Detection and Control of High Blood Pressure in the Community : Do We Need a Wake-Up Call?

Irene Meissner, Jack P. Whisnant, Sheldon G. Sheps, Gary L. Schwartz, W. Michael O'Fallon, Jody L. Covalt, JoRean D. Sicks, Kent R. Bailey and David O. Wiebers

Hypertension 1999;34;466-471
Hypertension is published by the American Heart Association. 7272 Greenville Avenue, Dallas, TX 72514
 Print ISSN: 0194-911X. Online ISSN: 1524-4563

Detection and Control of High Blood Pressure in the Community

Do We Need a Wake-Up Call?

Irene Meissner, Jack P. Whisnant, Sheldon G. Sheps, Gary L. Schwartz, W. Michael O'Fallon, Jody L. Covalt, JoRean D. Sicks, Kent R. Bailey, David O. Wiebers

Abstract—At the community level, the effect of national programs in increasing hypertension awareness, prevention, treatment, and control is unclear. This study evaluated the degree of detection and control of high blood pressure in a random population-based sample of Olmsted County, Minnesota, residents ≥45 years old, of whom 636 subjects among 1245 eligible residents agreed to participate. Home interview and home and office measurements of blood pressure were used to estimate awareness, treatment, and control rates for hypertension in the community. Mean blood pressures (±SD) were 138/80±20/12 mm Hg for men and 137/76±23/11 mm Hg for women. The overall prevalence of hypertension was 53%. The percentage of subjects with treated and controlled hypertension was 16.6%. Thirty-nine percent of subjects were unaware of their hypertension. Despite clinical trial evidence of reduced morbidity and mortality with antihypertensive therapy, recently reported national data suggest a leveling-off trend for treatment and control of hypertension. This population-based study supports these observations and suggests that at a community level, hypertension awareness and blood pressure control rates are suboptimal, presumably because of decreased attention to the detection and control of hypertension. **(*Hypertension*. 1999;34:466-471.)**

Key Words: blood pressure ■ cerebrovascular disorders ■ hypertension detection and control ■ stroke

Because coronary heart disease and stroke continue to rank as the first and third leading causes of mortality in the United States, with direct and indirect costs up to $260 billion, primary prevention of these disorders is becoming increasingly crucial.[1] This goal requires identification and treatment of the associated risk factors in the population.

Hypertension is a main risk factor for both coronary heart disease and stroke. Comparison of the 1976 to 1980 National Health and Nutrition Examination Survey (NHANES II) with the 1988 to 1991 survey (NHANES III, phase I) showed an increase in awareness of high blood pressure from 51% to 73%[2,3] and an increase in treatment from 31% to 55%. Control rates (<140/90 mm Hg) increased from 10% to 29% in the same period. However, from the time of the Fifth Report of the Joint National Committee on Detection, Evaluation, and Treatment of High Blood Pressure (JNC V) in 1993,[4] awareness, treatment, and control of hypertension may be leveling off or deteriorating. Comparison of the results of the NHANES III, phase I survey showed a decrease in awareness from 73% to 68.4%, treatment from 55% to 53.6%, and control to <140/90 mm Hg from 29% to 27.4%.[5]

The present study, Stroke Prevention: Assessment of Risk in a Community (SPARC), was established in 1993 to identify prospectively the risk factors for stroke and cardiovascular disease in Olmsted County, Minnesota, a community studied closely for stroke incidence from the 1950s through the 1990s.[6–9] Randomly selected subjects were studied with multimodality testing: home and office blood pressure measurements, transthoracic and transesophageal echocardiography, and carotid ultrasonography. This report focuses on estimates of awareness, treatment, and control rates for hypertension in the population of Olmsted County, Minnesota, ≥45 years old to assess whether recent national survey estimates are applicable at the community level.

Methods

Population Sampling

The resources of the Rochester Epidemiology Project (REP) were used to enumerate the Olmsted County population.[10] With the use of data obtained from medical records at the Mayo Clinic and the Olmsted Medical Center (the major healthcare providers in the county), the REP files index all medical contacts made by residents of the population. Sampling at random from this REP file is equivalent to sampling at random from the population.[11] For this study, a stratified sampling scheme was designed with the REP files. The goal was to randomly select 580 persons distributed among 10 strata that were defined by gender and 5 age intervals: 45 to 54 years, 55 to 64 years, 65 to 74 years, 75 to 84 years, and ≥85 years old.

Received February 17, 1999; first decision March 11, 1999; revision accepted May 11, 1999.

From the Departments of Neurology (I.M., D.O.W.) and Health Sciences Research (J.P.W., W.M.O., K.R.B., D.O.W., J.L.C., J.D.S.) and the Division of Hypertension and Internal Medicine (S.G.S., G.L.S.), Mayo Clinic and Mayo Foundation, Rochester, Minn.

Reprint requests to Irene Meissner, MD, Department of Neurology, Mayo Clinic, 200 First St SW, Rochester, MN 55905.

Hypertension **is available at http://www.hypertensionaha.org**

Study Structure

Data for the SPARC study (which was approved by the Mayo Institutional Review Board) were collected during a home visit and clinic testing, which included office blood pressure measurement, transthoracic echocardiography, transesophageal echocardiography, carotid ultrasonography, and medical record review. Data reported for blood pressure measurement are from home and office visits.

Medical Record Review, Subject Contact, and Informed Consent

The complete inpatient and outpatient medical record of each potential study candidate was screened carefully for eligibility by both the trained coordinator and interviewer, who were registered nurses experienced in cerebrovascular disorders. Ineligibility criteria included dementia, severe disability, and terminal illness. Verbal consent for the home interview was given by telephone within 1 week of receipt of an explanatory letter that detailed the components of the study. Written consent for clinic blood pressure testing was obtained at the home interview.

The medical records for all participants were abstracted by an experienced nurse abstractor who used standardized data collection forms. The records of a randomly selected 20% sample of eligible nonparticipants were also reviewed to determine comparability between the participants and nonparticipants. Data regarding the diagnosis of hypertension and cardiac and cerebrovascular conditions documented up to the time of participation in the SPARC study were collected and used in the analyses of comorbid conditions.

Home Interview

Each home interview was conducted by the nurse coordinator or the nurse interviewer, both of whom had completed a prerequisite training program in general interviewing techniques, administration of the home questionnaire, and measurement of blood pressure with both a standard mercury column and a random-zero sphygmomanometer.[12,13]

The detailed interview documented the presence of medical disorders, including hypertension, diabetes, and cardiovascular disease; previous history of stroke or transient ischemic attacks; medication use; smoking history; alcohol consumption; and recent caffeine intake.

Home Blood Pressure Measurement

During the home visit, a total of 6 blood pressure measurements were recorded: 2 before (1 standard mercury and 1 random-zero) and 4 after (2 standard mercury and 2 random-zero) the interview. The subject was seated in a chair with a back support. Smoking was avoided before and during the measurement. An appropriate-sized cuff was used, and the blood pressure instrument was positioned on a flat surface at the approximate level of the heart. Because the Hawksley random-zero sphygmomanometer causes more arm compression, the standard mercury readings were obtained first, both before and after the interview. Initially, both left and right arm pressures were measured; the higher systolic reading was documented as the first standard mercury measurement. The arm with the higher pressure was used for all subsequent measurements. If the systolic readings were equal bilaterally, the arm with the higher diastolic pressure was used for all remaining blood pressure measurements. For all readings, Korotkoff phases 1 and 5 established the levels of systolic and diastolic pressures, respectively.

Office Blood Pressure Measurement

Each study subject had blood pressure measured by a study technician in the office setting on 2 consecutive days. After the patient had rested for 5 minutes in the supine position, parallel sets of 6 blood pressure readings were obtained with a mercury sphygmomanometer in the following order: 2 supine, 2 sitting, and 2 standing. One to 2 minutes elapsed between each blood pressure reading in each position. Another set of parallel blood pressure readings, as described above, was obtained the next day.

Definitions of Hypertension and Blood Pressure Levels

For age-adjusted prevalence estimates, blood pressure levels were determined by averaging the last 2 random-zero measurements obtained at the home visit to allow for comparison of trends between 1986 and 1996. Estimates of awareness, treatment, and control among hypertensive subjects were obtained as follows: (1) The average of 6 readings (2 home measurements and 4 office measurements made in the sitting position) was applied to the JNC V criteria for hypertension, which corresponded closely to the NHANES III, phase I method. (2) The average of the last 2 random-zero readings obtained at the home visit was applied to the JNC V. (3) Diagnosis and treatment information were obtained at the home interview from responses to the following questions: a. Has a doctor ever told you that you had high blood pressure or hypertension? b. Are you currently taking any medications for blood pressure? The responses to these questions were recorded as "yes," "no," or "do not know." Women who reported an increase in blood pressure only during pregnancy were not considered to have hypertension.

Uncontrolled hypertension was defined as either a measured systolic blood pressure of $\geq$140 mm Hg or a diastolic blood pressure of $\geq$90 mm Hg. Controlled hypertension was defined as a reading $<$140/90 mm Hg in subjects with a reported history of hypertension or who took antihypertensive medications. Aware subjects with hypertension were defined as those who answered affirmatively to question 3a. Unaware subjects with hypertension were defined as those answering negatively to question 3a but whose blood pressure readings met the criteria for hypertension. Treatment for hypertension was defined as an affirmative answer to question 3b and confirmation by a review of the subject's medications.

Statistical Analysis

Prevalences of hypertension and other medical conditions in the population were estimated[14] with their corresponding SEs by use of SUDAAN[15] software to adjust properly for the different sampling fractions within strata. Multiple linear regression[16] was used to compare blood pressure levels between 1986 and 1996, and adjustments for differences in comorbidity and confounding variables were made. The 2-sample χ^2 test was used to compare percentages of participants and refusers with various medical conditions.[14,17]

Results

Cohort Description

The REP diagnostic indexing system was used to enumerate Olmsted County residents $\geq$45 years old. The population was 94% white, 4% Asian or Pacific Islander, 1% black, and 1% from other races or ethnic groups.

During the 2-year period from June 20, 1993, to August 10, 1995, 636 subjects (51%) were recruited from a random sample of 1245 eligible residents and participated in the home interview and blood pressure measurement. Office blood pressure measurements were performed in 598 subjects; 38 dropped out of the study after the home interview.

Of the 230 ineligible subjects, 86 (37%) were excluded because of terminal illness, 70 (30%) because of dementia, 39 (17%) because of functional disability, and 35 (15%) because of esophageal disease that precluded transesophageal echocardiography, which was performed for another part of this study.

A comparison of 15 comorbid conditions, as well as age and gender, between participants and a random sample (20%) of the 609 eligible nonparticipants demonstrated no significant differences, thus confirming that participants were a representative sample of the population (Table).

Comparison of Participants and Refusers: Comorbid Conditions, Gender, and Age

	Participants*		Refusers†		
Factor	No.	%	No.	%	*P* Value‡
Condition					
Hypertension	216	35.6	56	38.9	0.47
Transient ischemic attack	17	2.8	3	2.1	0.63
Cerebral infarction	21	3.5	5	3.5	1.00
Intracerebral hemorrhage	1	0.2	1	0.7	0.27
Subarachnoid hemorrhage	1	0.2	0	0	0.63
Cardiac failure	26	4.3	6	4.2	0.95
Myocardial infarction	49	8.1	7	4.9	0.19
Mitral valve disease	26	4.3	4	2.8	0.40
Aortic valve disease	126	20.8	38	26.4	0.14
Aortic stenosis	10	1.6	2	1.4	0.82
Left ventricular hypertrophy	86	14.2	18	12.5	0.60
Dilated cardiomyopathy	2	0.3	0	0	0.49
Atrial fibrillation/flutter	44	7.3	12	8.3	0.66
Diabetes	58	9.6	7	4.9	0.07
Angina pectoris	102	16.8	12	8.3	0.01
Gender					
Men	302	49.8	64	44.1	0.22
Women	304	50.2	81	55.9	
Age, y (mean±SD)					
Men	302	65.8±13.3	64	67.1±14.4	0.59
Women	304	65.6±13.5	81	69.0±14.1	0.06
Overall	606	65.7±13.4	145	68.2±14.2	0.07

*Identified by abstraction of the medical records of 606 of the 636 participants.
†Identified from 145 refusers.
‡A *P* value of 0.003 is considered significant at the 0.05 level because of multiple comparisons.

Home and Office Blood Pressure

Figure 1 shows age-specific systolic and diastolic blood pressures in men and women. Mean blood pressures (±SD) were 138/80±20/12 mm Hg for men and 137/76±23/11 mm Hg for women. The prevalence of hypertension by home readings alone was 43±2%. When the 4 office and 2 standard mercury home readings were averaged, the prevalence of hypertension remained nearly constant at 41±2%. When the subjects' perception of their hypertension status was included with the observed readings at home and office,

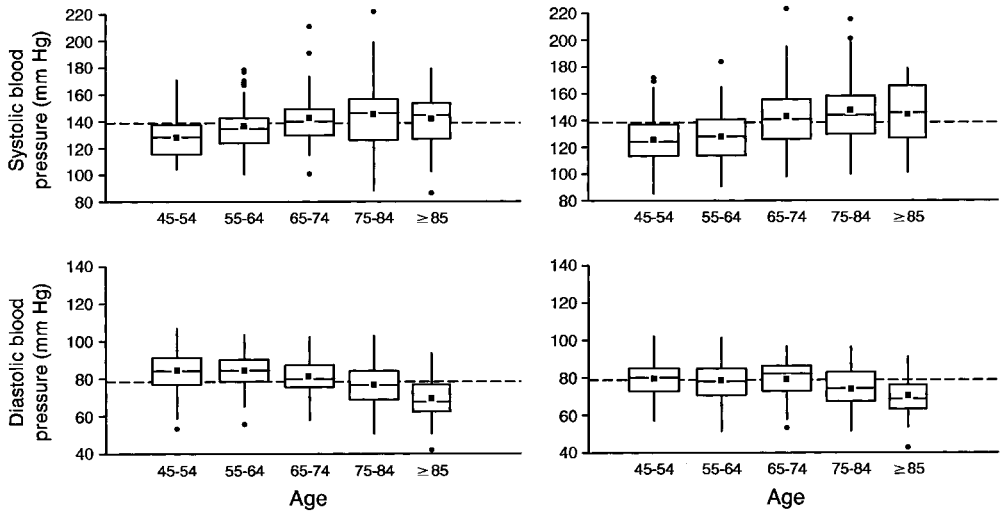

Figure 1. Age-specific systolic and diastolic blood pressure distributions in men (left) and women (right), with the average of the last 2 random-zero readings from the home visit. The dotted horizontal line indicates overall mean blood pressures.

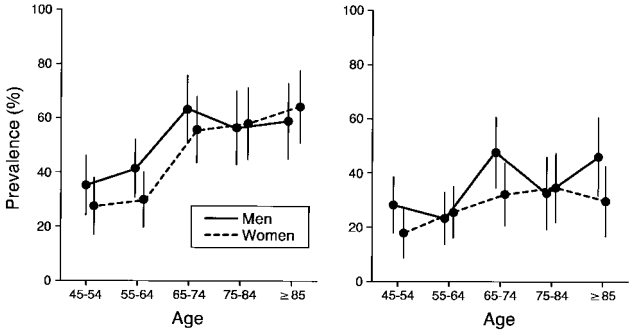

Figure 2. Left, Age-specific prevalences of uncontrolled hypertension by JNC V criteria (≥140/90 mm Hg) in men and women. Right, Age-specific prevalences of stage 1 hypertension by JNC V criteria (140/90 to 159/99 mm Hg).

the overall prevalence of hypertension became 53±2% and 54±2%, respectively. Figure 2 (left) shows the age-specific prevalences of uncontrolled hypertension. The prevalence of stage 1 hypertension (defined as a reading of 140/90 to 159/99 mm Hg) is shown in Figure 2 (right).

Figure 3 shows awareness, treatment, and control among the hypertensive subjects. The percentage of subjects with treated and controlled hypertension was 16.6%. The proportion of subjects who had treated but uncontrolled hypertension was 27.9%. Thirty-nine percent of subjects were unaware of their hypertensive status. These proportions were calculated with the JNC V recommendation of averaging 2 standard mercury blood pressure measurements, which were obtained when the subject was seated at each of the 3 different visits (1 home and 2 office), and they were essentially identical to those obtained with the random-zero measurements at 1 visit alone.

Discussion

This study illustrates a disturbingly low awareness and control of hypertension in a community that is socioeconomically prosperous, with easy access to both primary and tertiary medical care.

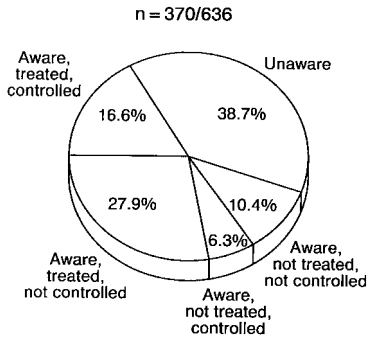

Figure 3. Awareness of hypertension and its treatment and control (expressed as percentages), according to JNC V criteria (≥140/90 mm Hg). Hypertension was a blood pressure of ≥140/90 mm Hg or a subject-reported history of hypertension; treatment was a subject-reported use of antihypertensive medication; control was a blood pressure of <140/90 mm Hg in subjects with a reported history of hypertension; and awareness was a subject-reported history of hypertension.

The method used in this study to estimate awareness, treatment, and control rates of hypertension was very similar to that used in NHANES III, phase I. The national trend toward leveling off of blood pressure awareness and control that was observed between NHANES III, phase I and NHANES III, phase II is supported by the data from this community study. Figure 4 compares the awareness, treatment, and control of blood pressure between the present study and NHANES III, phase I, focusing on the cohort of white, non-Hispanic subjects ≥50 years old, and suggests decreased awareness and control in most categories in Olmsted County, Minn. Although no single community is completely representative of the nation as a whole, the results are consistent with comparisons of previous population-based studies of various chronic diseases in Rochester, Minnesota, and with those of other communities in the United States. With the exception of a higher proportion of the working population employed in the healthcare industry (24% versus 8% nationally) and corresponding higher educational levels, which should tend to mitigate the observed trends, the demographic characteristics of Olmsted County residents resemble those of the US white population.[11]

The results of this study were compared with the results from a 1986 Rochester, Minn, survey that used identical blood pressure collection techniques in a randomly selected sample. Compared with the 1986 survey, the mean systolic blood pressure is 6.6 mm Hg higher and the mean diastolic blood pressure is 3.6 mm Hg higher in the present study. These differences represent a 4.9% higher systolic blood pressure and a 5.0% higher diastolic blood pressure. In the present study, fewer subjects were aware that they had high blood pressure, and fewer subjects had their blood pressure controlled with treatment than in 1986. These differences are consistent for both genders, all ages, and all blood pressures. Systolic and diastolic pressures are significantly higher in the present study than in 1986, even after adjustment for differences in comorbidity and confounding variables, including age, sex, body mass index, cigarette smoking, ischemic heart disease, congestive heart failure, and aortic regurgitation ($P=0.001$). Evidence demonstrates that population demographics in Olmsted County, Minnesota, have not changed significantly during the past decade.[18]

These disconcerting findings of increasing hypertension and decreasing awareness and control of hypertension are supported by data from the Minnesota Heart Survey, which reported a decline in the proportion of hypertensive men who were aware of their hypertension, treated, and controlled, from 66% (1980 to 1982) to 61% (1990 to 1992) and a similar decline in women from 77% (1985 to 1989) to 73% (1990 to 1992).[19]

An Iowa population-based cohort reported an increase in the prevalence of increased systolic pressure during the 1980s.[20] In contrast, data regarding community blood pressure levels on the East Coast revealed an overall decrease in the prevalence of systolic hypertension.[20] Both studies defined hypertension by the criteria of the World Health Organization (≥160/95 mm Hg).[20] Substitution of the JNC V criteria for hypertension (≥140/90 mm Hg) would attenuate these reported differences. The reasons for the apparent

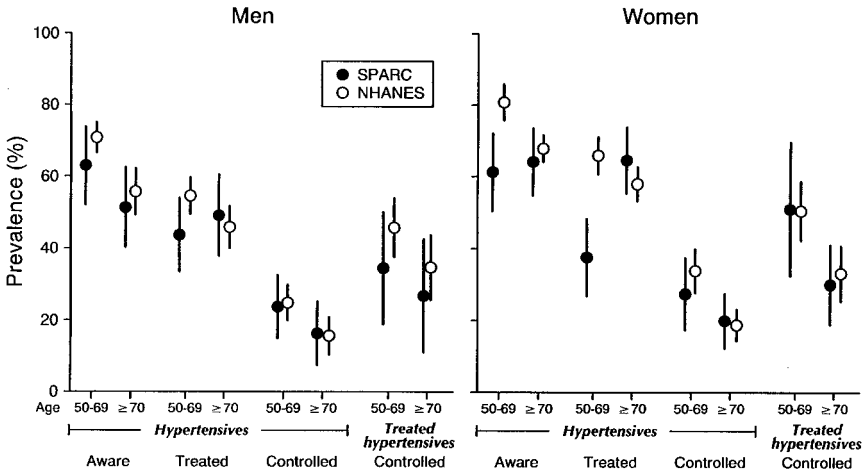

Figure 4. Awareness, treatment, and control of blood pressure among white, non-Hispanic subjects ≥50 years old in 2 studies: SPARC and NHANES III.

geographic differences are unclear; changing demographics and baseline health may have had an impact on the degree of detection and the aggressiveness of treatment.

A retrospective blood pressure study that involved a Portland, Ore–based cohort >65 years of age revealed that although the proportion of subjects with treated hypertension increased dramatically during the 1980s, the proportion of subjects with persistent uncontrolled hypertension at the beginning of the 1990s approached 70%.[21]

Data conflict in regard to the accuracy and reliability of the random-zero Hawksley sphygmomanometer.[22,23] In this study, comparison of standard mercury and random-zero measurements showed a negligible methodological difference of 0.8±7.0 mm Hg systolic and 0.5±4.9 mm Hg diastolic. The use of the average of the 2 after-interview random-zero measurements as the summary home measurements provided comparability with the 1986 survey and eliminated the selection effect of use of the arm with the initially higher standard reading and the before-interview potential blood pressure increase. This was done specifically to address the issue of "regression to the mean" that could lead to initial spurious high blood pressure readings. These data suggest that if used properly, random-zero measurements are accurate and comparable to values obtained with standard column sphygmomanometry, but they do not provide an advantage.

This study demonstrates that at the community level, rates of awareness and control of hypertension are suboptimal. The results of this survey confirm recent national data that demonstrate a decline in awareness, treatment, and control rates for hypertension. The explanation for this decline is not readily apparent from our study but is an important subject for future clinical research. Understanding the causes is a necessary first step toward reversing these unfavorable trends. Several potential questions could be explored. What is the contribution of complacency by healthcare providers and the public? Has there been a reduction at the community level in programs for blood pressure awareness and control in favor of other health issues? What is the impact of the high cost of contemporary therapies on control and long-term compliance with therapy? Have healthcare providers accepted the need to treat isolated systolic hypertension in the elderly? What is the effect of managed care? These questions and others need to be answered if progress is to be made in the prevention of stroke and cardiovascular disease. With the overall increasingly prolonged survival of the elderly population, continued efforts are necessary to clarify the definition of hypertension, identify prognostic indicators for target organ damage, and heighten community awareness of the risks of increased blood pressure across the spectrum of severity.

Acknowledgments

This study was supported in part by grants NS-06663 and AR-30582 from the National Institutes of Health, Public Health Service. We are indebted to Lori A. Reese for her enthusiastic assistance with patient recruitment; Elizabeth E. Worrall, Tanya M. Petterson, and Teresa J.H. Christianson for their assistance with analysis; Connie Bissen for excellent technical assistance; and Deborah M. Pluth for her efforts in typing the manuscript.

References

1. American Heart Association. Cited by Sacco RL, ed. New approaches to the treatment of ischemic stroke, part I: ischemic stroke: a disease update. *Am J Med*. Continuing Education Series. Excerpta Medica. 1996:3–9.
2. Burt VL, Cutler JA, Higgins M, Horan MJ, Labarthe D, Whelton P, Brown C, Roccella EJ. Trends in the prevalence, awareness, treatment, and control of hypertension in the adult US population: data from the Health Examination Surveys, 1960 to 1991. *Hypertension*. 1995;26: 60–69.
3. Burt VL, Whelton P, Roccella EJ, Brown C, Cutler JA, Higgins M, Horan MJ, Labarthe D. Prevalence of hypertension in the US adult population: results from the Third National Health and Nutrition Examination Survey, 1988–1991. *Hypertension*. 1995;25:305–313.
4. Joint National Committee on Detection, Evaluation, and Treatment of High Blood Pressure. The fifth report of the Joint National Committee on Detection, Evaluation, and Treatment of High Blood Pressure. *Arch Intern Med*. 1993;153:154–183.
5. Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. The sixth report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure. *Arch Intern Med*. 1997;157:2413–2446.
6. Garraway WM, Whisnant JP, Furlan AJ, Phillips LH II, Kurland LT, O'Fallon WM. The declining incidence of stroke. *N Engl J Med*. 1979; 300:449–452.
7. Garraway WM, Whisnant JP. The changing pattern of hypertension and the declining incidence of stroke. *JAMA*. 1987;258:214–217.
8. Homer D, Whisnant JP, Schoenberg BS. Trends in the incidence rates of stroke in Rochester, Minnesota, since 1935. *Ann Neurol*. 1987;22: 245–251.
9. Broderick JP, Phillips SJ, Whisnant JP, O'Fallon WM, Bergstralh EJ. Incidence rates of stroke in the eighties: the end of the decline in stroke? *Stroke*. 1989;20:577–582.

10. Whisnant JP, Melton LJ III, Davis PH, O'Fallon WM, Nishimaru K, Schoenberg BS. Comparison of case ascertainment by medical record linkage and cohort follow-up to determine incidence rates for transient ischemic attacks and stroke. *J Clin Epidemiol*. 1990;43:791–797.
11. Melton LJ III. History of the Rochester Epidemiology Project. *Mayo Clin Proc*. 1996;71:266–274.
12. Wright BM, Dore CF. A random-zero sphygmomanometer. *Lancet*. 1970; 1:337–338.
13. Parker D, Liu K, Dyer AR, Giumetti D, Liao YL, Stamler J. A comparison of the random-zero and standard mercury sphygmomanometers. *Hypertension*. 1988;11:269–272.
14. Cochran WG. *Sampling Techniques*. 3rd ed. New York, NY: John Wiley & Sons; 1977.
15. Shah BV, Barnwell BG, Bieler GS. *SUDAAN Users Manual, Release 7.0*. Research Triangle Park, NC: Research Triangle Institute; 1996.
16. Weisberg S. *Applied Linear Regression*. 2nd ed. New York, NY: John Wiley & Sons; 1985.
17. Bishop YMM, Fienberg SE, Holland PW. *Discrete Multivariate Analysis: Theory and Practice*. Cambridge, Mass: MIT Press; 1975.
18. Starsinic DE, Forstall RL. *Patterns of Metropolitan Area and County Population Growth: 1980 to 1987*. Washington, DC: US Department of Commerce, Bureau of the Census; 1989. No. 1039, Series P-25.
19. Luepker RV, McGovern PG, Sprafka JM, Shahar E, Doliszny KM, Blackburn H. Unfavorable trends in the detection and treatment of hypertension: The Minnesota Heart Survey. *Circulation*. 1995;91:938. Abstract.
20. Glynn RJ, Brock DB, Harris T, Havlik RJ, Chrischilles EA, Ostfeld AM, Taylor JO, Hennekens CH. Use of antihypertensive drugs and trends in blood pressure in the elderly. *Arch Intern Med*. 1995;155:1855–1860.
21. Barker WH, Mullooly JP, Linton KL. Trends in hypertension prevalence, treatment, and control in a well-defined older population. *Hypertension*. 1998;31:552–559.
22. Conroy RM, O'Brien E, O'Malley K, Atkins N. Measurement error in the Hawksley random zero sphygmomanometer: what damage has been done and what can we learn? *BMJ*. 1993;306:1319–1322.
23. Garrow J, Summerbell C. The Hawksley random zero sphygmomanometer: repeat experiment exonerates instrument. *BMJ*. 1993;307:123. Letter.