Distribution of Blood Pressure and Hypertension in Canada and the United States

Michel R. Joffres, Pavel Hamet, David R. MacLean, Gilbert J. L’italien, and George Fodor

**Background:** Two North American population based surveys, the Third National Health and Nutrition Examination Survey (NHANES III) and the Canadian Heart Health Surveys (CHHS) have similar time frames and methods that allow comparisons between these countries in terms of the distribution of systolic (SBP) and diastolic (DBP) blood pressure and the levels of hypertension awareness, treatment, and control.

**Methods:** Cross-sectional population surveys using similar methods conducted home interviews and clinic visits (CHHS), and medical examinations (NHANES III). The CHHS included the ten Canadian provinces (1986–1992) and NHANES III, a representative sample of the United States population (1988–1994). Blood pressure measurements were available for 23,111 Canadians (age 18–74 years), and restricted to the 15,326 US participants in the same age range (age 18–74 years) with both systolic and diastolic mean values. Standardized techniques were used for BP measurements. Mean of all available measurements was used from four measurements for the CHHS and six measurements for NHANES III. A mean SBP/DBP of 140/90 mm Hg or treated with medication was used from the earlier decades of life, an overall low control of hypertension. Hypertension prevalence using the same definitions and the same age range (18–74 years) was NHANES III: 20.1%, CHHS: 21.1%. Although the prevalence of isolated systolic hypertension (ISH) was similar in both studies, around 8% to 9%, the CHHS had higher ISH prevalence than NHANES III in the younger age groups and lower prevalence in the older age groups. Elevated SBP dominated the prevalence figures after the 1950s in both studies. Compared to NHANES III, the CHHS showed a lower proportion (43% v 50%) of individuals with optimal BP (<120/80 mm Hg) and a very low proportion of hypertensives under control (13% v 25%). About half of diabetic participants were hypertensive (using 140/90 mm Hg) in both countries with a very low level of control in Canada (9%) v the US (36%) for ages 18 to 74 years.

**Conclusions:** The results of these two surveys highlight the importance of SBP, in the later decades of life, an overall low control of hypertension in both countries, and a better overall awareness, treatment, and control of hypertension in the US than in Canada for that period. Dissemination of hypertension guidelines and a more aggressive focus on SBP are urgently needed in Canada, with special attention to diabetics.

**Key Words:** Hypertension, prevalence, control, surveys.

Received March 20, 2001. Accepted June 5, 2001.

From the Department of Community Health and Epidemiology (MRJ, DRM), Faculty of Medicine, Dalhousie University, Halifax, Nova Scotia, Canada; Research Centre (PH), Centre Hospitalier Universitaire, Montréal, Canada; Bristol-Myers Squibb Pharmaceutical Research Institute (GJL), Wallimford, Connecticut; and Heart Check (GF), HIPRC, University of Ottawa Heart Institute, Ottawa Civic Hospital, Ottawa, Ontario, Canada.

The Canadian Heart Health Surveys were supported by the National Health Research Development Program of Health Canada, provincial departments of health, and provincial Heart and Stroke Foundations. NHANES III data were obtained through the publicly available databases, U.S. Department of Health and Human Services (DHHS), National Center for Health Statistics. This study was supported in part by an unrestricted educational grant from Bristol-Myers Squibb Canada for data analysis.

Address correspondence and reprint requests to Dr. Michel R. Joffres, Department of Community Health and Epidemiology, Faculty of Medicine, Dalhousie University, 5849 University Avenue, Halifax, Nova Scotia, Canada, B3H 4H7; e-mail: michel.joffres@dal.ca
BP data,¹–⁴ there has never been any direct comparison of some aspects of these distributions. This study presents unpublished data from the 10 Canadian provinces and compares prevalence of systolic (SBP) and diastolic (DBP) BP, and level of control using the same definitions between NHANES III and Canadian Heart Health Surveys (CHHS), with a focus on SBP.

Methods

CHHS

In each of the 10 Canadian provinces, health insurance registries were used as sampling frames. These registries are regularly updated and contain a nearly complete listing of the target population, as virtually all Canadians are covered by provincial health insurance plans. A stratified, two-stage, replicated probability sample design targeted 2200 people in each province. These subjects were between 18 and 74 years old and were not living in institutions, First Nation’s reserves, or in military camps. The surveys took place between 1986 and 1992. A total of 29,855 individuals were randomly selected as participants, of which 23,129 participated in the surveys. Details of the study methodology have been published elsewhere.²,⁵ A common methodology was used in all 10 surveys. Selected subjects were first contacted by a letter then by a phone call from trained public health nurses. An initial home interview lasting 40 to 60 min was then conducted to obtain basic demographic and lifestyle data, as well as to ascertain the individual’s level of knowledge and awareness of cardiovascular disease (CVD) risk factors. Two BP measurements were taken, one at the beginning of the interview and one at the end. Approximately 2 weeks later, participants were invited to visit a clinic, where fasting blood samples, anthropometric measures, and two additional BP measurements were taken.

The BP was measured by a trained nurse at the beginning and at the end of each visit. Standardization for identification of the Korotkoff sounds followed the manual developed for the Hypertension Detection and Follow-up Program, School of Public Health, University of Texas. Standard mercury sphygmomanometers, 15-inch stethoscopes, and correctly sized cuffs were used.

Participants had been instructed not to smoke for at least 30 min before the measurement and not to drink alcohol for at least 8 h. Before BP measurement, the subjects first rested quietly for 5 min. In a sitting position, the participant’s right arm was held at heart level. When not possible to measure BP on the right arm, the left arm was used. The maximum inflation level was determined before the actual measurement. The first and fifth Korotkoff sounds were recorded for the systolic and diastolic BP, respectively, and for sounds continuing to 0 mm Hg, the fourth Korotkoff sound was used. The mean BP (four measurements for most participants) was used. Pulse was also recorded.

NHANES III

Methods used in phase 1 and 2 (1988 to 1994) have been described in more details elsewhere (http://www.cdc.gov/nchswww/nchshome.htm).¹,⁴

Briefly, to compare with the CHHS, a national probability sample of 39,695 persons aged 2 months and older was selected during 6 years for NHANES III. Of those, 33,994 (86%) were interviewed in their homes. All interviewed persons were invited for a medical examination. Seventy-eight percent (30,818) of the selected persons were examined, and an additional 493 persons were given a special, limited examination in their homes. Three BP measurements were taken at the end of a 1-h interview by a trained lay interviewer at 1-min interval. A second set of three measurements was taken by a physician during the medical examination. Similar to the CHHS, a standard mercury sphygmomanometer was used, appropriated cuff sizes and the standard measurement procedure was used in both surveys. As in CHHS, the mean of all available BP measurements was used. A total of 15,326 individuals within the age range of the CHHS, 18 to 74 years, with a valid mean SBP and DBP were available for the analyses for NHANES III.

In both studies, hypertension was defined as a mean SBP ≥140 mm Hg, or a mean DBP ≥90 mm Hg, or being prescribed medication. The wording of the question for the variables used in the programming was similar in both surveys for the key questions. CHHS: Before this interview have you ever had your BP checked? How long ago did you have your BP checked? Were you ever told by a doctor, nurse, or some other health care professional that you had high BP? Are you now taking medication for your high BP? NHANES III: About how long has it been since you last had your BP taken by a doctor or other health professional? (Includes the answer NEVER). Have you ever been told by a doctor or other health professional that you had hypertension, also called high BP? Are you now taking prescribed medicine?

All reported measurements for both studies have been weighted to account for the sampling design, and therefore, represent population estimates. Given the difference in sampling methodologies between the two surveys, the multitude of potential comparisons, and the large sample size, there has been no attempt to use complex statistical methods to test differences between means or proportions.

For all the figures, the same definitions have been used for hypertension between NHANES III and the CHHS. A mean DBP of ≥90 mm Hg, a mean SBP ≥140 mm Hg, and current treatment with medication were used to define hypertension. Individuals who reported having been told by a physician or a nurse that they had high BP but were not treated (with medications or nonpharmacologicals), and who had a normal mean BP were not included in the hypertension group in the CHHS. The total population estimates have not been age adjusted, as population distributions were almost identical and the total values rep-
resented actual population burden. To match the CHHS age range, only the data for the NHANES III participants aged 18 to 74 years were included in the analysis. SAS 6.12 and 8.1 (SAS institute Inc., Gary, NC) was used for all analyses.

Results

The means of SBP and DBP are presented for both NHANES III and CHHS for men, women, and the total population, by 5-year age groups (Fig. 1). The distribution of SBP shows the usual pattern: increasing with age, higher in men than women until the mid-sixties, with a steeper increase in women starting in the late thirties, and a higher mean for women than men in the seventh decade for the CHHS. The DBP increases until the fifties and then decreases in both men and women in both surveys, but more rapidly in NHANES III than in the CHHS. The CHHS curve was higher than the NHANES III curve for both SBP and DBP. The overall means (SBP/DBP, mm Hg) were NHANES III (120.5/74.0) and CHHS (123.0/77.0).

Fig. 2 presents the prevalence of hypertension by age group in both studies. Within each hypertension age group, the cumulative bar graph shows the contribution of each component: both SBP and DBP elevation (systolic and diastolic hypertension [SDH]), in isolation, for DBP (isolated diastolic hypertension [IDH]), SBP (isolated systolic hypertension [ISH]), and the population controlled for their high BP by treatment to a level /11021/140/90 mm Hg.

Overall, the prevalence of hypertension in the 18- to 74-year olds was higher for the CHHS than for NHANES III (21.1% v 20.1%). The 18 to 34 years of age showed a slightly higher prevalence in the CHHS (6.2%) than in NHANES III (4.0%), whereas the reverse was true for the 65 to 74 years of age group (CHHS 56.8% v NHANES III 58.5%). Although hypertension prevalence was very similar in each age group, the distribution of hypertension types and level of control was quite different in each age group between the two surveys. In particular, each CHHS age group had a lower level of control and a higher prevalence of SDH.

The prevalence of ISH using different criteria (SBP ≥140 mm Hg and DBP <90 mm Hg; SBP ≥160 mm Hg and DBP <90 mm Hg) is presented in Table 1 for both studies. Overall, the prevalence of ISH (SBP ≥140 mm Hg) was around 8% to 9% for men and women in both studies, increased with age, was higher in the older age groups in NHANES III, but higher in the CHHS in the younger age groups. Using a higher cut-off point of 160 mm Hg or greater, prevalence of ISH was around 1% in both studies, very low in the younger age groups (<45 years), and higher in NHANES III than in the CHHS among the older age groups.

After removing treated individuals from calculations, prevalence figures showed different patterns between surveys in men and women. The Third National Health and Nutrition Examination Survey figures were lower than the CHHS for the older age groups for men but not for women.

Fig. 3 compares the distribution of the actual BP measurements between NHANES III and the CHHS following the Sixth Report of the Joint National Committee on prevention, detection, evaluation, and treatment of high blood pressure (JNC VI) criteria. Although prevalence of stages 1, 2, and 3 were similar in both studies, NHANES III observed more (50% v 43%) individuals in the optimal range (<120/80 mm Hg), whereas CHHS uncovered a slightly higher prevalence in the normal and high-normal ranges (120 to 139/80 to 89 mm Hg).

Levels of awareness, treatment, and control were lower in Canada than in NHANES III (Fig. 4). The level of control in the CHHS was about half that of NHANES III (25% v 13%). The proportion of hypertensives unaware of their hypertension was much higher in the CHHS than in NHANES III (43% v 30%).

Fig. 5 displays a scatter plot of SBP against DBP for the CHHS for hypertensive subjects. Although 13% of the population were under the 140/90 mm Hg levels (ie,
treated and controlled), the scatter plot shows that there were few people in the very high ranges of SBP (>180 mm Hg) and DBP (>105 mm Hg). The total number of individuals with elevated SBP was 69% (38/51) against 49% (31/62) with elevated DBP. Prevalence of isolated SBP was 38% and less that half had isolated DBP (18%), whereas the prevalence of individuals with SDH was 31%.

In Fig. 6 the plot of SBP against DBP showed a similar pattern among hypertensive subjects in NHANES III, with more individuals in the controlled area (25%) than the CHHS. There was also a high prevalence of individuals with ISH (43%), and elevated SBP (61%), compared with the prevalence of isolated high DBP (13%) or elevated DBP (31%).

Fig. 7 presents the prevalence of elevated SBP, DBP, or both, among uncontrolled (treated or not) hypertensives, by study. For both studies about 94% of these hypertensives aged 50 years and older had an elevated SBP, whereas for those younger than 50 years of age, the prevalence of elevated DBP was higher than the prevalence of elevated SBP and almost the same in both studies. In the older age group, the CHHS had a higher prevalence than NHANES III of elevated DBP (43% v 25%) and SDH (36% v 19%).

Fig. 8 is analogous to Fig. 2, but depicts the situation among diabetics. In both studies diabetes status was defined as self-reported diabetes. The overall prevalence of hypertension among diabetics is around 50% in both surveys with the CHHS having a higher prevalence in the 35-
to 64-year olds (55% v 46%). The Third National Health and Nutrition Examination Survey had a much higher proportion of controlled hypertensive diabetics and a lower proportion of diabetics with SDH in all ages than the CHHS. For both surveys, ISH prevalence was similar, and highest in the 65- to 74-year olds.

Discussion

These data compare populations at a time when guidelines for defining hypertension and control were mainly focusing on DBP. Our previous study\(^2\) pointed at some major gaps in the level of awareness, treatment, and control of hypertension in Canada. There is some evidence, both in Canada and the United States,\(^6,7\) that we have not made any progress in the control of hypertension, and that we might indeed be losing some ground. Therefore, these data could be a conservative evaluation of the current situation.

The difference in methodology between these surveys should have a minimal impact on these comparisons. One of the main differences was the use of six BP measurements in NHANES III versus four in CHHS. All BP were taken by trained nurses in the CHHS, whereas NHANES III used trained lay interviewers for the home measurements and physicians for the last three measurements in the mobile examination center.

The age-related changes in BP that we see in both surveys, with an increase in ISH with age, cannot be attributed solely to a differential effect of treatment on DBP, where DBP would decrease below 90 mm Hg, whereas the SBP would remain above 140 mm Hg. Using longitudinal data from Framingham, Franklin et al\(^8\) conclude that “The late fall in DBP after age 60 years, associated with a continual rise in SBP, cannot be explained by ‘burned out’ diastolic hypertension or by ‘selective survivorship’ but is consistent with increased large artery stiffness.” The important message is that “Higher SBP, left untreated, may accelerate large artery stiffness and thus perpetuate a vicious cycle.” Risk increases with increasing levels of SBP, DBP, although there might be
some differences in the absolute risk between populations, probably due to the interaction with other risk factors. Although this issue is widely recognized, the artificial dichotomy created by guidelines has also created a gap outside the high-risk approach, that is, at the population level.

The past Canadian recommendations were based for a great part on the 90 mm Hg diastolic level and differ in that respect with the World Health Organization and JNCVI guidelines. They are heavily weighted toward clinical trial evidence, and little toward the accumulated epidemiologic convergence of increasing risk with increased SBP levels. One of the dilemmas is whether to treat individuals with ISH between 140 and 160 mm Hg when we do not have the clinical trial evidence that it reduces morbidity and mortality. Although the Canadian recommendations recognize that the therapeutic goal for treating hypertension should be 140/90 mm Hg, the initiation of therapy is not recommended before an ISH 160 mm Hg in individuals without target organ damage or other major risk factors, independently of whether or not a nonpharmacologic approach has been initiated and is successful. This seems to be questionable. If we accept that the maximum benefit is below 140/90 mm Hg, why consider only those who have 160 mm Hg and more to start treatment? This clinical trial only, evidence-based approach may be congruent with a meta-analysis of trials of ISH in the elderly by Staessen et al, which points to the benefits of reducing ISH in the elderly, mainly relative to stroke risk, and even to a reduction in CVD events after age 80 years. Nevertheless, using such a high cut-off point of 160 mm Hg targets a very high risk but a minority of the population at risk. In further analysis, for the CHHS, we found that 89% of all ISH in untreated individuals lies between 140 and 160 mm Hg (96% aged <60 years, 82% aged 60 years and older). From a population perspective, this leaves a significant portion of the population (Table 1 and Figs. 5 and 6) at increased risk of CVD events, particularly stroke, although the level of risk may be lower. While we wait for clinical trials for ISH between 140 and 160 mm Hg, the wisdom of not treating individuals in that BP range should be reexamined. Also to be questioned is the value of using the concept of number—needed-to-treat derived from relatively short-term trials, when some benefits might be expressed beyond the end of the trial, and therefore not captured by this statistic. Short-term trials will inflate the number—needed-to-treat for lower levels of BP as the risk difference will be small due to an apparent but underestimated lower risk in the 140 to 160 mm Hg group, which would become apparent after a longer follow-up period.

Another important point is the coexistence of other risk factors that should lead the therapeutic decision. In the CHHS (data not presented), 97% of the hypertensive population aged 60 to 74 years have one or more of the major CVD risk factors (ie, smoking, hyperlipidemia, overweight, diabetes, or are sedentary). This means that if we were to use presence of other risk factors as a criterion to initiate hypertension treatment, most of these hypertensives should be treated anyway.

The prevalence of hypertension among individuals reporting diabetes is similar between CHHS and NHANES III (Fig. 8). Nevertheless, there is a striking difference in the percentage of diabetics who are controlled between the two studies that needs to be understood, as this group is at a high risk and that therapeutic benefits extend well below 140/90 mm Hg. With a decreasing prevalence of high DBP in this group with age, the importance of managing SBP among diabetics needs to be stressed.

It could be argued that because we have a “free” health care system in Canada, with better access, mainly for the uninsured, these major differences must result from the way the Canadian system screened and managed individuals with hypertension. This is particularly true in regard to systolic hypertension. The attitude and focus of physicians needs to change from a diastolic-based definition of control to recognizing the additional importance of SBP. Kannel in his recent review has reemphasized this point. Lloyd-Jones and colleagues also found that among Framingham participants, poor BP control was mainly due to lack of systolic control, even among treated subjects. The EISBERG project in elderly patients equally emphasizes the challenge of systolic control.

In further analysis, among treated (controlled or not) hypertensives comparing NHANES III with the CHHS, 54% v 44% where controlled to SBP goal, 83% v 67% to DBP goal and 48% v 38% were controlled to both. The Framingham study shows figures similar to NHANES III (49%, 90%, and 48% respectively). In the total hypertensives population, comparing NHANES III to the CHHS (Figs. 5 and 6), 38% v 31% where controlled to SBP goal, 68% v 51% to DBP goal and 25% v 13% were controlled to both in the CHHS. The importance of the lack of control of SBP is also illustrated by Fig. 7 showing that among uncontrolled hypertensives age ≥50 years, 93% to 94% of hypertensive individuals have an elevated SBP.

It is difficult to attribute some of the major differences seen between these studies only to methodologic differences. Outside of very small differences in age distribution, measurement techniques were very similar, and the questions related to BP almost identical. NHANES III used six BP measures versus four in the CHHS, but that would not explain such important differences in some of these prevalence figures. Using JNC VI criteria, a comparison of BP levels between NHANES III and CHHS revealed very small differences in prevalence of hypertension by stages using only measured BP (Fig. 3). This was reflected by the very close mean BP. Nevertheless, there were much lower levels of hypertension awareness, treatment, and control in Canada than in the United States. Hypertension control in Canada was about half the value of NHANES III (13% v 25%). Some of these differences may also be attributable to better past population-based
interventions in the United States, and more incentive in the United States to treat high BP than in Canada.

These data suggest that if a better level of awareness, treatment, and control could be achieved, Canadians could further improve their overall BP levels and significantly decrease their CVD risk. Although the last Canadian recommendations have made significant progress, in particular in the recognition of nonpharmacologic interventions and the issue of multiple risk factors, the focus back to the DBP as the initial basis for the management of hypertension needs to be reviewed.

References