pressure, not taking medication to lower blood pressure (USA)
13 Unaware: No self report of having been diagnosed as hypertensive by a doctor or nurse (England); No self report of
14 having been told that they have high blood pressure and no self report of blood pressure medication use in the past
15 month (Canada); No self report of having been told that they have high blood pressure (USA)
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STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

	Item No	Recommendation
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract Done 'National Surveys'
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found Done
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported Done
Objectives	3	State specific objectives, including any prespecified hypotheses Done
Methods		
Study design	4	Present key elements of study design early in the paper Done
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection Done
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants Done –Brief description-
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable Done when relevant.
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group Done
Bias	9	Describe any efforts to address potential sources of bias Not applicable Limitations covered later
Study size	10	Explain how the study size was arrived at Referred to survey methodology papers
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why Done
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding Done- Confounding not considered in this type of analysis
		(b) Describe any methods used to examine subgroups and interactions Not applicable
		(c) Explain how missing data were addressed Not applicable
		(d) If applicable, describe analytical methods taking account of sampling strategy Done

(e) Describe any sensitivity analyses

Results			
Participants	13*	(a)	Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
			Numbers provided in tables
		(b)	Give reasons for non-participation at each stage
			Not relevant for this study. Provided in the original survey method papers
		(c)	Consider use of a flow diagram
Descriptive data	14*	(a)	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
			Not relevant for this study. Provided in the original survey method papers
		(b)	Indicate number of participants with missing data for each variable of interest
			Numbers provided in tables
Outcome data	15*		Report numbers of outcome events or summary measures
			Numbers provided in tables
Main results	16	(a)	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
			Not applicable
		(b)	Report category boundaries when continuous variables were categorized
			Standard error provided to simplify tables. Would be too cumbersome to add all CI
		(c)	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17		Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
			Not applicable
Discussion			
Key results	18		Summarise key results with reference to study objectives
			Done
Limitations	19		Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
			Done
Interpretation	20		Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
			Done
Generalisability	21		Discuss the generalisability (external validity) of the study results
			Done—Since these are national representative populations surveys
Other information			

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Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based
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Done

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Hypertension Prevalence, Awareness, Treatment, and Control in National Surveys from England, the USA, and Canada, and Correlation with Stroke and Ischemic Heart Disease Mortality



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SCHOLARONE™
Manuscripts

Hypertension Prevalence, Awareness, Treatment, and Control in National Surveys from England, the USA, and Canada, and Correlation with Stroke and Ischemic Heart Disease Mortality

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Ethical approval was not required for these secondary analyses since all the original studies had their own ethical approval process.

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Statement of independence of researchers from funders - The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention, the Public Health Agency of Canada or the UK Department of Health.

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Data sharing statement. All the authors had access to the original tables from the different studies. There is no additional data available.

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Article Summary

1) Article focus

- Comparison of hypertension prevalence, awareness, treatment, and control in 3 National studies, England, USA, and Canada
- Correlation with stroke and ischemic heart disease mortality

2) Key messages

- Important variation by country
- Strong relationship between hypertension indicators and stroke mortality
- Gaps in the management of hypertension

3) Strengths and limitations

- Strengths
 - National population data
 - Detailed data on hypertension characteristics
 - Strong correlation with meaningful outcome, mortality
- Limitations
 - Data from England from 2006, but provide an important basis for measuring progress (current data not yet available)
 - Limited to 3 countries
 - Ecological correlation with mortality that excludes looking at confounders

ABSTRACT

Objective Comparison of recent national survey data on prevalence, awareness, treatment and control of hypertension in England, the USA and Canada, and correlation of these parameters with each country stroke and ischemic heart disease (IHD) mortality.

Methods Non-institutionalized population surveys from England (2006), the USA (2007-2010) and Canada (2007-2009) using standardized protocols and devices. Analysis included individuals age 20-79 years. Stroke and IHD mortality rates were plotted against countries' specific prevalence data.

Results Mean systolic blood pressure (SBP) was higher in England than in the USA and Canada in all age-gender groups. Mean diastolic blood pressure (DBP) was similar in the three countries before age 50 and then fell more rapidly in the USA and was the lowest in the USA. Only 34% had a BP under 140/90 mmHg in England, compared with 50% in the USA and 66% in Canada. Pre-hypertension and stage 1 and 2 hypertension prevalence figures were the highest in England. Hypertension prevalence (≥ 140 mmHg SBP and/or ≥ 90 mmHg DBP) was lower in Canada (19.5%) than in the USA (29%) and England (30%). Hypertension awareness was higher in both the USA (81%) and Canada (83%), than in England (65%). England also had lower levels of hypertension treatment (51%; USA 74%; Canada 80%) and control ($< 140/90$ mmHg; 27%; USA 53%; Canada 66%). Canada had the lowest Stroke and IHD mortality rates, England the highest, and rates were inversely related to the mean SBP in each country and strongly related to blood pressure indicators, the strongest relationship being between low hypertension awareness and stroke mortality.

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Conclusion While current prevention efforts in England should result in future improved figures, especially at younger ages, these data still show important gaps in the management of hypertension in these countries, with consequences on stroke and IHD mortality.

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Introduction

Increased blood pressure is the leading risk factor for premature death, stroke, and heart disease worldwide.¹ In the year 2000, the world was estimated to have close to 1 billion people with hypertension and predicted an increase to 1.56 billion by 2025.² The global economic burden of increased blood pressure was estimated to consume 370 billion US \$ worldwide and 10 % of health care expenditures.³ Usual blood pressure is strongly and directly related to vascular and overall mortality without evidence of a threshold down to at least 115/75mmHg⁴ with small changes in blood pressure resulting in substantial changes in vascular disease.⁵

Based on clinical and population research, increased blood pressure, hypertension and hypertension related complications are largely preventable. Lifestyle changes can lower blood pressure and prevent hypertension while antihypertensive drug therapy can effectively reduce the cardiovascular events attributed to hypertension.¹⁻⁶ Nevertheless, most people with hypertension worldwide are not effectively treated and controlled to recommended blood pressure targets.⁷ There are few national programs to serve as models for prevention and control of hypertension and few countries have embarked on national hypertension prevention and control programs. The United States (USA) blood pressure education program was established in 1972⁸, while Canada (2000) and England (2004) have more recent initiatives.^{9,10} This manuscript compares recent data on prevalence, awareness, treatment and control of hypertension in England, the USA and Canada and correlates these hypertension-related parameters in the three countries to mortality from stroke and ischemic heart disease (IHD).

Methods

Survey methods used in England, the USA, and Canada are summarized in Table 1. Detailed methodology for each survey is available elsewhere.¹¹⁻¹³ Briefly, each survey is a representative sample of each country's non-institutionalized population and uses standardized protocols and

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2
3 devices. While the England (2006) and Canada (2007-2009) surveys used automatic oscillometric
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5 devices, the USA (2007-2010) survey used mercury wall sphygmomanometer models. The number
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7 of blood pressure measurements available for analysis varied by count of blood pressure measures
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9 and survey protocols (Table 1).

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11 In these analyses, hypertension was defined as a mean systolic blood pressure (SBP) ≥ 140 mmHg
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13 or a mean diastolic blood pressure (DBP) ≥ 90 mmHg or a respondent self-report of medication to
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15 lower blood pressure. Pre-hypertension (SBP 120-139 mmHg or DBP 80-89 mmHg), stage 1 (SBP
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17 140-159 mmHg or DBP 90-99 mmHg), and stage 2 (SBP ≥ 160 mmHg or DBP ≥ 100 mmHg)
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19 hypertension were defined according to the Seventh Report of the Joint National Committee on the
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21 Prevention, Detection, Evaluation and Treatment of High Blood Pressure (JNC 7) definitions.⁶
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23 Prevalence, awareness, treatment, control and awareness of hypertension were defined using
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25 commonly recognized standards. Prevalence was defined as SBP ≥ 140 or DBP ≥ 90 or currently
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27 taking medication to lower their blood pressure. Awareness was defined by self-report and
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29 included having been diagnosed as hypertensive by a doctor or nurse, excluding women diagnosed
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31 during pregnancy (England), medication to lower blood pressure in the past month or reported
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33 high blood pressure (Canada), or having been diagnosed as hypertensive by a doctor or nurse,
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35 excluding women diagnosed during pregnancy (USA). Treatment was defined as taking medication
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37 to lower blood pressure, as recorded by the nurse (England), or a self-report of taking medication
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39 to lower blood pressure (Canada, USA). Treated and controlled was defined as taking medication to
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41 lower blood pressure and SBP < 140 mmHg and DBP < 90 mmHg; treated and uncontrolled a SBP
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43 ≥ 140 mmHg or DBP ≥ 90 mmHg while on medication to lower blood pressure. Aware, yet not
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45 treated, was defined by self-report and included having been diagnosed as hypertensive by a doctor
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47 or nurse (England) / health care provider (Canada, USA), and not taking medication to lower blood
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49 pressure.
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3 Survey data were not age and sex standardized. They represent the current country-specific figures,
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5 and therefore correspond more precisely to each country's crude mortality rates for stroke and
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7 IHD. All prevalence figures are weighted using survey weights to represent each country's
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9 population. Standard errors were computed taking into account each country's sampling
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11 methodology.¹¹⁻¹³ To be comparable across the three surveys, the analysis was restricted to
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13 individuals age 20-79 years and excluded pregnant women. The Canadian Health Measures Survey
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15 (CHMS) data analysis was performed using SAS® Enterprise Guide (Version 4.1, SAS Institute Inc.,
16
17 Cary, NC, 2006). The Health Survey for England (HSE) data analysis was performed using SPSS 19.
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19 The National Health and Nutrition Examination Survey (NHANES) data analysis was performed
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21 using SAS version 9.2 and SAS-Callable SUDAAN version 10 (RTI International)], to account for the
22
23 complex sampling design.
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27 The latest WHO country specific mortality data available were from 2008 for Canada and the USA¹⁴
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29 and we used 2006 data for England.¹⁵ Crude mortality rates per 100,000 were obtained for men and
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31 women for stroke and ischemic heart disease (IHD) and plotted against country specific prevalence
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33 data for hypertension awareness, treatment, and control.
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38 Results

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40 The distribution of SBP and DBP by sex, age, and country shows an increase in SBP with age and an
41
42 increase, plateau and decrease of DBP with aging (Figure 1; Appendix 1 Table). SBP is higher in
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44 men than women in the younger age groups and becomes higher in women than men after age 60
45
46 years in Canada and age 70 years in England and USA. Mean SBP is overall higher in England than in
47
48 the USA and Canada in all age-gender groups. DBP is similar in the 3 countries before age 50 and
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50 then falls more rapidly in the USA and is overall lower in men and women from the USA.
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54 The distribution of measured blood pressure (including treated individuals), by level, in Table 2
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56 reflects the findings in Figure 1. Only 34% of adults aged 20-79 years would be classified as having
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3 a normal blood pressure (<120/80 mmHg) in England, compared with 50% in the USA and 66% in
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5 Canada. Pre-hypertension and stage 1 and 2 hypertension prevalence figures are also much higher
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7 in England than in the USA and Canada.
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10 The prevalence of hypertension, and awareness, treatment, and control levels among those with
11
12 hypertension are shown in Table 3. The prevalence of hypertension is lowest in Canada (19.5%)
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14 and higher in the USA (29%) and England (30%). Hypertension awareness is close to 80% in both
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16 the USA (81%) and Canada (83%) and lower in England (65%). England also has lower levels of
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18 hypertension treatment (England 51%; USA 74%; Canada 80%) and control (England 27%; USA
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20 53%; Canada 66%). These patterns are similar in the different age and sex sub groups (Table 3).
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22 Among individuals treated for hypertension (i.e., taking medication to lower blood pressure), the
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24 proportion being controlled is lowest in England (53%), while 71% in the USA and 82% in Canada
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26 are controlled.
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30 The mean SBP and DBP are provided in Appendix 2 by the different prevalence categories of Table
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32 3. The data are consistent with those in the previous tables showing the highest SBP mean in
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34 England in all categories. For DBP, England has also higher means than the USA and Canada among
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36 all hypertensives and aware and treated categories.
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39 At the time when these surveys were conducted, Canada had the lowest stroke and IHD mortality
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41 rates while England had the highest. Rates of both outcomes were inversely related to the mean
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43 SBP in each country (Figure 2). We found a strong relationship between the selected blood
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45 pressure indicators and stroke and IHD mortality, the strongest relationship being between
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47 hypertension awareness and stroke mortality, especially in women (Figure 3). Stroke rates were
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49 higher in women than men for any level of each of the BP indicators and the opposite was true for
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51 IHD (Figure 2-3).
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56 Discussion

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3 Although all 3 countries evaluated have had substantive improvement in most hypertension
4 treatment indicators over the past two decades¹⁶⁻²⁰, this study found marked differences in
5 hypertension prevalence, awareness, treatment and control rates in England, the USA, and Canada.
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10 Canada has the lowest prevalence of hypertension at 19% followed by England and United States at
11 about 30% each. A previous study based on earlier cycles of these surveys also found little
12 difference in the prevalence of hypertension between England and the USA.²¹ The main
13 determinants of hypertension are known. These include poor dietary habits, excess sodium intake,
14 physical inactivity, obesity, excess alcohol consumption, as well as age, gender, race and
15 sociodemographic factors. The national differences in prevalence are likely related to differences in
16 the interaction between these determinants as well as differences in the clinical systems,
17 community programs, and environmental and policy supports for hypertension prevention and
18 management. Compared to the USA, Canada has a lower rate of obesity but to our knowledge there
19 has never been a comprehensive comparison of the determinants of blood pressure using
20 appropriately adjusted data in these countries. A comprehensive comparison of the determinants of
21 hypertension and the policies that fail to address adverse differences in the modifiable
22 determinants would be an important next step. This is also important since these data show an
23 important difference in the younger age groups between England, Canada and the USA. Since blood
24 pressure tracks with age²², efforts to influence the determinants of hypertension are essential to
25 reduce hypertension prevalence in the older age groups. The recent decrease in childhood obesity
26 in England²³ should be followed by a reduction in blood pressure in the next surveys.

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47 Our study has also found important differences in the awareness, treatment and control of
48 hypertension in the three countries. England, the USA, and Canada all have developed differing
49 approaches to improve hypertension treatment and control. In the USA, several diverse
50 approaches have been taken.^{6, 8, 24} Historically the USA has had one of the world's highest rates of
51 hypertension awareness, treatment and control and has also seen improvements in these indicators
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3 with intensified efforts;¹⁸ however, despite broad clinical and community efforts, over half of adults
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5 with hypertension are uncontrolled based on current guidelines.¹⁹ Recent national activities and
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7 recommendations are staged to positively impact hypertension estimates.²⁵⁻²⁹
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10 Importantly, we also found national-level differences in mortality rates from stroke and IHD, which
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12 paralleled the differences in hypertension awareness, treatment, and control between these 3
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14 countries. Both stroke and IHD mortality were strongly inversely correlated with mean SBP in each
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16 country.
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18 Efforts in England have included episodic national hypertension recommendations developed by
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20 the British Hypertension Society (B.H.S - a non-governmental organization of specialists and
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22 researchers) with the recommendations more recently being developed by a governmental
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24 organization in collaboration with the BHS.³⁰ Implementation programs have included an extensive
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26 public program to educate people on the risks of salt for hypertension³¹ and also to an extensive
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28 government program to pay General Practitioners bonus payments for achieving benchmarks for
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30 hypertension care³² – although the efficacy of payment for performance for improving hypertension
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32 control has been questioned.³³
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36 In 2000, Canada launched an annually updated hypertension recommendations program (Canadian
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38 Hypertension Education Program (CHEP)).⁹ In 2006, the program was assisted by an extensive
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40 initiative to inform the public about hypertension and the health risks and opportunities to reduce
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42 dietary salt.³⁴ The introduction of CHEP in Canada is temporally related to improvements in
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44 management patterns and has been also temporally associated with reduced CVD in Canada.³⁵
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47 It is difficult to assess how much the different national approaches to hypertension detection and
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49 management impact on the differences observed in our study. British Guidelines in place in
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51 2006^{10,39} and since³⁰ do not recommend the routine use of antihypertensive treatment for those
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53 with a systolic BP >140 mmHg and/or diastolic BP > 90 mmHg, rather only if such people have an
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55 estimated 10 year CV risk of > 20%. Consequently treatment rates and control rates might be
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3 expected to be lower in England than in the USA & Canada. Furthermore, in England, the National
4 Institute for Health and Clinical Excellence's Quality and Outcomes Framework, which includes
5 measures used in the calculation of provider reimbursement, included a higher blood pressure
6 target (<150/90) during the period of data used for these analyses. This will be lowered (to
7 <140/90) in 2013/2014 to align with national guidelines. In addition to the new National Institute
8 for Health and Clinical Excellence (NICE) guidelines³⁰, the national salt reduction program in
9 England would be expected to result in further reductions in the prevalence of hypertension and
10 improvement in hypertension treatment indicators in the recent and future years as Canadian and
11 Finnish data suggest.^{36,37}

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23 There are several potential limitations to our current analyses. In addition to low response rates
24 and hence small numbers in some strata, each country uses different methodology to assess blood
25 pressure and relatively small differences in blood pressure can impact hypertension indicators. In
26 particular Canada has adopted the use of a fully automated blood pressure device that operates in
27 the absence of an observer and averages the last 5 of six blood pressure readings. The Canadian
28 method reduces the influence of the observer (white coat effect) on blood pressure and results in a
29 slightly lower average blood pressure than a single auscultatory blood pressure reading.

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Nevertheless using an algorithm to adjust the data in the Canadian survey³⁸ to represent single
manual reading results in little change in the major hypertension indicators as the difference in
methods at the therapeutic cut point of 140/90 mmHg is relatively small, but might reduce the
differences between the US and Canada. The close relationship between stroke mortality and
hypertension prevalence and hypertension indicators suggest that blood pressure and
hypertension differences seen in this study are real and biologically important. We acknowledge
the limitation of using three points for our mortality graphs, which require a high level of
correlation to be statistically significant.

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3 We did not use age- or gender-adjusted data from the different countries. The lack of adjustment
4 was intended so that hypertension risk factors could be directly compared to stroke mortality for
5 each country. In addition, in a separate analysis, comparison of age-adjusted data to a common
6 standard population showed very little difference with the current figures. We were not able to
7 obtain more recent common mortality data than 2008 for all countries. There is some overlap
8 between the timing of the US and Canadian surveys, but the English survey was conducted more
9 than one year earlier. Management of hypertension in England is likely to have improved since
10 2006. Increased blood pressure and hypertension represent major global threats to population
11 health, with stroke and IHD being the most closely related adverse outcomes.⁴ Interventions to
12 lower average population blood pressure and interventions to identify and control blood pressure
13 in those with hypertension are critical to prevent blood pressure related complications.²⁻⁶
14 Nevertheless, hypertension control rates are low even in developed countries and most countries
15 do not have formal programs to control hypertension.⁴⁰ Further, population surveys indicate that
16 approximately 29% of men and 25% of women have uncontrolled hypertension with increasing
17 numbers of hypertension cases globally due to population growth and ageing.⁴¹ Hence, countries
18 worldwide should consider introducing and evaluating coordinated programs to improve the
19 prevention, detection, awareness, treatment, and control of hypertension, and our data suggest that
20 the more assertive approach apparent in North America is associated with large benefits in terms of
21 reduced cardiovascular mortality. A greater focus on prevention of high blood pressure in the
22 younger age groups is also necessary.
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For peer review only

Figure 1. Distribution of Systolic and Diastolic Blood Pressure by Country, Age and Sex.

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Figure 2. Stroke and Ischemic Heart Disease (IHD) Mortality* by Country Mean SBP

*2008 mortality rate per 100,000 (WHO) for USA and Canada; 2006 Statistics for England and Wales.

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3 Figure 3. Stroke and IHD mortality by Country Prevalence of Hypertension Awareness, Treatment and Control
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6 *2008 mortality rate per 100,000 (WHO) for USA and Canada; 2006 Statistics for England and Wales
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Table 1. Survey methods, by country.

<i>Country</i>	<i>Years of Survey</i>	<i>Sampling</i>	<i>n</i>	<i>Age Range</i>	<i>Response Rate</i>
England	2006	Multistage	6,873	20-79	68% household response rate, 88% individual response rate in co-operating households and 66% with nurse visit (examination response rate).
Canada	2007-2009	Multistage	3,485	20-79	Household response rate = 70% Individual response rate to the household questionnaire = 88% Examination response rate = 85%
US	2007-2010	Multistage	10,003	20-79	Interview response rate = 79% Examination response rate = 76% 93% of those examined had ≥ 2 blood pressure measurements

<i>Country</i>	<i>Blood Pressure Device</i>	<i>Technician</i>	<i>N of Blood Pressure Measures</i>	<i>Study Protocol Used</i>
England	Omron HEM 907	Nurse	3	Mean of second and third measures taken 1 minute apart after 5 minutes rest
Canada	Bp TRU™ BP-300*	Health measures specialists	6	Average of last 5 of 6 measures taken one minute apart after a 5 minute rest period
US	Calibrated® V-Lok® cuff, Latex Inflation Bulb, Air-Flo® Control Valve. Baumanometer® calibrated mercury wall model.	Physician	3	Mean of second and third measurement taken 30 seconds apart after resting quietly in a sitting position for 5 minutes†

*Bp TRU™ BP-100 used during home visits for respondents who were unable or unwilling to go at the mobile clinic.

† US NHANES survey protocol: After resting quietly in a sitting position for 5 minutes, three consecutive blood pressure readings were obtained. If a blood pressure measurement was interrupted or incomplete, a fourth attempt could be made.

All valid blood pressure readings excluding pregnant women.

Table 2. Distribution of Measured Blood Pressure by Level, Sex, Age, and Country.

	Total	Normal			Pre-Hypertension			Stage 1			Stage 2		
		n	%	se	n	%	se	n	%	se	n	%	se
<i>ENGLAND</i>													
All	7,382	2,528	34.2	0.7	3,242	43.9	0.7	1,235	16.7	0.5	376	5.1	0.3
Sex													
Males	3,555	761	21.4	0.8	1,903	53.5	0.9	709	19.9	0.7	182	5.1	0.4
Females	3,826	1,767	46.2	0.9	1,339	35	0.9	526	13.7	0.6	195	5.1	0.4
Age													
20-39	2,618	1,273	48.6	1.2	1,115	42.6	1.1	210	8	0.6	20	0.8	0.2
40-59	2,962	966	32.6	0.9	1,360	45.9	0.9	482	16.3	0.7	155	5.2	0.4
60-79	1,801	289	16.1	1	767	42.6	1.5	543	30.2	1.3	201	11.2	0.9
<i>CANADA</i>													
All	3,485	2,214	66.1	1.7	955	27.2	1.4	259	5.4	0.3	57	1.3 ^E	0.2 ^E
Sex													
Males	1,649	951	60.6	2.4	538	32.9	2.2	140	5.9	0.5	20	0.7 ^E	0.2 ^E
Females	1,836	1,263	71.6	1.4	417	21.6	1.1	119	4.8	0.6	37	2.0 ^E	0.5 ^E
Age													
20-39	1,159	992	84.0	1.9	155	15.2	1.8	F	F	F	F	F	F
40-59	1,231	785	63.4	3.3	351	30.2	2.8	81	5.3	0.7	14	1.1 ^E	0.3 ^E
60-79	1,095	437	39.4	2.0	449	42.9	2.2	168	13.8	1.1	41	3.9 ^E	1.0 ^E
<i>USA</i>													
All	10,003	4,663	50.3	0.8	3,615	36.0	0.7	1,296	11.0	0.4	429	2.7	0.2
Sex													
Males	5,033	1,998	42.2	1.0	2,109	42.7	1.0	713	12.2	0.6	213	2.8	0.3
Females	4,970	2,665	58.3	1.0	1,506	29.3	0.8	583	9.7	0.5	216	2.7	0.2
Age													
20-39	3,394	2,210	65.2	1.1	1,007	29.7	1.1	148	4.4	0.4	29	0.7	0.1
40-59	3,586	1,608	46.5	1.3	1,371	39.1	1.1	473	11.9	0.7	134	2.6	0.3
60-79	3,023	845	30.8	1.3	1,237	41.3	1.2	675	21.2	1.1	266	6.7	0.5

^E Interpret with caution (coefficient of variation 16.6% to 33.3%)

^F Too unreliable to be reported (coefficient of variation greater than 33.3%)

Normal: Systolic<120 and diastolic<80. Pre-Hypertension: 120≤Systolic<140 or 80≤diastolic<90. Stage 1: 140≤Systolic<160 or 90≤diastolic<100. Stage 2: Systolic≥160 or diastolic≥100. Regardless of medication use

Table 3. Hypertension Prevalence and Percentage with Hypertension, Aware, Treated, Controlled, by sex, age group, and country.

	Prevalence		Aware		Treated		Treated & Controlled		Treated & not controlled		Aware, not treated	
	%	SE	%	SE	%	SE	%	SE	%	SE	%	SE
ENGLAND												
All	30.0	0.7	65.3	1.2	51.3	1.2	27.3	1.1	23.9	0.9	14.1	0.8
Sex												
Male	32.9	0.9	60.6	1.5	45.1	1.6	23.9	1.4	21.2	1.2	15.5	1.1
Female	27.3	0.8	70.7	1.5	58.2	1.6	31.1	1.6	27	1.4	12.5	1.1
Age												
20-39	9.3	0.7	35	3.1	10.6	2.1	5	1.4	5.6	1.7	24.4	2.9
40-59	27.9	0.8	59.3	1.7	40.8	1.8	23.1	1.5	17.7	1.2	18.5	1.3
60-80	63.7	1.3	76.1	1.6	67.4	1.7	35.1	1.8	32.3	1.6	8.7	0.9
CANADA												
All	19.5	0.6	83.4	1.8	79.9	2.0	65.8	2.0	14.0	2.0	3.5 ^E	0.9 ^E
Sex												
Male	19.7	1.1	80.4	2.2	76.5	2.1	66.8	3.0	9.7 ^E	2.0 ^E	3.9 ^E	0.9 ^E
Female	19.3	0.6	86.5	2.0	83.3	2.4	64.9	2.8	18.4 ^E	3.2 ^E	F	F
Age												
20-39	2.0 ^E	0.6 ^E	64.4	9.8	58.4 ^E	10.3 ^E	56.8 ^E	10.6 ^E	F	F	F	F
40-59	18.4	1.5	80.4	2.7	73.4	3.7	65.4	3.8	8.0 ^E	1.8 ^E	7.0 ^E	2.3 ^E
60-79	53.2	2.4	86.7	1.8	85.7	2.1	66.8	1.8	19.0	2.6	F	F
USA												
All	29.1	0.8	81.1	1.0	74.0	1.1	52.8	1.0	21.2	0.7	7.0	0.7
Sex												
Male	29.4	1	77.7	1.4	69.1	1.5	48.7	1.6	20.3	1.1	8.6	1
Female	28.8	0.9	84.6	1.2	79.1	1.4	57	1.5	22.1	1	5.5	0.7
Age												
20-39	7.7	0.6	61.1	4.6	47.2	4.0	35.0	3.6	12.2	2.4	13.9	2.5
40-59	31.1	1.2	82.4	1.4	73.1	1.8	53.5	1.7	19.6	1.3	9.4	1.0
60-79	63.6	1.3	84.2	1.3	80.9	1.4	56.1	1.5	24.8	0.9	3.3	0.6

^E Interpret with caution (coefficient of variation 16.6% to 33.3%)

^F Too unreliable to be reported (coefficient of variation greater than 33.3%)

Hypertension: Systolic pressure ≥ 140 or diastolic pressure ≥ 90 or currently taking blood pressure lowering medication
Awareness, treatment and control were assessed among those with hypertension.

1 Aware: Self-report of having been diagnosed as hypertensive by a doctor or nurse, excluding women diagnosed during
2 pregnancy (ENGLAND); Self-reported BP medication use in the past month or self-reported high blood pressure (Canada);
3 Self-report of having been diagnosed as hypertensive by a doctor or nurse, excluding women diagnosed during pregnancy
4 (USA)
5 Treated: Taking medication to lower blood pressure recorded by the nurse (ENGLAND); Taking medication to lower blood
6 pressure, self-report (Canada, USA);
7 Treated and controlled: Taking medication to lower blood pressure and DBP <90 mm Hg and SBP <140 mm Hg
8 Treated and uncontrolled: Taking medication to lower blood pressure and DBP ≥90 mm Hg or SBP ≥140 mm Hg
9 Aware, not treated: Self-reported of having been diagnosed as hypertensive by a doctor or nurse, not taking medication to
10 lower blood pressure (ENGLAND); Self-reported of having been told by health care provider that they have high blood
11 pressure, not taking medication to lower blood pressure (Canada); Self-reported of having been told by health care
12 provider that they have high blood pressure, not taking medication to lower blood pressure (USA)
13 Unaware: No self report of having been diagnosed as hypertensive by a doctor or nurse (ENGLAND); No self report of
14 having been told that they have high blood pressure and no self report of BP medication use in the past month (Canada);
15 No self report of having been told that they have high blood pressure (USA)
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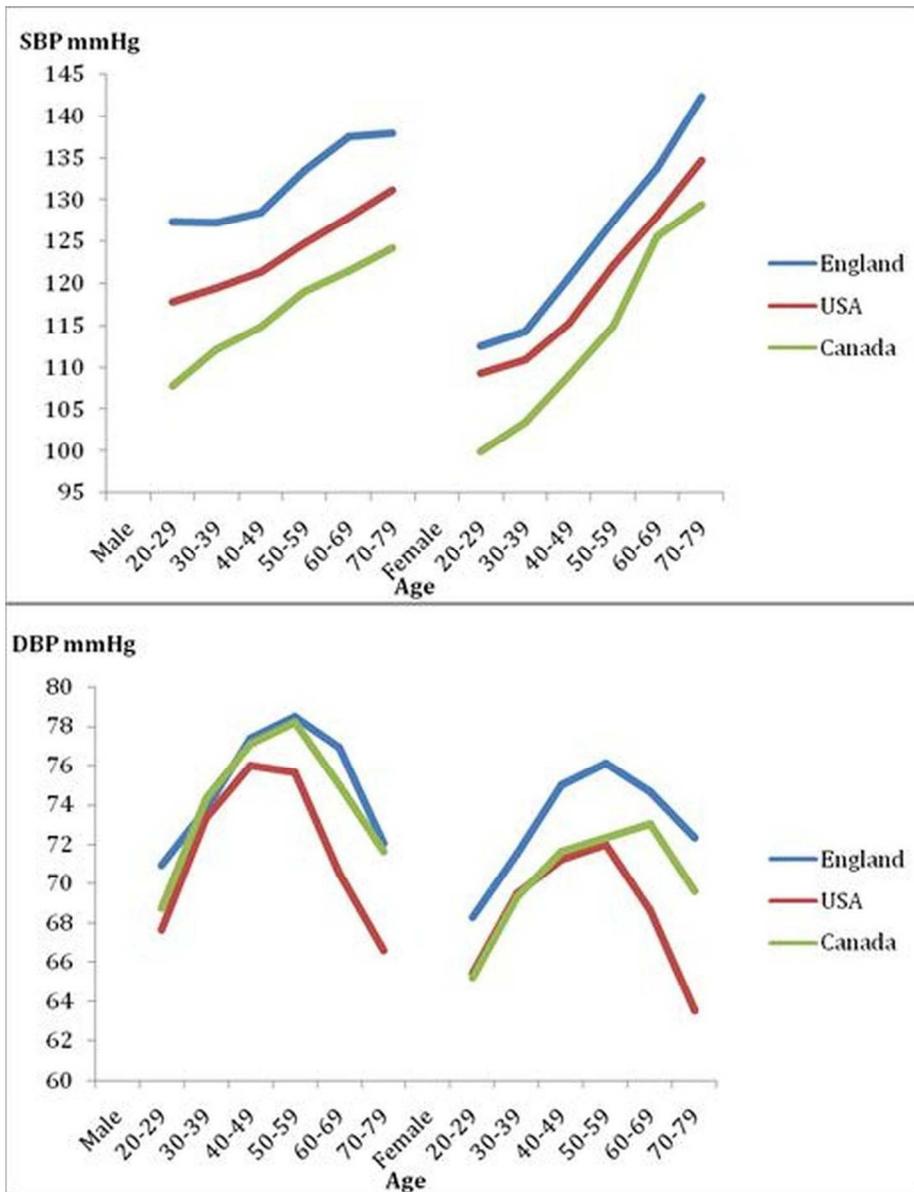


Figure 1. Distribution of Systolic and Diastolic Blood Pressure by Country, Age and Sex.

119x155mm (300 x 300 DPI)

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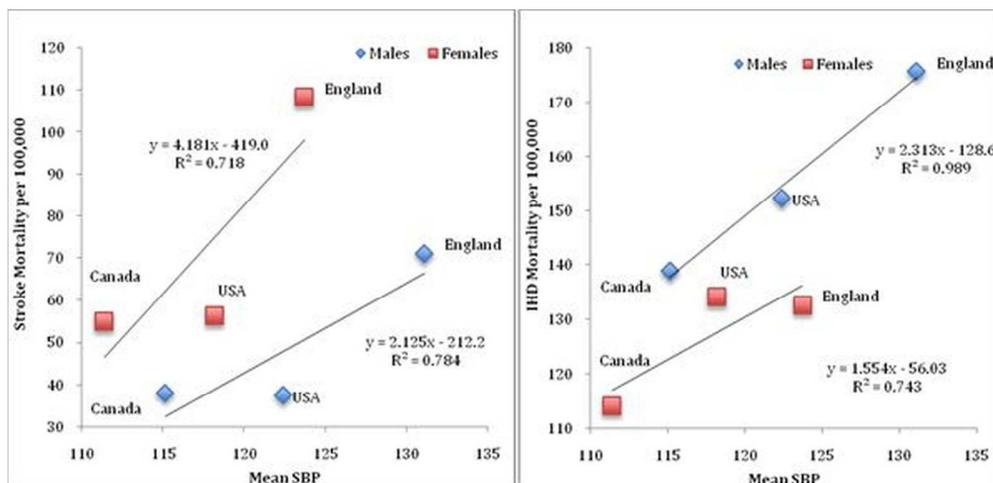


Figure 2. Stroke and Ischemic Heart Disease (IHD) Mortality* by Country Mean SBP
119x57mm (300 x 300 DPI)

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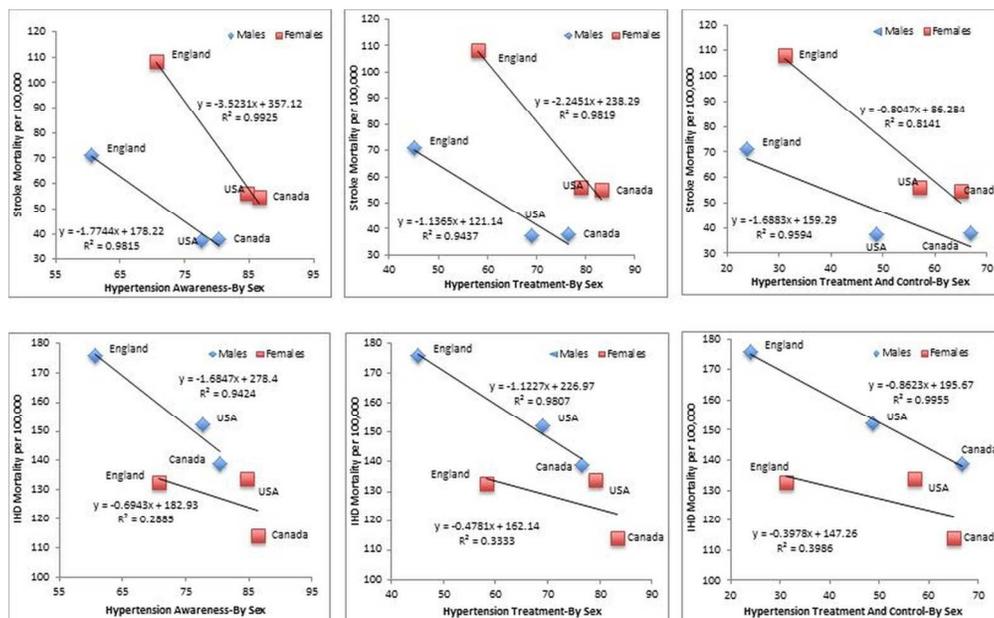


Figure 3. Stroke and IHD mortality by Country Prevalence of Hypertension Awareness, Treatment and Control
119x73mm (300 x 300 DPI)

Appendix 1. Mean Systolic and Diastolic Blood Pressure by Sex, Age, and Country.

	England				CANADA					USA					
	n	SBP	se	DBP	se	n	SBP	se	DBP	se	n	SBP	se	DBP	se
Males															
20-24	153	126.7	0.8	69.2	0.8	127	106.6	0.7	67.5	0.8	436	117.0	0.6	66.3	0.9
25-29	196	127.9	0.8	72.5	0.8	98	108.9	1.0	70.1	0.8	413	118.6	0.8	68.9	0.6
30-34	275	127.5	0.7	73.5	0.6	134	112.2	0.9	73.8	0.7	410	118.4	0.6	71.6	0.5
35-39	320	126.8	0.7	74.1	0.6	165	112.1	0.8	74.7	0.6	468	120.3	0.6	74.7	0.6
40-44	389	126.5	0.6	75.7	0.5	190	113.5	0.8	76.5	0.6	442	120.7	0.8	76.1	0.7
45-49	335	130.9	0.9	79.5	0.7	173	115.9	0.9	77.7	0.6	448	121.8	0.9	75.9	0.8
50-54	316	132.2	0.9	78.4	0.6	134	117.9	1.0	78.8	0.6	510	124.4	0.9	75.9	0.7
55-59	384	134.6	0.8	78.6	0.6	85	120.6	1.6	77.4	0.9	383	125.1	0.9	75.2	0.7
60-64	326	137.0	0.9	77.5	0.6	201	120.5	1.0	76.2	0.6	517	128.3	1.0	72.4	0.9
65-69	141	138.2	2.1	76.1	1.1	141	122.7	1.3	73.6	0.7	381	127.0	1.4	67.9	1.1
70-74	124	137.3	1.7	72.1	1.0	107	125.2	1.6	72.8	1.0	345	130.0	1.3	67.1	0.7
75-79	84	138.9	1.9	71.9	1.1	94	123.2	1.6	70.3	0.9	280	132.3	1.6	66.0	1.0
All males	3,043	131.1	0.3	75.3	0.2	1649	115.1	0.3	74.5	0.2	5033	122.4	0.3	72.3	0.4
Females															
20-24	215	112.2	0.6	67.4	0.5	100	101.7	0.9	66.6	0.8	423	108.6	0.6	64.4	0.6
25-29	252	112.9	0.6	69.2	0.6	142	98.2	0.7	63.9	0.7	388	109.7	0.5	66.3	0.7
30-34	348	113.0	0.6	70.6	0.5	172	103.3	0.8	69.0	0.6	404	109.5	0.7	67.6	0.7
35-39	462	115.4	0.6	72.3	0.5	221	103.4	0.8	69.6	0.6	452	112.0	0.7	71.0	0.5
40-44	492	118.9	0.7	74.2	0.5	192	105.6	0.8	69.6	0.6	488	113.1	0.8	70.5	0.7
45-49	414	123.1	0.9	76.0	0.6	204	111.5	1.0	73.0	0.7	486	117.3	1.0	71.9	0.8
50-54	383	125.6	1.0	76.3	0.6	133	115.3	1.2	73.2	0.7	452	120.0	0.7	72.4	0.6
55-59	451	129.1	0.9	75.9	0.5	120	114.7	1.4	71.3	0.8	377	124.5	1.3	71.5	0.8
60-64	403	131.9	0.9	75.3	0.5	193	123.0	1.3	72.4	0.6	536	127.3	1.0	70.1	0.8
65-69	183	135.7	1.4	73.9	0.8	146	129.3	1.5	73.9	0.8	343	128.9	1.5	66.4	1.2
70-74	121	140.3	1.8	73.4	0.8	114	125.8	1.4	69.3	0.9	365	134.0	1.2	64.7	0.8
75-79	106	144.1	2.0	71.3	1.1	99	134.2	2.2	70.0	1.0	256	135.7	1.2	61.8	1.2
All females	3,830	123.7	0.4	73.1	0.2	1836	111.4	0.4	70.2	0.2	4970	118.1	0.4	69.0	0.4

Appendix 2. Mean Systolic (SBP) and Diastolic (DBP) Blood Pressure (mm Hg) among Hypertensive Individuals, by Awareness, Treatment and Control, and by Country.

		ENGLAND		CANADA		USA	
		SBP	DBP	SBP	DBP	SBP	DBP
Non hypertensive	mean	119.9	71.2	109.3	71.1	114.8	69.3
	se	0.2	0.1	0.2	0.2	0.2	0.4
All, Hypertensive	mean	144.3	81.0	129.5	77.3	133.7	74.0
	se	0.5	0.3	0.6	0.4	0.4	0.5
All, Aware	mean	141.7	78.5	126.1	75.2	130.8	72.3
	se	0.6	0.4	0.6	0.4	0.4	0.5
All, Treated	mean	138.8	75.9	125.2	74.4	129.0	71.1
	se	0.7	0.4	0.6	0.4	0.4	0.5
Treated and Controlled	mean	125.4	71.2	119.7	72.8	120.2	68.3
	se	0.5	0.4	0.5	0.4	0.3	0.5
Treated and not controlled	mean	154.1	81.2	151.1	81.9	151.0	78.0
	se	0.8	0.6	1.3	0.9	0.6	0.7
Aware, not treated	mean	151.5	88.1	147.2 ^E	93.8 ^E	149.3	85.1
	se	0.8	0.6	2.5 ^E	2.0 ^E	1.2	1.1
Unaware	mean	149.3	85.5	146.7	87.6	146.1	81.5
	se	0.5	0.5	1.0	0.7	0.6	1.3

^E Interpret with caution (coefficient of variation 16.6% to 33.3%)

Hypertension: Systolic pressure ≥ 140 or diastolic pressure ≥ 90 or currently taking blood pressure lowering medication

Aware: Self-report of having been diagnosed as hypertensive by a doctor or nurse, excluding women diagnosed during pregnancy (England);

Self-reported blood pressure medication use in the past month or self-reported high blood pressure (Canada); Self-report of having been diagnosed as hypertensive by a doctor or nurse, excluding women diagnosed during pregnancy (USA)

Treated: Taking medication to lower blood pressure recorded by the nurse (England); Taking medication to lower blood pressure, self-report (Canada, USA);

Treated and controlled: Taking medication to lower blood pressure and DBP < 90 mm Hg and SBP < 140 mm Hg

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3 Treated and uncontrolled: Taking medication to lower blood pressure and DBP ≥ 90 mm Hg or SBP ≥ 140 mm Hg

4 Aware, not treated: Self-reported of having been diagnosed as hypertensive by a doctor or nurse, not taking medication to lower blood
5 pressure (England); Self-reported of having been told by health care provider that they have high blood pressure, not taking medication to
6 lower blood pressure (Canada); Self-reported of having been told by health care provider that they have high blood pressure, not taking
7 medication to lower blood pressure (USA)
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9 Unaware: No self report of having been diagnosed as hypertensive by a doctor or nurse (England); No self report of having been told that they
10 have high blood pressure and no self report of blood pressure medication use in the past month (Canada); No self report of having been told
11 that they have high blood pressure (USA)
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Hypertension Prevalence, Awareness, Treatment, and Control in National Surveys from England, the USA, and Canada, and Correlation with Stroke and Ischemic Heart Disease Mortality

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Ethical approval was not required for these secondary analyses since all the original studies had their own ethical approval process.

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Statement of independence of researchers from funders - The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the Centers for Disease Control and Prevention, the Public Health Agency of Canada or the UK Department of Health.

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Data sharing statement. All the authors had access to the original tables from the different studies. There is no additional data available.

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Author's Contributions: Michel Joffres, Emanuela Falaschetti , Cathleen Gillespie, Cynthia Robitaille contributed to the data analysis, interpretation and writing. Fleetwood Loustalot, Neil Poulter, Finlay A. McAlister, Helen Johansen, Oliver Baclic, and Norm Campbell contributed to the data interpretation and writing.

Article Summary

- 1) Article focus
 - Comparison of hypertension prevalence, awareness, treatment, and control in 3 National studies, England, USA, and Canada
 - Correlation with stroke and ischemic heart disease mortality
- 2) Key messages
 - Important variation by country
 - Strong relationship between hypertension indicators and stroke mortality
 - Gaps in the management of hypertension
- 3) Strengths and limitations
 - Strengths
 - National population data
 - Detailed data on hypertension characteristics
 - Strong correlation with meaningful outcome, mortality
 - Limitations
 - Data from England from 2006, but provide an important basis for measuring progress (current data not yet available)
 - Limited to 3 countries
 - Ecological correlation with mortality that excludes looking at confounders

ABSTRACT

Objective Comparison of recent national survey data on prevalence, awareness, treatment and control of hypertension in England, the USA and Canada, and correlation of these parameters with each country stroke and ischemic heart disease (IHD) mortality.

Methods Non-institutionalized population surveys from England (2006), the USA (2007-2010) and Canada (2007-2009) using standardized protocols and devices. Analysis included individuals age 20-79 years. Stroke and IHD mortality rates were plotted against countries' specific prevalence data.

Results Mean systolic blood pressure (SBP) was higher in England than in the USA and Canada in all age-gender groups. Mean diastolic blood pressure (DBP) was similar in the three countries before age 50 and then fell more rapidly in the USA and was the lowest in the USA. Only 34% had a BP under 140/90 mmHg in England, compared with 50% in the USA and 66% in Canada. Pre-hypertension and stage 1 and 2 hypertension prevalence figures were the highest in England. Hypertension prevalence (≥ 140 mmHg SBP and/or ≥ 90 mmHg DBP) was lower in Canada (19.5%) than in the USA (29%) and England (30%). Hypertension awareness was higher in both the USA (81%) and Canada (83%), than in England (65%). England also had lower levels of hypertension treatment (51%; USA 74%; Canada 80%) and control ($< 140/90$ mmHg; 27%; USA 53%; Canada 66%). Canada had the lowest Stroke and IHD mortality rates, England the highest, and rates were inversely related to the mean SBP in each country and strongly related to blood pressure indicators, the strongest relationship being between low hypertension awareness and stroke mortality.

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2
3 **Conclusion** While current prevention efforts in England should result in future improved figures,
4 **especially at younger ages**, these data still show important gaps in the management of hypertension
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6 in these countries, with consequences on stroke and IHD mortality.
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Introduction

Increased blood pressure is the leading risk factor for premature death, stroke, and heart disease worldwide.¹ In the year 2000, the world was estimated to have close to 1 billion people with hypertension and predicted an increase to 1.56 billion by 2025.² The global economic burden of increased blood pressure was estimated to consume 370 billion US \$ worldwide and 10 % of health care expenditures.³ Usual blood pressure is strongly and directly related to vascular and overall mortality without evidence of a threshold down to at least 115/75mmHg⁴ with small changes in blood pressure resulting in substantial changes in vascular disease.⁵

Based on clinical and population research, increased blood pressure, hypertension and hypertension related complications are largely preventable. Lifestyle changes can lower blood pressure and prevent hypertension while antihypertensive drug therapy can effectively reduce the cardiovascular events attributed to hypertension.¹⁻⁶ Nevertheless, most people with hypertension worldwide are not effectively treated and controlled to recommended blood pressure targets.⁷ There are few national programs to serve as models for prevention and control of hypertension and few countries have embarked on national hypertension prevention and control programs. The United States (USA) blood pressure education program was established in 1972⁸, while Canada (2000) and England (2004) have more recent initiatives.^{9,10} This manuscript compares recent data on prevalence, awareness, treatment and control of hypertension in England, the USA and Canada and correlates these hypertension-related parameters in the three countries to mortality from stroke and ischemic heart disease (IHD).

Methods

Survey methods used in England, the USA, and Canada are summarized in Table 1. Detailed methodology for each survey is available elsewhere.¹¹⁻¹³ Briefly, each survey is a representative sample of each country's non-institutionalized population and uses standardized protocols and

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2
3 devices. While the England (2006) and Canada (2007-2009) surveys used automatic oscillometric
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5 devices, the USA (2007-2010) survey used mercury wall sphygmomanometer models. The number
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7 of blood pressure measurements available for analysis varied by count of blood pressure measures
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9 and survey protocols (Table 1).

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11 In these analyses, hypertension was defined as a mean systolic blood pressure (SBP) ≥ 140 mmHg
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13 or a mean diastolic blood pressure (DBP) ≥ 90 mmHg or a respondent self-report of medication to
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15 lower blood pressure. Pre-hypertension (SBP 120-139 mmHg or DBP 80-89 mmHg), stage 1 (SBP
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17 140-159 mmHg or DBP 90-99 mmHg), and stage 2 (SBP ≥ 160 mmHg or DBP ≥ 100 mmHg)

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19 hypertension were defined according to the Seventh Report of the Joint National Committee on the
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21 Prevention, Detection, Evaluation and Treatment of High Blood Pressure (JNC 7) definitions.⁶

22
23 Prevalence, awareness, treatment, control and awareness of hypertension were defined using
24
25 commonly recognized standards. Prevalence was defined as SBP ≥ 140 or DBP ≥ 90 or currently
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27 taking medication to lower their blood pressure. Awareness was defined by self-report and
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29 included having been diagnosed as hypertensive by a doctor or nurse, excluding women diagnosed
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31 during pregnancy (England), medication to lower blood pressure in the past month or reported
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33 high blood pressure (Canada), or having been diagnosed as hypertensive by a doctor or nurse,
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35 excluding women diagnosed during pregnancy (USA). Treatment was defined as taking medication
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37 to lower blood pressure, as recorded by the nurse (England), or a self-report of taking medication
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39 to lower blood pressure (Canada, USA). Treated and controlled was defined as taking medication to
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41 lower blood pressure and SBP < 140 mmHg and DBP < 90 mmHg; treated and uncontrolled a SBP
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43 ≥ 140 mmHg or DBP ≥ 90 mmHg while on medication to lower blood pressure. Aware, yet not
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45 treated, was defined by self-report and included having been diagnosed as hypertensive by a doctor
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47 or nurse (England) / health care provider (Canada, USA), and not taking medication to lower blood
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49 pressure.
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3 Survey data were not age and sex standardized. They represent the current country-specific figures,
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5 and therefore correspond more precisely to each country's crude mortality rates for stroke and
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7 IHD. All prevalence figures are weighted using survey weights to represent each country's
8
9 population. Standard errors were computed taking into account each country's sampling
10
11 methodology.¹¹⁻¹³ To be comparable across the three surveys, the analysis was restricted to
12
13 individuals age 20-79 years and excluded pregnant women. The Canadian Health Measures Survey
14
15 (CHMS) data analysis was performed using SAS® Enterprise Guide (Version 4.1, SAS Institute Inc.,
16
17 Cary, NC, 2006). The Health Survey for England (HSE) data analysis was performed using SPSS 19.
18
19 The National Health and Nutrition Examination Survey (NHANES) data analysis was performed
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21 using SAS version 9.2 and SAS-Callable SUDAAN version 10 (RTI International)], to account for the
22
23 complex sampling design.
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27 The latest WHO country specific mortality data available were from 2008 for Canada and the USA¹⁴
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29 and we used 2006 data for England.¹⁵ Crude mortality rates per 100,000 were obtained for men and
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31 women for stroke and ischemic heart disease (IHD) and plotted against country specific prevalence
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33 data for hypertension awareness, treatment, and control.
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38 Results

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40 The distribution of SBP and DBP by sex, age, and country shows an increase in SBP with age and an
41
42 increase, plateau and decrease of DBP with aging (Figure 1; Appendix 1 Table). SBP is higher in
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44 men than women in the younger age groups and becomes higher in women than men after age 60
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46 years in Canada and age 70 years in England and USA. Mean SBP is overall higher in England than in
47
48 the USA and Canada in all age-gender groups. DBP is similar in the 3 countries before age 50 and
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50 then falls more rapidly in the USA and is overall lower in men and women from the USA.
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54 The distribution of measured blood pressure (including treated individuals), by level, in Table 2
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56 reflects the findings in Figure 1. Only 34% of adults aged 20-79 years would be classified as having
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3 a normal blood pressure (<120/80 mmHg) in England, compared with 50% in the USA and 66% in
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5 Canada. Pre-hypertension and stage 1 and 2 hypertension prevalence figures are also much higher
6
7 in England than in the USA and Canada.
8

9
10 The prevalence of hypertension, and awareness, treatment, and control levels among those with
11
12 hypertension are shown in Table 3. The prevalence of hypertension is lowest in Canada (19.5%)
13
14 and higher in the USA (29%) and England (30%). Hypertension awareness is close to 80% in both
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16 the USA (81%) and Canada (83%) and lower in England (65%). England also has lower levels of
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18 hypertension treatment (England 51%; USA 74%; Canada 80%) and control (England 27%; USA
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20 53%; Canada 66%). These patterns are similar in the different age and sex sub groups (Table 3).
21
22 Among individuals treated for hypertension (i.e., taking medication to lower blood pressure), the
23
24 proportion being controlled is lowest in England (53%), while 71% in the USA and 82% in Canada
25
26 are controlled.
27
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29
30 The mean SBP and DBP are provided in Appendix 2 by the different prevalence categories of Table
31
32 3. The data are consistent with those in the previous tables showing the highest SBP mean in
33
34 England in all categories. For DBP, England has also higher means than the USA and Canada among
35
36 all hypertensives and aware and treated categories.
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39 At the time when these surveys were conducted, Canada had the lowest stroke and IHD mortality
40
41 rates while England had the highest. Rates of both outcomes were inversely related to the mean
42
43 SBP in each country (Figure 2). We found a strong relationship between the selected blood
44
45 pressure indicators and stroke and IHD mortality, the strongest relationship being between
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47 hypertension awareness and stroke mortality, especially in women (Figure 3). Stroke rates were
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49 higher in women than men for any level of each of the BP indicators and the opposite was true for
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51 IHD (Figure 2-3).
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56 Discussion

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3 Although all 3 countries evaluated have had substantive improvement in most hypertension
4 treatment indicators over the past two decades¹⁶⁻²⁰, this study found marked differences in
5 hypertension prevalence, awareness, treatment and control rates in England, the USA, and Canada.
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10 Canada has the lowest prevalence of hypertension at 19% followed by England and United States at
11 about 30% each. A previous study based on earlier cycles of these surveys also found little
12 difference in the prevalence of hypertension between England and the USA.²¹ The main
13 determinants of hypertension are known. These include poor dietary habits, excess sodium intake,
14 physical inactivity, obesity, excess alcohol consumption, as well as age, gender, race and
15 sociodemographic factors. The national differences in prevalence are likely related to differences in
16 the interaction between these determinants as well as differences in the clinical systems,
17 community programs, and environmental and policy supports for hypertension prevention and
18 management. Compared to the USA, Canada has a lower rate of obesity but to our knowledge there
19 has never been a comprehensive comparison of the determinants of blood pressure using
20 appropriately adjusted data in these countries. A comprehensive comparison of the determinants of
21 hypertension and the policies that fail to address adverse differences in the modifiable
22 determinants would be an important next step. This is also important since these data show an
23 important difference in the younger age groups between England, Canada and the USA. Since blood
24 pressure tracks with age²², efforts to influence the determinants of hypertension are essential to
25 reduce hypertension prevalence in the older age groups. The recent decrease in childhood obesity
26 in England²³ should be followed by a reduction in blood pressure in the next surveys.

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47 Our study has also found important differences in the awareness, treatment and control of
48 hypertension in the three countries. England, the USA, and Canada all have developed differing
49 approaches to improve hypertension treatment and control. In the USA, several diverse
50 approaches have been taken.^{6, 8, 24} Historically the USA has had one of the world's highest rates of
51 hypertension awareness, treatment and control and has also seen improvements in these indicators
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3 with intensified efforts;¹⁸ however, despite broad clinical and community efforts, over half of adults
4 with hypertension are uncontrolled based on current guidelines.¹⁹ Recent national activities and
5 recommendations are staged to positively impact hypertension estimates.²⁵⁻²⁹

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10 Importantly, we also found national-level differences in mortality rates from stroke and IHD, which
11 paralleled the differences in hypertension awareness, treatment, and control between these 3
12 countries. Both stroke and IHD mortality were strongly inversely correlated with mean SBP in each
13 country. Both stroke and IHD mortality were strongly inversely correlated with mean SBP in each
14 country. Both stroke and IHD mortality were strongly inversely correlated with mean SBP in each
15 country.

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18 Efforts in England have included episodic national hypertension recommendations developed by
19 the British Hypertension Society (B.H.S - a non-governmental organization of specialists and
20 researchers) with the recommendations more recently being developed by a governmental
21 organization in collaboration with the BHS.³⁰ Implementation programs have included an extensive
22 public program to educate people on the risks of salt for hypertension³¹ and also to an extensive
23 government program to pay General Practitioners bonus payments for achieving benchmarks for
24 hypertension care³² – although the efficacy of payment for performance for improving hypertension
25 control has been questioned.³³

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36 In 2000, Canada launched an annually updated hypertension recommendations program (Canadian
37 Hypertension Education Program (CHEP)).⁹ In 2006, the program was assisted by an extensive
38 initiative to inform the public about hypertension and the health risks and opportunities to reduce
39 dietary salt.³⁴ The introduction of CHEP in Canada is temporally related to improvements in
40 management patterns and has been also temporally associated with reduced CVD in Canada.³⁵

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48 It is difficult to assess how much the different national approaches to hypertension detection and
49 management impact on the differences observed in our study. British Guidelines in place in
50 2006^{10,39} and since³⁰ do not recommend the routine use of antihypertensive treatment for those
51 with a systolic BP >140 mmHg and/or diastolic BP > 90 mmHg, rather only if such people have an
52 estimated 10 year CV risk of > 20%. Consequently treatment rates and control rates might be
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3 expected to be lower in England than in the USA & Canada. Furthermore, in England, the National
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5 Institute for Health and Clinical Excellence's Quality and Outcomes Framework, which includes
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7 measures used in the calculation of provider reimbursement, included a higher blood pressure
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9 target (<150/90) during the period of data used for these analyses. This will be lowered (to
10
11 <140/90) in 2013/2014 to align with national guidelines. In addition to the new National Institute
12
13 for Health and Clinical Excellence (NICE) guidelines³⁰, the national salt reduction program in
14
15 England would be expected to result in further reductions in the prevalence of hypertension and
16
17 improvement in hypertension treatment indicators in the recent and future years as Canadian and
18
19 Finnish data suggest.^{36,37}

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23 There are several potential limitations to our current analyses. In addition to low response rates
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25 and hence small numbers in some strata, each country uses different methodology to assess blood
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27 pressure and relatively small differences in blood pressure can impact hypertension indicators. In
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29 particular Canada has adopted the use of a fully automated blood pressure device that operates in
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31 the absence of an observer and averages the last 5 of six blood pressure readings. The Canadian
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33 method reduces the influence of the observer (white coat effect) on blood pressure and results in a
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35 slightly lower average blood pressure than a single auscultatory blood pressure reading.
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38 Nevertheless using an algorithm to adjust the data in the Canadian survey³⁸ to represent single
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40 manual reading results in little change in the major hypertension indicators as the difference in
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42 methods at the therapeutic cut point of 140/90 mmHg is relatively small, but might reduce the
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44 differences between the US and Canada. The close relationship between stroke mortality and
45
46 hypertension prevalence and hypertension indicators suggest that blood pressure and
47
48 hypertension differences seen in this study are real and biologically important. We acknowledge
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50 the limitation of using three points for our mortality graphs, which require a high level of
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52 correlation to be statistically significant.
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3 We did not use age- or gender-adjusted data from the different countries. The lack of adjustment
4 was intended so that hypertension risk factors could be directly compared to stroke mortality for
5 each country. In addition, in a separate analysis, comparison of age-adjusted data to a common
6 standard population showed very little difference with the current figures. We were not able to
7 obtain more recent common mortality data than 2008 for all countries. There is some overlap
8 between the timing of the US and Canadian surveys, but the English survey was conducted more
9 than one year earlier. Management of hypertension in England is likely to have improved since
10 2006. Increased blood pressure and hypertension represent major global threats to population
11 health, with stroke and IHD being the most closely related adverse outcomes.⁴ Interventions to
12 lower average population blood pressure and interventions to identify and control blood pressure
13 in those with hypertension are critical to prevent blood pressure related complications.²⁻⁶
14 Nevertheless, hypertension control rates are low even in developed countries and most countries
15 do not have formal programs to control hypertension.⁴⁰ Further, population surveys indicate that
16 approximately 29% of men and 25% of women have uncontrolled hypertension with increasing
17 numbers of hypertension cases globally due to population growth and ageing.⁴¹ Hence, countries
18 worldwide should consider introducing and evaluating coordinated programs to improve the
19 prevention, detection, awareness, treatment, and control of hypertension, and our data suggest that
20 the more assertive approach apparent in North America is associated with large benefits in terms of
21 reduced cardiovascular mortality. A greater focus on prevention of high blood pressure in the
22 younger age groups is also necessary.
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Table 1. Survey methods, by country.

<i>Country</i>	<i>Years of Survey</i>	<i>Sampling</i>	<i>n</i>	<i>Age Range</i>	<i>Response Rate</i>
England	2006	Multistage	6,873	20-79	68% household response rate, 88% individual response rate in co-operating households and 66% with nurse visit (examination response rate).
Canada	2007-2009	Multistage	3,485	20-79	Household response rate = 70% Individual response rate to the household questionnaire = 88% Examination response rate = 85%
US	2007-2010	Multistage	10,003	20-79	Interview response rate = 79% Examination response rate = 76% 93% of those examined had ≥ 2 blood pressure measurements

<i>Country</i>	<i>Blood Pressure Device</i>	<i>Technician</i>	<i>N of Blood Pressure Measures</i>	<i>Study Protocol Used</i>
England	Omron HEM 907	Nurse	3	Mean of second and third measures taken 1 minute apart after 5 minutes rest
Canada	Bp TRU™ BP-300*	Health measures specialists	6	Average of last 5 of 6 measures taken one minute apart after a 5 minute rest period
US	Calibrated® V-Lok® cuff, Latex Inflation Bulb, Air-Flo® Control Valve. Baumanometer® calibrated mercury wall model.	Physician	3	Mean of second and third measurement taken 30 seconds apart after resting quietly in a sitting position for 5 minutes†

*Bp TRU™ BP-100 used during home visits for respondents who were unable or unwilling to go at the mobile clinic.

† US NHANES survey protocol: After resting quietly in a sitting position for 5 minutes, three consecutive blood pressure readings were obtained. If a blood pressure measurement was interrupted or incomplete, a fourth attempt could be made.

All valid blood pressure readings excluding pregnant women.

Figure 1. Distribution of Systolic and Diastolic Blood Pressure by Country, Age and Sex.

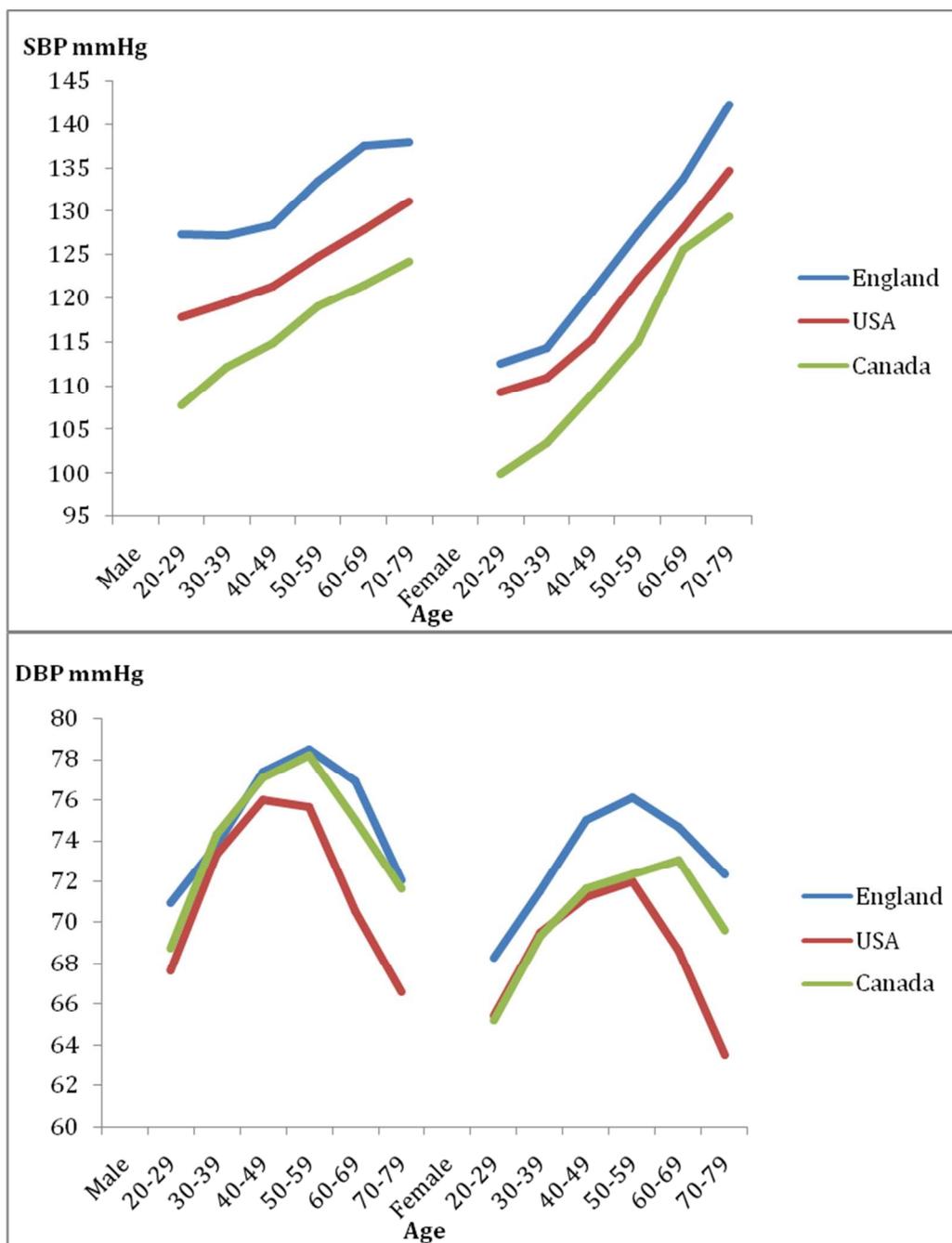


Table 2. Distribution of Measured Blood Pressure by Level, Sex, Age, and Country.

	Total	Normal			Pre-Hypertension			Stage 1			Stage 2		
		n	%	se	n	%	se	n	%	se	n	%	se
<i>ENGLAND</i>													
All	7,382	2,528	34.2	0.7	3,242	43.9	0.7	1,235	16.7	0.5	376	5.1	0.3
Sex													
Males	3,555	761	21.4	0.8	1,903	53.5	0.9	709	19.9	0.7	182	5.1	0.4
Females	3,826	1,767	46.2	0.9	1,339	35	0.9	526	13.7	0.6	195	5.1	0.4
Age													
20-39	2,618	1,273	48.6	1.2	1,115	42.6	1.1	210	8	0.6	20	0.8	0.2
40-59	2,962	966	32.6	0.9	1,360	45.9	0.9	482	16.3	0.7	155	5.2	0.4
60-79	1,801	289	16.1	1	767	42.6	1.5	543	30.2	1.3	201	11.2	0.9
<i>CANADA</i>													
All	3,485	2,214	66.1	1.7	955	27.2	1.4	259	5.4	0.3	57	1.3 ^E	0.2 ^E
Sex													
Males	1,649	951	60.6	2.4	538	32.9	2.2	140	5.9	0.5	20	0.7 ^E	0.2 ^E
Females	1,836	1,263	71.6	1.4	417	21.6	1.1	119	4.8	0.6	37	2.0 ^E	0.5 ^E
Age													
20-39	1,159	992	84.0	1.9	155	15.2	1.8	F	F	F	F	F	F
40-59	1,231	785	63.4	3.3	351	30.2	2.8	81	5.3	0.7	14	1.1 ^E	0.3 ^E
60-79	1,095	437	39.4	2.0	449	42.9	2.2	168	13.8	1.1	41	3.9 ^E	1.0 ^E
<i>USA</i>													
All	10,003	4,663	50.3	0.8	3,615	36.0	0.7	1,296	11.0	0.4	429	2.7	0.2
Sex													
Males	5,033	1,998	42.2	1.0	2,109	42.7	1.0	713	12.2	0.6	213	2.8	0.3
Females	4,970	2,665	58.3	1.0	1,506	29.3	0.8	583	9.7	0.5	216	2.7	0.2
Age													
20-39	3,394	2,210	65.2	1.1	1,007	29.7	1.1	148	4.4	0.4	29	0.7	0.1
40-59	3,586	1,608	46.5	1.3	1,371	39.1	1.1	473	11.9	0.7	134	2.6	0.3
60-79	3,023	845	30.8	1.3	1,237	41.3	1.2	675	21.2	1.1	266	6.7	0.5

^E Interpret with caution (coefficient of variation 16.6% to 33.3%)

^F Too unreliable to be reported (coefficient of variation greater than 33.3%)

Normal: Systolic<120 and diastolic<80. Pre-Hypertension: 120≤Systolic<140 or 80≤diastolic<90. Stage 1: 140≤Systolic<160 or 90≤diastolic<100. Stage 2: Systolic≥160 or diastolic≥100. Regardless of medication use

Table 3. Hypertension Prevalence and Percentage with Hypertension, Aware, Treated, Controlled, by sex, age group, and country.

	Prevalence		Aware		Treated		Treated & Controlled		Treated & not controlled		Aware, not treated	
	%	SE	%	SE	%	SE	%	SE	%	SE	%	SE
ENGLAND												
All	30.0	0.7	65.3	1.2	51.3	1.2	27.3	1.1	23.9	0.9	14.1	0.8
Sex												
Male	32.9	0.9	60.6	1.5	45.1	1.6	23.9	1.4	21.2	1.2	15.5	1.1
Female	27.3	0.8	70.7	1.5	58.2	1.6	31.1	1.6	27	1.4	12.5	1.1
Age												
20-39	9.3	0.7	35	3.1	10.6	2.1	5	1.4	5.6	1.7	24.4	2.9
40-59	27.9	0.8	59.3	1.7	40.8	1.8	23.1	1.5	17.7	1.2	18.5	1.3
60-80	63.7	1.3	76.1	1.6	67.4	1.7	35.1	1.8	32.3	1.6	8.7	0.9
CANADA												
All	19.5	0.6	83.4	1.8	79.9	2.0	65.8	2.0	14.0	2.0	3.5 ^E	0.9 ^E
Sex												
Male	19.7	1.1	80.4	2.2	76.5	2.1	66.8	3.0	9.7 ^E	2.0 ^E	3.9 ^E	0.9 ^E
Female	19.3	0.6	86.5	2.0	83.3	2.4	64.9	2.8	18.4 ^E	3.2 ^E	F	F
Age												
20-39	2.0 ^E	0.6 ^E	64.4	9.8	58.4 ^E	10.3 ^E	56.8 ^E	10.6 ^E	F	F	F	F
40-59	18.4	1.5	80.4	2.7	73.4	3.7	65.4	3.8	8.0 ^E	1.8 ^E	7.0 ^E	2.3 ^E
60-79	53.2	2.4	86.7	1.8	85.7	2.1	66.8	1.8	19.0	2.6	F	F
USA												
All	29.1	0.8	81.1	1.0	74.0	1.1	52.8	1.0	21.2	0.7	7.0	0.7
Sex												
Male	29.4	1	77.7	1.4	69.1	1.5	48.7	1.6	20.3	1.1	8.6	1
Female	28.8	0.9	84.6	1.2	79.1	1.4	57	1.5	22.1	1	5.5	0.7
Age												
20-39	7.7	0.6	61.1	4.6	47.2	4.0	35.0	3.6	12.2	2.4	13.9	2.5
40-59	31.1	1.2	82.4	1.4	73.1	1.8	53.5	1.7	19.6	1.3	9.4	1.0
60-79	63.6	1.3	84.2	1.3	80.9	1.4	56.1	1.5	24.8	0.9	3.3	0.6

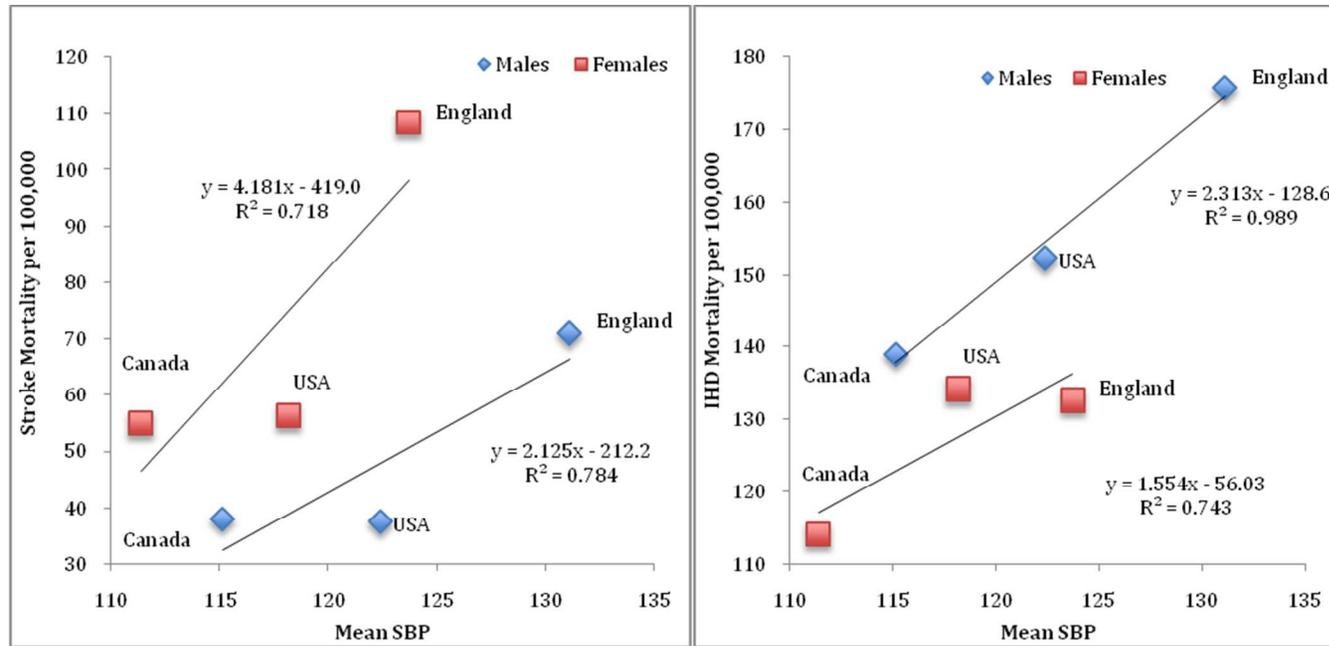
^E Interpret with caution (coefficient of variation 16.6% to 33.3%)

^F Too unreliable to be reported (coefficient of variation greater than 33.3%)

Hypertension: Systolic pressure ≥ 140 or diastolic pressure ≥ 90 or currently taking blood pressure lowering medication
Awareness, treatment and control were assessed among those with hypertension.

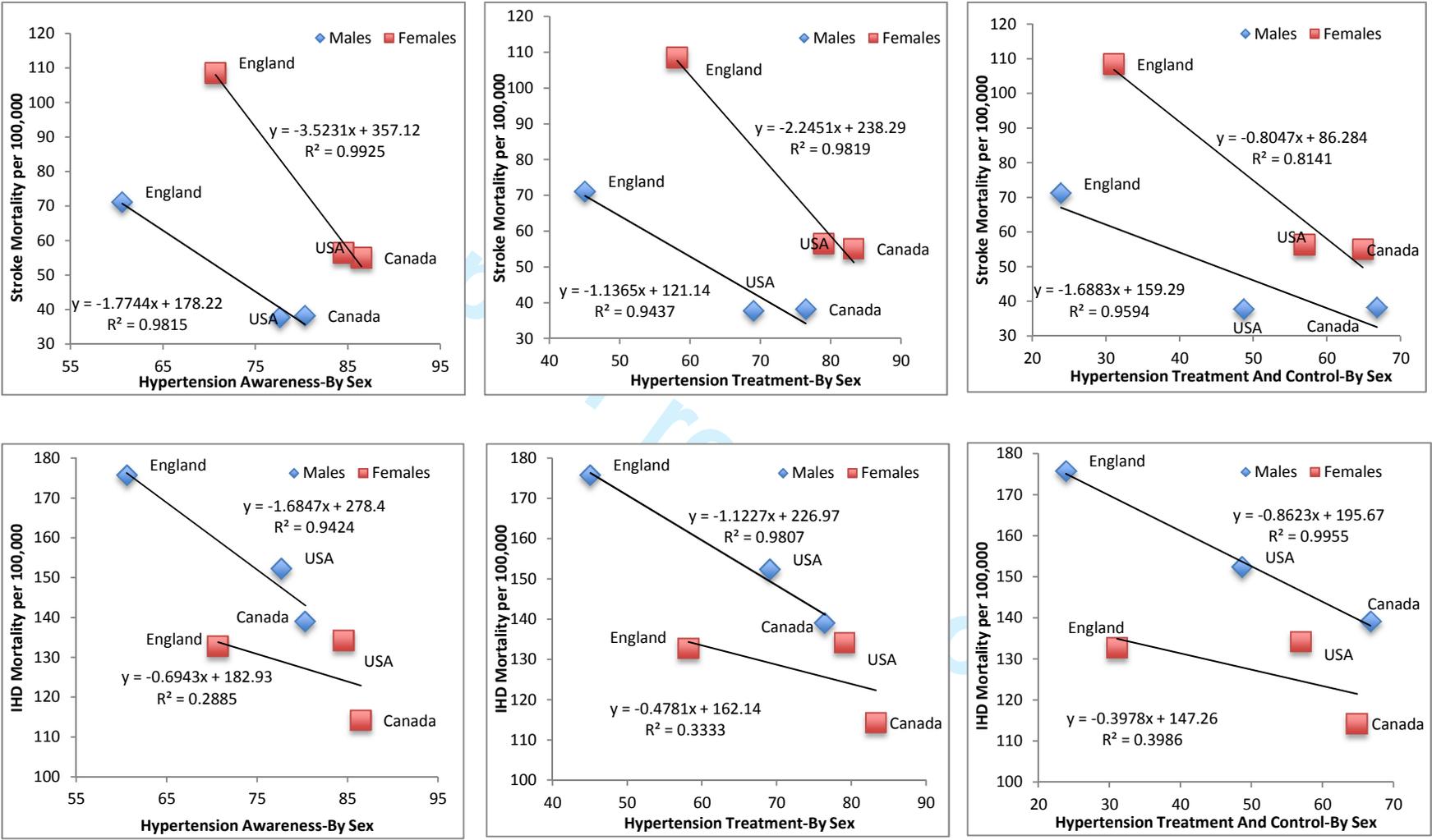
1 Aware: Self-report of having been diagnosed as hypertensive by a doctor or nurse, excluding women diagnosed during
2 pregnancy (ENGLAND); Self-reported BP medication use in the past month or self-reported high blood pressure (Canada);
3 Self-report of having been diagnosed as hypertensive by a doctor or nurse, excluding women diagnosed during pregnancy
4 (USA)
5 Treated: Taking medication to lower blood pressure recorded by the nurse (ENGLAND); Taking medication to lower blood
6 pressure, self-report (Canada, USA);
7 Treated and controlled: Taking medication to lower blood pressure and DBP <90 mm Hg and SBP <140 mm Hg
8 Treated and uncontrolled: Taking medication to lower blood pressure and DBP ≥90 mm Hg or SBP ≥140 mm Hg
9 Aware, not treated: Self-reported of having been diagnosed as hypertensive by a doctor or nurse, **not** taking medication to
10 lower blood pressure (ENGLAND); Self-reported of having been told by health care provider that they have high blood
11 pressure, not taking medication to lower blood pressure (Canada); Self-reported of having been told by health care
12 provider that they have high blood pressure, not taking medication to lower blood pressure (USA)
13 Unaware: No self report of having been diagnosed as hypertensive by a doctor or nurse (ENGLAND); No self report of
14 having been told that they have high blood pressure and no self report of BP medication use in the past month (Canada);
15 No self report of having been told that they have high blood pressure (USA)
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Figure 2. Stroke and Ischemic Heart Disease (IHD) Mortality* by Country Mean SBP



*2008 mortality rate per 100,000 (WHO) for USA and Canada; 2006 Statistics for England and Wales.

Figure 3. Stroke and IHD mortality by Country Prevalence of Hypertension Awareness, Treatment and Control



*2008 mortality rate per 100,000 (WHO) for USA and Canada; 2006 Statistics for England and Wales.

Appendix 1. Mean Systolic and Diastolic Blood Pressure by Sex, Age, and Country.

	England					CANADA					USA				
	n	SBP	se	DBP	se	n	SBP	se	DBP	se	n	SBP	se	DBP	se
Males															
20-24	153	126.7	0.8	69.2	0.8	127	106.6	0.7	67.5	0.8	436	117.0	0.6	66.3	0.9
25-29	196	127.9	0.8	72.5	0.8	98	108.9	1.0	70.1	0.8	413	118.6	0.8	68.9	0.6
30-34	275	127.5	0.7	73.5	0.6	134	112.2	0.9	73.8	0.7	410	118.4	0.6	71.6	0.5
35-39	320	126.8	0.7	74.1	0.6	165	112.1	0.8	74.7	0.6	468	120.3	0.6	74.7	0.6
40-44	389	126.5	0.6	75.7	0.5	190	113.5	0.8	76.5	0.6	442	120.7	0.8	76.1	0.7
45-49	335	130.9	0.9	79.5	0.7	173	115.9	0.9	77.7	0.6	448	121.8	0.9	75.9	0.8
50-54	316	132.2	0.9	78.4	0.6	134	117.9	1.0	78.8	0.6	510	124.4	0.9	75.9	0.7
55-59	384	134.6	0.8	78.6	0.6	85	120.6	1.6	77.4	0.9	383	125.1	0.9	75.2	0.7
60-64	326	137.0	0.9	77.5	0.6	201	120.5	1.0	76.2	0.6	517	128.3	1.0	72.4	0.9
65-69	141	138.2	2.1	76.1	1.1	141	122.7	1.3	73.6	0.7	381	127.0	1.4	67.9	1.1
70-74	124	137.3	1.7	72.1	1.0	107	125.2	1.6	72.8	1.0	345	130.0	1.3	67.1	0.7
75-79	84	138.9	1.9	71.9	1.1	94	123.2	1.6	70.3	0.9	280	132.3	1.6	66.0	1.0
All males	3,043	131.1	0.3	75.3	0.2	1649	115.1	0.3	74.5	0.2	5033	122.4	0.3	72.3	0.4
Females															
20-24	215	112.2	0.6	67.4	0.5	100	101.7	0.9	66.6	0.8	423	108.6	0.6	64.4	0.6
25-29	252	112.9	0.6	69.2	0.6	142	98.2	0.7	63.9	0.7	388	109.7	0.5	66.3	0.7
30-34	348	113.0	0.6	70.6	0.5	172	103.3	0.8	69.0	0.6	404	109.5	0.7	67.6	0.7
35-39	462	115.4	0.6	72.3	0.5	221	103.4	0.8	69.6	0.6	452	112.0	0.7	71.0	0.5
40-44	492	118.9	0.7	74.2	0.5	192	105.6	0.8	69.6	0.6	488	113.1	0.8	70.5	0.7
45-49	414	123.1	0.9	76.0	0.6	204	111.5	1.0	73.0	0.7	486	117.3	1.0	71.9	0.8
50-54	383	125.6	1.0	76.3	0.6	133	115.3	1.2	73.2	0.7	452	120.0	0.7	72.4	0.6
55-59	451	129.1	0.9	75.9	0.5	120	114.7	1.4	71.3	0.8	377	124.5	1.3	71.5	0.8
60-64	403	131.9	0.9	75.3	0.5	193	123.0	1.3	72.4	0.6	536	127.3	1.0	70.1	0.8
65-69	183	135.7	1.4	73.9	0.8	146	129.3	1.5	73.9	0.8	343	128.9	1.5	66.4	1.2
70-74	121	140.3	1.8	73.4	0.8	114	125.8	1.4	69.3	0.9	365	134.0	1.2	64.7	0.8
75-79	106	144.1	2.0	71.3	1.1	99	134.2	2.2	70.0	1.0	256	135.7	1.2	61.8	1.2
All females	3,830	123.7	0.4	73.1	0.2	1836	111.4	0.4	70.2	0.2	4970	118.1	0.4	69.0	0.4

Appendix 2. Mean Systolic (SBP) and Diastolic (DBP) Blood Pressure (mm Hg) among Hypertensive Individuals, by Awareness, Treatment and Control, and by Country.

		ENGLAND		CANADA		USA	
		SBP	DBP	SBP	DBP	SBP	DBP
Non hypertensive	mean	119.9	71.2	109.3	71.1	114.8	69.3
	se	0.2	0.1	0.2	0.2	0.2	0.4
All, Hypertensive	mean	144.3	81.0	129.5	77.3	133.7	74.0
	se	0.5	0.3	0.6	0.4	0.4	0.5
All, Aware	mean	141.7	78.5	126.1	75.2	130.8	72.3
	se	0.6	0.4	0.6	0.4	0.4	0.5
All, Treated	mean	138.8	75.9	125.2	74.4	129.0	71.1
	se	0.7	0.4	0.6	0.4	0.4	0.5
Treated and Controlled	mean	125.4	71.2	119.7	72.8	120.2	68.3
	se	0.5	0.4	0.5	0.4	0.3	0.5
Treated and not controlled	mean	154.1	81.2	151.1	81.9	151.0	78.0
	se	0.8	0.6	1.3	0.9	0.6	0.7
Aware, not treated	mean	151.5	88.1	147.2 ^E	93.8 ^E	149.3	85.1
	se	0.8	0.6	2.5 ^E	2.0 ^E	1.2	1.1
Unaware	mean	149.3	85.5	146.7	87.6	146.1	81.5
	se	0.5	0.5	1.0	0.7	0.6	1.3

^E Interpret with caution (coefficient of variation 16.6% to 33.3%)

Hypertension: Systolic pressure ≥ 140 or diastolic pressure ≥ 90 or currently taking blood pressure lowering medication

Aware: Self-report of having been diagnosed as hypertensive by a doctor or nurse, excluding women diagnosed during pregnancy (England); Self-reported blood pressure medication use in the past month or self-reported high blood pressure (Canada); Self-report of having been diagnosed as hypertensive by a doctor or nurse, excluding women diagnosed during pregnancy (USA)

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5 Treated: Taking medication to lower blood pressure recorded by the nurse (England); Taking medication to lower blood
6 pressure, self-report (Canada, USA);

7 Treated and controlled: Taking medication to lower blood pressure and DBP <90 mm Hg and SBP <140 mm Hg

8 Treated and uncontrolled: Taking medication to lower blood pressure and DBP ≥90 mm Hg or SBP ≥140 mm Hg

9 Aware, not treated: Self-reported of having been diagnosed as hypertensive by a doctor or nurse, **not** taking medication
10 to lower blood pressure (England); Self-reported of having been told by health care provider that they have high blood
11 pressure, not taking medication to lower blood pressure (Canada); Self-reported of having been told by health care
12 provider that they have high blood pressure, not taking medication to lower blood pressure (USA)

13 Unaware: No self report of having been diagnosed as hypertensive by a doctor or nurse (England); No self report of
14 having been told that they have high blood pressure and no self report of blood pressure medication use in the past
15 month (Canada); No self report of having been told that they have high blood pressure (USA)

STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

	Item No	Recommendation
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract Done 'National Surveys'
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found Done
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported Done
Objectives	3	State specific objectives, including any prespecified hypotheses Done
Methods		
Study design	4	Present key elements of study design early in the paper Done
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection Done
Participants	6	(a) Give the eligibility criteria, and the sources and methods of selection of participants Done –Brief description-
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable Done when relevant.
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group Done
Bias	9	Describe any efforts to address potential sources of bias Not applicable Limitations covered later
Study size	10	Explain how the study size was arrived at Referred to survey methodology papers
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why Done
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding Done- Confounding not considered in this type of analysis
		(b) Describe any methods used to examine subgroups and interactions Not applicable
		(c) Explain how missing data were addressed Not applicable
		(d) If applicable, describe analytical methods taking account of sampling strategy Done

(e) Describe any sensitivity analyses

Results			
Participants	13*	(a)	Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
			Numbers provided in tables
		(b)	Give reasons for non-participation at each stage
			Not relevant for this study. Provided in the original survey method papers
		(c)	Consider use of a flow diagram
Descriptive data	14*	(a)	Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
			Not relevant for this study. Provided in the original survey method papers
		(b)	Indicate number of participants with missing data for each variable of interest
			Numbers provided in tables
Outcome data	15*		Report numbers of outcome events or summary measures
			Numbers provided in tables
Main results	16	(a)	Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
			Not applicable
		(b)	Report category boundaries when continuous variables were categorized
			Standard error provided to simplify tables. Would be too cumbersome to add all CI
		(c)	If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17		Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
			Not applicable
Discussion			
Key results	18		Summarise key results with reference to study objectives
			Done
Limitations	19		Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
			Done
Interpretation	20		Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
			Done
Generalisability	21		Discuss the generalisability (external validity) of the study results
			Done—Since these are national representative populations surveys
Other information			

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Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based
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Done

For peer review only