Hypertension Prevalence and Blood Pressure Levels in 6 European Countries, Canada, and the United States

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Context Geographic variations in cardiovascular disease (CVD) and associated risk factors have been recognized worldwide. However, little attention has been directed to potential differences in hypertension between Europe and North America.

Objective To determine whether higher blood pressure (BP) levels and hypertension are more prevalent in Europe than in the United States and Canada.

Design, Setting, and Participants Sample surveys that were national in scope and conducted in the 1990s were identified in Germany, Finland, Sweden, England, Spain, Italy, Canada, and the United States. Collaborating investigators provided tabular data in a consistent format by age and sex for persons at least 35 years of age. Population registries were the main basis for sampling. Survey sizes ranged from 1800 to 23 100, with response rates of 61% to 87.5%. The data were analyzed to provide age-specific and age-adjusted estimates of BP and hypertension prevalence by country and region (eg, European vs North American).

Main Outcome Measures Blood pressure levels and prevalence of hypertension in Europe, the United States, and Canada.

Results Average BP was 136/83 mm Hg in the European countries and 127/77 mm Hg in Canada and the United States among men and women combined who were 35 to 74 years of age. This difference already existed among younger persons (35-39 years) in whom treatment was uncommon (ie, 124/78 mm Hg and 115/75 mm Hg, respectively), and the slope with age was steeper in the European countries. For all age groups, BP measurements were lowest in the United States and highest in Germany. The age- and sex-adjusted prevalence of hypertension was 28% in the North American countries and 44% in the European countries at the 140/90 mm Hg threshold. The findings for men and women by region were similar. Hypertension prevalence was strongly correlated with stroke mortality ($r=0.78$) and more modestly with total CVD ($r=0.44$).

Conclusions Despite extensive research on geographic patterns of CVD, the 60% higher prevalence of hypertension in Europe compared with the United States and Canada has not been generally appreciated. The implication of this finding for national prevention strategies should be vigorously explored.

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Cardiovascular disease (CVD) remains the most common cause of death in industrialized countries, and hypertension is the most frequent treatable risk factor. The analysis of international variation in risk factors has historically resulted in important insights into the etiology of CVD.[1] Moreover, international comparisons provide useful information about achievable levels of risk reduction.

Most etiologic research studies[1,2] on geographic variation in hypertension have investigated specific hypotheses, such as the role of fat or salt consumption, often choosing extreme social environments to maximize contrasts. Other projects, most notably the World Health Organization Monitoring of Trends and Determinants in Cardiovascular Disease (WHO MONICA) Project, sought to characterize overall coronary risk profiles and monitor trends.[3,4] In recent years, many countries have undertaken large-scale national health surveys that include rigorous measurement of cardiovascular risk status. Considerable epidemiologic research has been conducted using these surveys, such as the US National Health and Nutrition Examination Surveys (NHANES).[5,6] When measurements are

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Table 1. Characteristics of the National Surveys From Europe and North America

Country	Survey Year(s)	Population	No. of Respondents	Participation Rate, %*	Age Range, y	Sampling Method†
Canada	1986-1992	National	23 129	77.5	18-74	Multistage, medical insurance registries
England	1998	National	13 586	87.5	16-≥80	Multistage, postcode address
Finland	1997	National	7159	72	25-64	Population registry
Germany	1997-1999	National	7124	61.4	18-79	Population registry
Italy	1998	National	8233	. . .	35-74	Multistage, population registry
Spain	1990	National	2021	73	35-65	Multistage, national registry
Sweden	1999	Regional	1823	72	25-74	Population registry
United States	1988-1994	National	17 530	82	18-≥80	Multistage, population registry

*Ellipsis indicates data not available.
†All stratified sampling methods.

comparable, these national surveys can also be used to address important questions in international epidemiology.[7,8]

Some traits, such as obesity, are easily measured in large samples, whereas for more complicated traits, such as diabetes, standardized protocols make it possible to conduct comparable surveys worldwide.[9,10] Hypertension prevalence is difficult to determine in a standardized manner in population surveys, however. The measurement device used, training of survey personnel, sequence of examinations, definition of treatment status, and a variety of other factors can all vary among surveys and lead to random and systematic error. Published studies often do not even provide adequate information to make age standardization possible. Improved methods have made recent surveys more comparable, however, and a standardized approach to data analysis can reduce confounding from factors such as age.

Prompted by the recent publication of hypertension data from health survey in England,[11] we sought to determine whether the apparent finding of higher blood pressure (BP) measurements and prevalence of hypertension than in the United States would be seen in other parts of Europe and North America. To achieve this goal, we analyzed original data obtained from a sample of large population surveys.

METHODS

Study Design

We conducted a review of surveys on hypertension in North America and Europe published since 1990 to identify those that were national in scope. Two North American (United States[12] and Canada[13]) and 6 European (England,[11] Finland,[14] Germany,[15] Italy,[16] Spain,[17] and Sweden[18]) surveys were included. After achieving consensus on the main goals and resolving the methodologic issues, data collection forms were distributed. Each collaborator was asked to provide average sex- and age-specific data by 5-year age groups for BP, body mass index (BMI, measured as the weight in kilograms divided by the height in meters squared), and counts of hypertensive individuals by treatment and control status. A description of the key aspects of each survey, including the BP measurement procedure, was collected in a standardized format.

Some of the studies were based on a random probability sample of the entire nation, whereas others were a series of regional samples; none were restricted mainly to a single province or subregion within the country, however (TABLE 1). The number of participants ranged from 1823 to 23 129, and the participation rate varied from 61% to 87.5%. Sampling was conducted mainly on population registries. The age distribution of participants in the original surveys varied from 35 to 64 years to 18 to 80 years or older.

Data Selection

The mercury sphygmomanometer was used for BP measurements in every country except England, where the Dinamap 8100, an automatic oscillometric BP measurement device (Criticon, Berkshire, England), was used. The examination was conducted in a clinic in Finland, Germany, Italy, Spain, and Sweden. In England, the examination took place at home, whereas in Canada and the United States, BP was measured both at home and in a clinic. All studies had at least 2 measurements, and the second BP measurement from the clinic visit was used to create the mean for the age-sex groups, except for England, where the second home BP measurement was used. The rest period between the first and the second BP measurements was 1 to 3 minutes in all surveys, except Canada, where it was 10 to 60 minutes (TABLE 2).

Hypertension was defined as a BP of 140/90 mm Hg or higher or current use of antihypertensive medication. The treatment rate was the number of hypertensive individuals who were receiving antihypertensive medication divided by the total number of hypertensive individuals. In England, medication use was documented, whereas in all other surveys it was based on self-report. The rate of hypertension control was defined as the number of treated hypertensive individuals with BP less than 140/90 mm Hg divided by the total number of hypertensive individuals.

Data Analysis

Blood pressure, BMI, hypertension prevalence, treatment, and control were calculated for 5-year age-sex groups. To achieve maximum overlap, we restricted the analysis to 35 to 74 years for age-specific estimates of BP and hypertension prevalence and 35 to 64 years for age-adjusted results and mortality data. In the US NHANES, whites, blacks, and Hispanics were combined with the appropriate weighting for population size. In England, minority groups were also weighted according to the population size, and in Germany the data were weighted according to the population sizes of former East and West Germany. Hypertension prevalence and control were adjusted by age, averaging the 5-year age groups and combining the data for men and women. For regional comparison of the North American countries vs the European countries, mean BP measurements, prevalences, and control rates were averaged, considering each country as a single unit (ie, without weighting by population size). Age-adjusted data for stroke and CVD mortality based on *International Classification of Diseases, Ninth Revision (ICD-9)* for the entire age range were obtained from the WHO Collaborating Center on Surveillance of Cardiovascular Disease.[19]

RESULTS

Mean BP Measurements in the Individual Countries

Modest heterogeneity was observed in systolic BP among the European countries (FIGURE 1). In the youngest age groups, Germany, England, and Finland appeared to cluster at the top of the distribution, whereas Italy and Spain assumed a middle position; the United States and Canada were well below all the European countries. In the older age groups, Germany and Sweden had the highest levels and Italy the lowest mean BP measurements among the European countries. This pattern was similar for men and women by region (data not shown). Canada diverged from the United States in the oldest age groups, reaching a maximum difference of approximately 5 mm Hg. Age-specific diastolic BP measurements followed the expected inverted U pattern with age (Figure 1). Again, Germany had the highest diastolic BP measurements. England had relatively low diastolic BP measurements, consistent with the use of the automatic device in that survey. Some of these age groups are small, and they should be interpreted with some caution, particularly in elderly individuals for whom treatment might have a differential impact across countries.

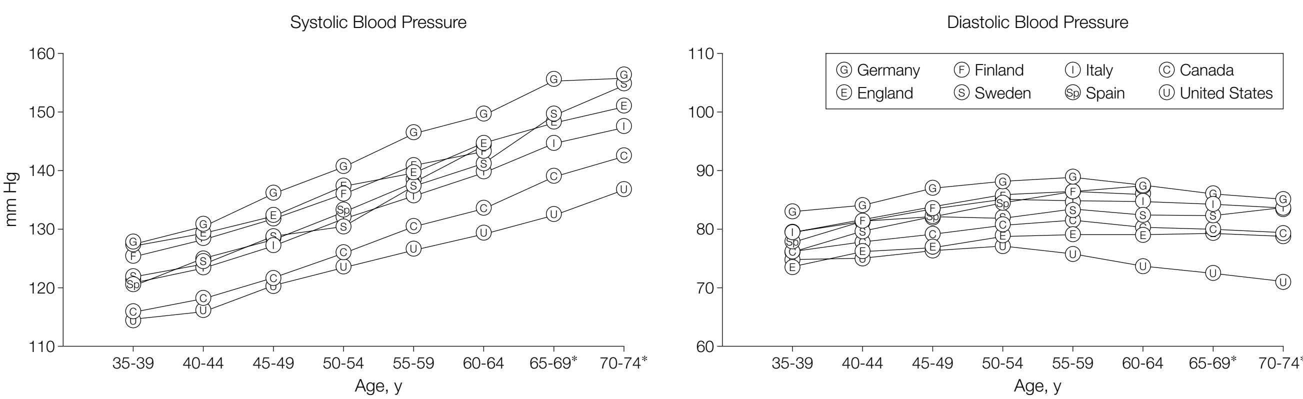
Mean BP Measurements in Europe and North America

Although heterogeneity existed, as a group the European countries uniformly had higher BP measurements than did the United States and Canada, and a gap was present in the age-specific trends between the 2 sets of countries. We therefore combined the surveys by region to enhance the precision of the comparisons (FIGURE 2). Mean systolic and diastolic BP measurements were higher in the European countries than in Canada and the United

Table 2. Blood Pressure (BP) Measurement Techniques of the Surveys

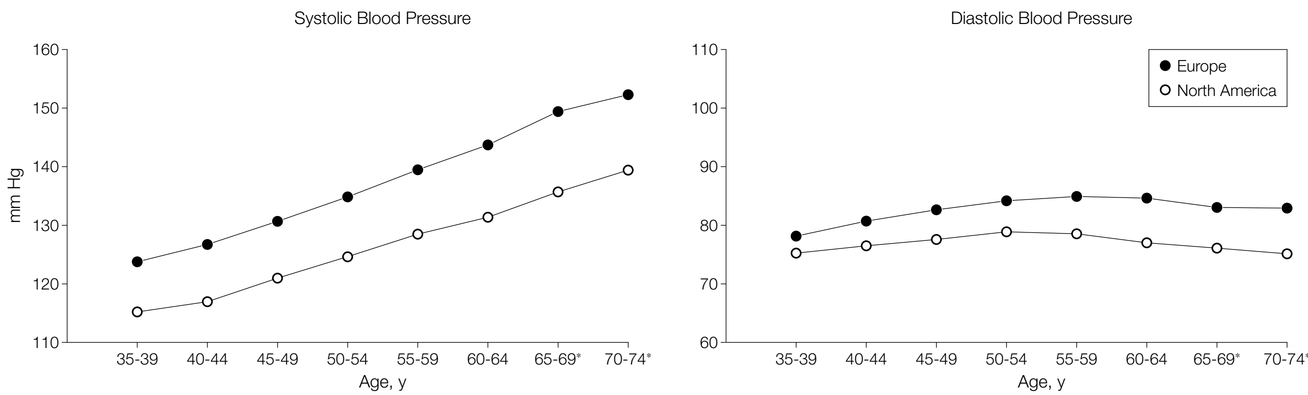
Country	BP Device	Type of Health Care Worker Measuring BP	Training Period, d	No. of Cuff Sizes Used	Posture While BP Measured	No. of BP Measurements	Resting Time Before Measurements, min	Resting Time Between Measurements, min
Canada	Mercury sphygmomanometer	Nurse	2	3	Sitting	4	5	10-60
England	Dinamap 8100	Nurse	2	4	Sitting	3	5	1
Finland	Mercury sphygmomanometer	Nurse	8	3	Sitting	2	5	1
Germany	Mercury sphygmomanometer	Trained personnel	2	3	Sitting	3	5	3
Italy	Mercury sphygmomanometer	Nurse/trained personnel	3	2	Sitting	2	5	3
Spain	Mercury sphygmomanometer	Physician	2	2	Sitting	3	5	2
Sweden	Mercury sphygmomanometer	Nurse/trained personnel	4	3	Sitting	2	5	1
United States	Mercury sphygmomanometer	Physician	1.5	4	Sitting	6	5	1

Figure 1. Mean Systolic and Diastolic Blood Pressures in 6 European and 2 North American Countries, Men and Women Combined, by Age



Asterisk indicates that data for Finland and Spain were not available in the 2 highest age groups.

Figure 2. Mean Systolic and Diastolic Blood Pressures in 6 European and 2 North American Countries, Men and Women Combined, by Age



Asterisk indicates that data for Finland and Spain were not available in the 2 highest age groups.

Table 3. Hypertension Prevalence and Treatment and Body Mass Index (BMI) Among Persons 35 to 64 Years Old in 6 European Countries, Canada, and the United States*

	Prevalence, %				
Country	All	Men	Women	Hypertensive Persons Taking Medications, %	BMI
North America	27.6	30.4	24.8	44.4	27.1
United States	27.8	29.8	25.8	52.5	27.4
Canada	27.4	31.0	23.8	36.3	26.8
Europe	44.2	49.7	38.6	26.8	26.9
Italy	37.7	44.8	30.6	32.0	26.4
Sweden	38.4	44.8	32.0	26.2	26.5
England	41.7	46.9	36.5	24.8	27.1
Spain	46.8	49.0	44.6	26.8	27.4
Finland	48.7	55.7	41.6	25.0	27.1
Germany	55.3	60.2	50.3	26.0	27.3

*Age adjusted. BMI calculated as weight in kilograms divided by the height in meters squared.

States for the entire age range (35-74 years), with average values of 136/83 mm Hg in Europe and 127/77 mm Hg in North America. This difference already existed among persons 35 to 39 years old (ie, 124/78 mm Hg and 115/75 mm Hg, respectively). Mean systolic BP differences increased to 13 mm Hg by the age of 65 years (Figure 2).

Hypertension Prevalence

In TABLE 3 and FIGURE 3, we present the age- and sex-adjusted prevalence of hypertension at the standard threshold (ie, BP ≥140/90 mm Hg or treatment with antihypertensive medication). The prevalence was highest in Germany (55%), followed by Finland (49%), Spain (47%), England (42%), Sweden (38%), and Italy (38%). Prevalences in the United States and Canada were half of the rate in Germany (28% and 27%, respectively). The prevalence of hypertension for the European average was 44.2% compared with 27.6% in North America. The BMI was the only lifestyle measure available to our analysis. The range was narrow (26.4-27.4) and weakly correlated with hypertension prevalence ($r=0.22$). The BMI in North America was 27.1 vs 26.9 in Europe, suggesting that obesity explains little of the overall difference in BP.

Age-specific hypertension prevalence increased similarly to systolic BP for the individual countries, with a higher intercept and slightly higher slope in Europe (Figure 3). Hypertension prevalence by age in the Canadian survey was the same as in the United States. The prevalence in the age group 35 to 44 years was 14% in the North American countries and 27% in Europe, increasing to 53% and 78%, respectively, among persons aged 65 to 74 years.

Hypertension Control

Hypertension treatment in the European countries was on average lower than in the North American countries (Table 3). The rank order for the proportion of persons undergoing treatment with a BP lower than 140/90 mm Hg in the European countries was England, Italy, Germany, Finland, Sweden, and Spain; however, the variation was small, ranging from 5% to 9%. For the European countries, on average only 8% of hypertensive individuals had their condition controlled compared with 23% in Canada and the United States (persons 35-64 years of age).

Hypertension Prevalence vs Mortality From Stroke and CVD

As an external test of the validity of the survey data, the prevalence of hypertension was correlated with hypertension-related causes of death. The primary comparison was based on stroke, since it is the clinical outcome most closely related to hypertension (FIGURE 4). The correlation coefficient for hypertension prevalence vs stroke was 0.78 ($P=.028$). The average mortality rate from stroke in the European countries was 41.2 per 100000 population vs 27.6 per 100000 in Canada and the United States. Because coding practices may vary among countries for specific disease categories, we also examined mortality from all CVD; hypertension prevalence was still correlated with the rate in individual countries, albeit at a lower level ($r=0.44$). The lower magnitude of the correlation for CVD is consistent with independent influences of other risk factors, such as smoking and hypercholesterolemia, which were not accounted for in this analysis.

COMMENT

Using recent national survey data, we found that mean BP measurements and hypertension prevalence are much higher in a sample of 6 European countries than in Canada and the United States. This pattern is strongly correlated with death rates from stroke, the cardiovascular condition with the highest relative risk from hypertension. Previous research from WHO MONICA found the same relationship between hypertension prevalence and stroke incidence in a sample of 35 populations in Europe and Asia.[20] Although these data invite a self-evident interpretation, several important questions remain. Survey data for hypertension are difficult to standardize, and mean differences in the range observed herein might be to some extent artifactual. However, the possibility that the pattern of bias would be completely regional seems remote. In fact, a strength of our analysis is that the studies are representative of whole countries or important regions and that we include surveys from northern, central, and southern Europe. In addition, numerous other individual studies,[3,4,21-24] including most prominently WHO MONICA, found similar patterns using a common method. Even higher BP measurements have been reported in Eastern Europe.[23,24] In a comparison of the Polish MONICA project with the US-based Atherosclerosis Risk in Communities study, systolic BP measurements in Poland were 20 mm Hg higher than in the United States.[23]

Despite the straightforward nature of our result, we acknowledge that a variety of methodologic issues could undermine the validity of the apparent conclusions suggested by these data. Participation was between 72% and 87.5% in all but the German survey (61%), so it is likely that we analyzed adequately representative samples. The survey years of Spain, the United States, and Canada were the earliest, which could affect comparisons if BP measurements are declining. Although a single BP measurement does not characterize an individual well, accurate group means can still be obtained with a single reading taken under appropriate conditions. Analysis of NHANES (where BP was measured 6 times) demonstrated that hypertension prevalence does not change whether one uses only the second BP measurement or all recorded measurements. We acknowledge that this relationship may vary with timing between measurements and other factors; however, the second BP measurement provides the most comparable index across this group of studies. The Dinamap, which was used only in England, has been shown to yield slightly higher values for systolic BP, usually in the range of 2 to 3 mm Hg, although diastolic BP can be 5 to 7 mm Hg lower compared with mercury devices.[25-27] We used national mortality data for external validation of the gradient in hypertension prevalence. Although concerns exist regarding reliability of cause-of-death certification, the accuracy of classification for CVD in these countries has been well validated.[28-30]

Although lower BP measurements have been previously reported in the United States relative to European countries[11,21,23] and a north-south gradient in Europe has also been found in previous studies, we acknowledge that inconsistencies exist between our data and some published studies. A prior survey in Catalonia, Spain, found lower hypertension prevalence relative to other countries in Europe, and the prevalence in Germany was not as high.[4] Although our studies lack direct standardization, both the Spanish and the German samples are representative of the whole population. On the other hand, the relatively higher hypertension prevalence in Spain compared with other European countries could reflect the earlier survey year (1990) or the use of only 2 cuff sizes. In fact, there is evidence that some reduction in BP has occurred in Spain since that survey.[31] Overall, we believe that the contrasts between the European countries and Canada and the United States are real and of substantial magnitude. For discrimination between European countries, however, these data may lack sufficient precision, and WHO MONICA

Figure 3. Hypertension Prevalences in 6 European and 2 North American Countries, Men and Women Combined, by Age Group

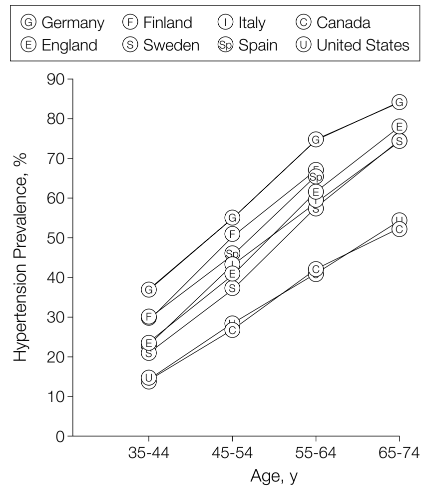
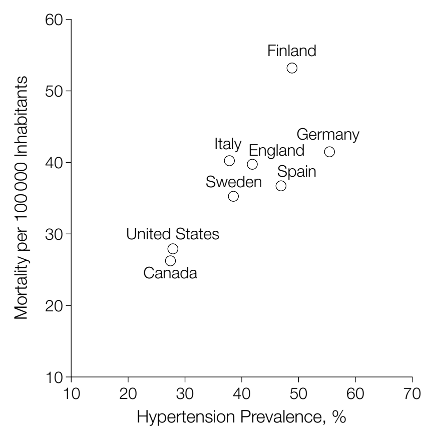


Figure 4. Hypertension Prevalences vs Stroke Mortality in 6 European and 2 North American Countries, Men and Women Combined (35-64 Years), Age Adjusted



has addressed that question more effectively.[3,4]

Why has this significant difference in BP measurements and prevalence of hypertension not been better recognized and what might the underlying causes be? Lack of attention to this finding may have resulted from inherent skepticism that the BP measurements are comparable in separate studies, combined with the lack of a ready explanation. In the United States, enormous attention has been focused on racial differences, particularly between blacks and whites, although these differences are only half as large as those between the United States and Europe.[12] Genetic factors have been at the top of the agenda to explain black-white differentials, although African origin populations in contrasting social contexts also show wide variation in hypertension prevalence.[32] North American populations are predominantly of European ancestry, and genetics is not a plausible explanation of the finding reported herein.

The only etiologic risk factor collected in a systematic way by our surveys was BMI, which was weakly correlated with hypertension prevalence. This result is not unexpected given the narrow range of BMI across the countries. Data from the International Study of Electrolyte Excretion and Blood Pressure (INTERSALT) do not suggest large differences in intake in sodium or potassium between the US and European components of that study,[2] although the samples were relatively small and not necessarily representative. In view of the recent evidence that intake of fruits and vegetables has a substantial impact on BP,[33] difference in dietary composition is another important hypothesis to consider. A recent analysis of the NHANES data, for example, found a correlation between dietary intake and BP among regional populations within the United States.[34] An examination of broad consumption patterns among the countries studied herein provides some support to this hypothesis,[35,36] although a more detailed analysis would obviously be required. Alcohol intake is higher in Europe overall.[37] Variation in physical activity has been less well characterized, to our knowledge, and cigarette smoking, although more common in Europe, does not have an important influence on BP.[38] Unfortunately, our data do not permit a direct examination of these important causal hypotheses, and the purpose of our study was solely to describe the epidemiologic patterns of BP and hypertension. Further research based on collection of risk factor data would be required to test etiologic hypotheses.

Treatment guidelines vary among the countries we studied, as does the consistency with which they are implemented. Lower thresholds and treatment goals have been used throughout this period in Canada and the United States, increasing the numbers of treated cases and lowering the mean BP in the population, at least among elderly individuals. As noted in Table 3, large differences in the proportion of patients who receive treatment and among those who are treated and have a BP below 140/90 mm Hg are apparent among these countries. This variation in treatment could introduce 2 opposing biases. First, BP measurements would be lower in those age groups where large numbers of patients are treated, increasing the cross-Atlantic contrast. This effect would not be observed in patients younger than 55 years, however. Second, high rates of screening and detection could result in some additional patients with true BP measurements less than 140/90 mm Hg receiving treatment in Canada and the United States (ie, false-positive clinical diagnosis), thereby increasing the number of participants counted as hypertensive cases. On balance, these biases tend to cancel each other and could not have created the large observed differences.

Trend data suggest that hypertension has declined 16% in the United States during the last 20 years.[34] Systolic BP measurements were 5 to 7 mm Hg lower among persons in NHANES III (1988-1991) compared with NHANES II (1976-1980).[39] Part of this decline may be methodologic, but some proportion is thought to reflect population trends. Countervailing changes in risk factors for hypertension are occurring in the United States. During the last 3 decades little change in sodium intake has taken place and fat content and alcohol intake have declined, whereas total intake of calories and associated obesity have increased.[40]

Stroke rates in the United States decreased precipitously during this period, and antihypertensive treatment is generally credited with much of this decline.[40] If downward trends in BP have occurred selectively in Canada and the United States, this might account for some of the significant contrast with the European countries and suggest the magnitude of the benefit that can be achieved with a population-wide prevention strategy. The United States and Canada currently have the lowest stroke rates in the world, clearly a benefit of low BP in the population. Of course, these findings provide no general measure of the relative effectiveness of the medical care system in the respective regions. It is also apparent that much more improvement in hypertension control is necessary in the United States and Canada as well to reduce overall CVD risk, particularly among younger men and some ethnic groups.

Based on the evidence presented herein, Europe should be considered a high prevalence hypertension region. Our study provides no direct information on what the causal explanations might be but rather places this topic on the research agenda. Among the most relevant factors are nutrient intake, obesity, physical activity, alcohol intake, environmental toxins, psychosocial stressors, and genetic susceptibility.[41] One of the most provocative questions raised by these data is whether incompletely characterized lifestyle factors that are amenable to a population level prevention strategy can be identified. Cultural similarities between Europe and North America in so many other aspects of lifestyle suggest that if these factors could be identified, improvements could be made without requiring radical changes in the existing lifestyle. The potential for both prevention and better pharmacologic control would thus appear to be substantial for Europe. The need to further increase awareness of this common risk factor among both physicians and the public is evident.

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