Title
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Journal
JAMA Internal Medicine, 149(4)

ISSN
2168-6106

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Publication Date
1989-04-01

DOI
10.1001/archinte.149.4.780

Peer reviewed

Race and Sex Differentials in the Impact of Hypertension in the United States

The National Health and Nutrition Examination Survey I Epidemiologic Follow-up Study

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• Hypertension was evaluated longitudinally in a nationally representative sample of the US population. This study, based on the data from the National Health and Nutrition Examination Survey NHANES I Epidemiologic Follow-up Study, analyzed changes in blood pressure and frequency of treatment, hypertension incidence, and ten-year survival of the cohort relative to hypertension status at baseline. Higher prevalence rates for each older age group, especially in women, as previously reported on data from community studies were confirmed. However, this analysis found minimal differences in the incidence of hypertension between men and women for all age groups. Incidence rates for blacks were at least twice the rates for whites for almost every age-sex group. Decreased survival in older hypertensive men probably explained the higher prevalence in older women. Treatment and location of measurement in clinic or household must be major considerations in the calculation of incident cases.

(*Arch Intern Med* 1989;149:780-788)

Epidemiologic studies of community populations have estimated the prevalence of hypertension, have identified risk factors for hypertension, and have described the relationship of hypertension to mortality, specifically from cerebrovascular disease, coronary heart disease, and kidney failure. Clinical trials have evaluated the impact of treatment on controlling hypertension and reducing mortality.[1] Few studies have estimated incidence, and even fewer have studied racial differences.[2] This analysis of the National Health and Nutrition Examination Survey I (NHANES I) Epidemiologic Follow-up Study (NHEFS) data broadens the spectrum and provides an insight into the extent of the health problem from hypertension in the US population in terms of morbidity and mortality. This study not only provides estimates of the prevalence and incidence of hypertension by age, race, and sex but also clarifies the difference in the prevalence vs incidence rates for the specific age, race, and sex group. Treatment and prevention have been based primarily on prevalence rates. The addition of this knowledge to other well-reported epidemiologic investigations should improve the focus for implementation of prevention and treatment of hypertension for the nation.

The specific purposes of this report are to describe the distributions of systolic and diastolic blood pressure in the US population at two points in time, to describe incidence rates of hypertension, and to present the relationship of the baseline distribution to mortality. In addition, the uniqueness of these NHEFS data in providing long-term follow-up of a national sample has permitted an investigation of the existence of blood pressure tracking. Finally, because of different methods employed within this longitudinal data set, evaluation of measurements of blood pressure taken at different locations, that is, home and clinic settings, is presented.

Accepted for publication Oct 26, 1988.

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STUDY POPULATIONS AND METHODS

Study Population

The NHEFS included 14 407 participants from the 1971 to 1975 NHANES I who, at the time of the original survey, were 25 to 74 years of age and at follow-up were 35 to 86 years of age. For this study, 12 036 white persons and 2199 black persons from the NHANES I sample were included. Persons of other race groups were excluded because of a lack of adequate numbers for analysis.

The NHANES I, a representative sample of the civilian noninstitutionalized US population, included a medical history, standardized medical examination, dietary history, laboratory tests, and anthropometric measures. The NHEFS was initiated to investigate the relationship of the baseline physiologic, nutritional, social, psychological, and demographic factors to subsequent morbidity or mortality from diseases and conditions. Ninety-three percent of the original cohort was traced. Of those traced, interviews were completed for 93% of those who survived and 84% of those who died. The NHEFS interview included questions on health conditions as well as sections on nutrition, related health behavior, specific medications, and socioeconomic characteristics. Three consecutive blood pressure readings, pulse rate, and weight were included. Information from hospital records for episodes

Table 1.—Prevalence Rates of Hypertension by [illegible], Age, Race, and Sex at Baseline

Sex, Race, and Age, y	No. of Persons	Rate per 100: Normal	Hypertension: Borderline	Isolated	Definite	Treated
White, men						
25-34	963	74.1	16.6	0.2	8.5	0.5
35-44	799	61.8	19.2	0.2	16.2	2.6
45-54	892	46.3	25.8	1.0	20.1	6.8
55-64	740	38.4	25.7	2.0	21.0	13.1
65+	1496	32.2	25.3	6.7	19.4	16.4
White, women						
25-34	1967	87.5	8.0	0.2	3.5	0.8
35-44	1608	76.1	2.9	0.2	7.2	3.6
45-54	1042	56.3	18.9	1.4	13.7	9.6
55-64	816	37.8	23.9	3.2	16.9	18.3
65+	1673	22.7	23.1	7.1	19.1	28.0
Black, men						
25-34	139	67.6	18.7	0.0	13.0	0.7
35-44	107	44.9	14.0	0.0	36.4	4.7
45-54	152	38.2	18.4	0.7	31.6	11.2
55-64	106	26.4	21.7	2.8	33.0	16.0
65+	312	21.2	21.2	6.1	29.8	21.8
Black, women						
25-34	367	72.8	13.9	0.3	9.5	3.5
35-44	362	49.2	18.5	1.4	20.7	10.2
45-54	165	33.3	14.6	1.8	31.5	18.8
55-64	138	20.3	16.7	4.4	29.7	29.0
65+	329	12.8	16.1	11.6	28.6	31.0

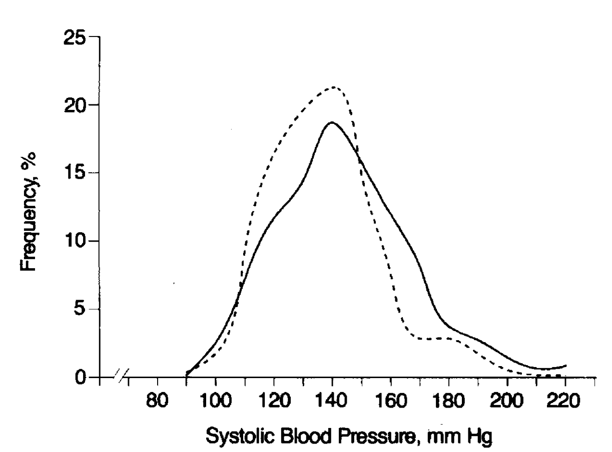

Fig 1.—Smoothed frequency distributions of first systolic blood pressure for white men aged 65 to 74 years at baseline (solid line) (National Health and Nutrition Examination Survey [NHANES I]) and follow-up (broken line) study (National Health Epidemiologic Follow-up Study [NHEFS]).

identified on the household interview were obtained to supplement the medical history. Death certificates, hospital records, and a proxy interview for the NHANES I participants who died in the approximately ten-year period between the two surveys were also obtained. The average length of follow-up on participants who were alive was 9.5 years, with a range of five to 12 years. Sixty-seven percent had eight to ten years of follow-up, 7% had less than eight years of follow-up, and 26% had between 11 and 12 years of follow-up.[3,4]

Methods

For the NHANES I, blood pressure was measured at the time of the physical examination in the mobile examination center. The blood pressure was measured by a physician with a standard sphygmomanometer on the right arm using the bell of the stethoscope with the subject seated. The measurement was performed at the beginning of the examination. Disappearance of sound was used for the determination of diastolic blood pressure. Only one blood pressure measurement was available for all participants of the NHANES I.[5]

For the NHEFS, blood pressure was measured at the time of the household interview. Blood pressure was measured three times by a specially trained interviewer with a standard sphygmomanometer and the appropriate-sized cuff. The methods of determination were the same as those defined for NHANES I.

For comparability to the baseline blood pressure measurement, the first of the three blood pressure measurements was used in these analyses. Hypertension was classified in three mutually exclusive categories: normal, borderline, and definite. Persons with isolated elevated systolic blood pressure and persons taking treatment for hypertension were considered separately for some analysis. Normal was defined as a systolic blood pressure of less than 140 mm Hg and a diastolic blood pressure of less than 90 mm Hg; borderline hypertension, as systolic blood pressure equal to or greater than 140 mm Hg but less than 160 mm Hg and/or diastolic blood pressure greater than or equal to 90 mm Hg but less than 95 mm Hg; and definite hypertension, as systolic pressure equal to or greater than 160 mm Hg and/or diastolic pressure equal to or greater than 95 mm Hg. Isolated systolic hypertension refers to systolic blood pressure equal to or greater than 160 mm Hg and diastolic pressure less than 90 mm Hg.

Treated hypertension was defined as hypertension in a patient currently taking antihypertension medications. The determination

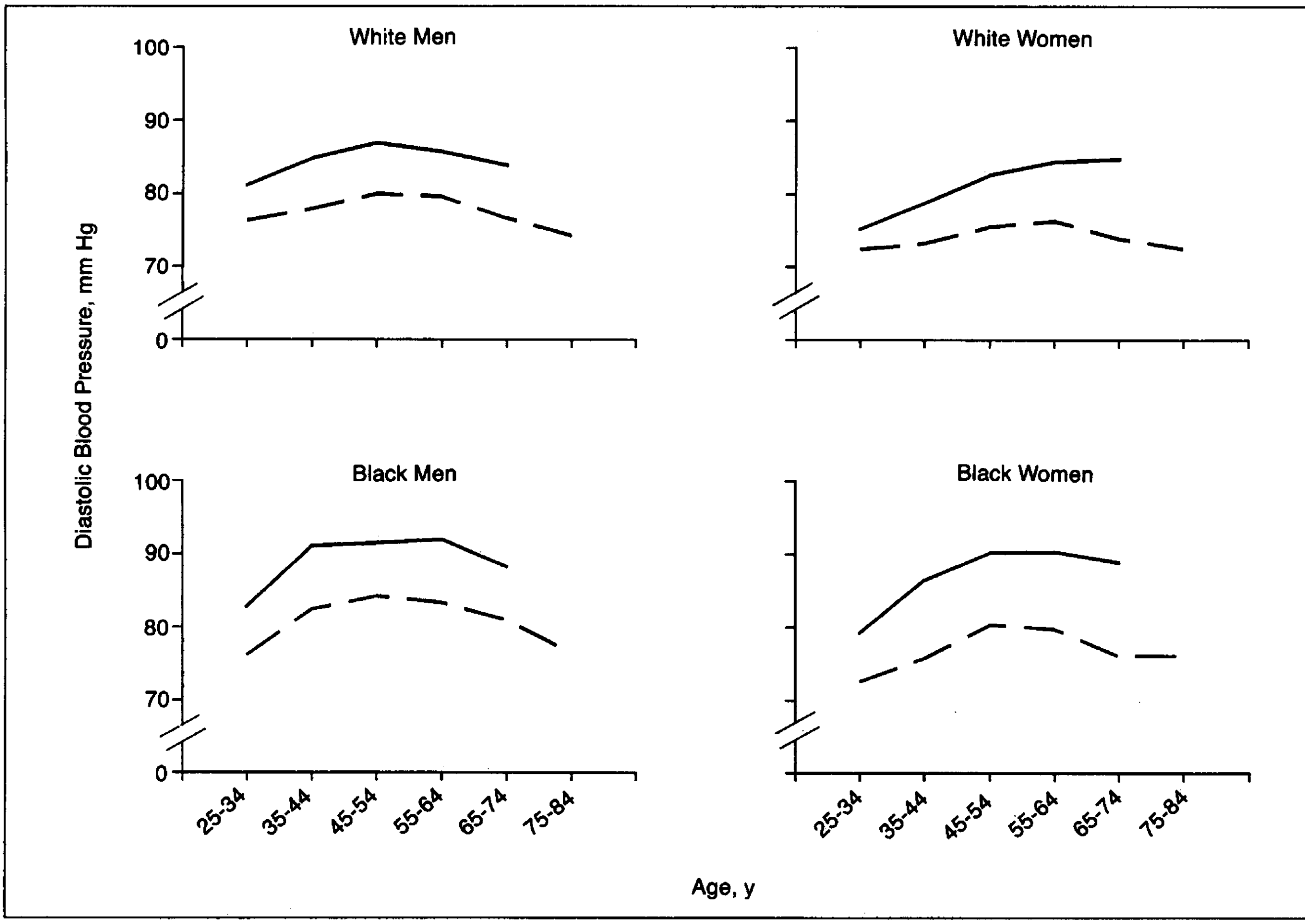

Fig 2.—Mean diastolic blood pressure by sex, race, and ten-year age intervals at baseline (solid lines) (National Health and Nutrition Examination Survey [NHANES I]) (1971 through 1975) and follow-up (broken lines) (National Health Epidemiologic Follow-up Study [NHEFS]) (1982 through 1984).

of treatment for elevated blood pressure was made from the participant's response to interview questions. In NHANES I, individuals in the nutrition subsample (about 50%) were asked about any medications taken for hypertension or high blood pressure within the previous six months. Participants in the detailed medical sample were asked about current use of medications. In the NHEFS, the question was limited to current use of blood pressure–lowering drugs.[6]

Analytic Procedures

Analytic strategies were developed to examine cross-sectional and longitudinal change in blood pressure and prevalence of hypertension between the two measurements in 1971 to 1975 and 1982 to 1984, as well as survival associated with baseline blood pressure during this interval. Secular change in the distributions of blood pressure at each time point, as well as the influence of the location of measurement (clinic vs household) were investigated by comparing means, medians, and various percentiles of blood pressure taken at baseline and follow-up for race, sex, and age groups.

Longitudinal change in blood pressure was examined in two ways. Incidence rates of borderline, isolated systolic, plus definite and treated hypertension were examined among people with normal blood pressure readings at the baseline. The concept of "tracking" of individual blood pressures over time in a defined population was examined by constructing race-, sex-, and age-specific quintiles of blood pressure at the baseline and follow-up examinations among persons who were not taking antihypertensive medication at either time point. The proportion of persons remaining in the same quintile over time was compared with the proportions shifting into the other four quintiles. Such an analysis is also influenced by, and must be interpreted in the light of, regression to the mean.

Among subjects aged 50 years and older, survival probabilities associated with level of baseline blood pressure (normal, borderline hypertension, and isolated systolic plus definite plus treated hypertension) were calculated with differential follow-up time taken into account by means of the Kaplan-Meier method.[7] The statistical significance of differences in survival between categories of baseline blood pressure was examined with a log-rank test.[8]

Persons with hypertension (borderline, definite, or isolated systolic) defined according to the criteria stated above and persons receiving treatment for hypertension were excluded from the analyses of incidence of hypertension.

RESULTS

Prevalence of Hypertension

Figure 1 illustrates a comparison of the full frequency distribution of systolic blood pressure measurements at NHANES I and at the follow-up. Specifically, the distributions were based on all white men between the ages of 65 and 74 years at the time of each survey, regardless of treatment status. These distributions are presented here as an example. All other race-sex-age distributions showed similar characteristics. The distribution of blood pressure among the NHANES I participants had a greater variance, with higher percentages of persons with higher blood pressure than in the NHEFS distribution. The median and the mean values of the NHEFS distribution were lower than those of the NHANES I distribution, confirming the

Table 2.—Prevalence Rates of Hypertension by Traditional Categories, Age, Race, and Sex at Follow-up

Sex, Race, and Age, y	No. of Persons	Rate per 100: Normal	Hypertension: Borderline	Isolated	Definite	Treated
White, men						
25-34	72	83.3	9.7	0.0	4.2	2.8
35-44	678	79.2	9.1	0.0	4.6	7.1
45-54	644	62.1	14.9	0.2	6.1	16.8
55-64	698	46.1	19.2	1.9	6.6	26.2
65-75	522	39.1	19.4	4.0	4.6	33.0
75+	641	33.4	22.2	8.9	5.0	30.6
White, women						
25-34	70	92.9	4.3	0.0	0.0	2.9
35-44	1390	87.5	4.6	0.2	1.4	6.3
45-54	1308	70.8	9.7	0.2	2.5	16.8
55-64	879	49.7	12.6	2.0	3.5	32.1
65-75	632	35.1	14.6	4.8	3.0	42.6
75+	963	24.1	17.3	7.3	2.2	49.1
Black, men						
25-34	7	85.7	0.0	0.0	14.3	0.0
35-44	81	53.1	18.5	1.2	13.6	13.6
45-54	62	35.5	9.7	0.0	14.5	40.3
55-64	95	34.7	13.7	5.3	11.6	34.7
65-75	67	25.4	14.9	7.5	9.0	43.3
75+	107	23.4	18.7	7.5	5.6	44.9
Black, women						
25-34	6	100.0	0.0	0.0	0.0	0.0
35-44	229	65.5	9.6	0.0	2.2	22.7
45-54	263	44.1	12.2	1.9	5.3	36.5
55-64	136	32.4	11.0	3.7	8.1	44.8
65-75	109	18.4	16.5	2.8	3.7	58.7
75+	161	12.4	14.3	9.9	4.4	59.0

noticeably shifted distribution to the lower blood pressure values.

Prevalence rates of hypertension were studied cross-sectionally at baseline (1971 to 1975) and at the follow-up survey (1982 to 1984) according to the continuous interval scale of the blood pressure measurement summarized by means and according to the categories of normal, borderline, and definite hypertension. Also, persons with isolated systolic hypertension and those who reported that they were receiving treatment were considered separately for the analysis. It should be noted that total definite hypertension is the sum of the categories definite, isolated systolic, and treated hypertension. All analyses were conducted separately for race and sex.

The mean diastolic blood pressures by sex, race, and ten-year age intervals are presented in Fig 2. Persons reported to be receiving treatment for elevated blood pressure were not included in the means. Cross-sectionally, there was a rise in diastolic blood pressure with age to the age of 40 years for men and 50 years for women, followed by little change with age until a decline after age 65 years. The decline was more apparent in the NHEFS, since the cohort included an adequate number of persons in the sample through age 84 years. The mean diastolic blood pressure measurement for the NHEFS participants was approximately 8 mm Hg lower than that for the NHANES I sample, with a greater magnitude in the difference for black women. The mean systolic blood pressure by age, race, and sex showed the same cross-sectional differences between NHANES I and NHEFS as seen for diastolic blood pressure. The SD for the age-race-sex-specific baseline distributions of prevalence of hypertension were similar to previously published prevalence rates for the NHANES I data.[9]

Prevalence rates are presented categorically for normal, borderline hypertension, and definite hypertension for race, sex, and ten-year age intervals for the two time periods in Tables 1 and 2. The rates for persons with isolated systolic hypertension and for those who were taking treatment for hypertension were considered separately. As reported previously, there was a consistent decrease in the proportion of persons within the normal range of blood pressure, resulting in impressively low proportions for persons within the normal range who were 65 to 74 years of age (Table 1).[10] Only 32% of white men, 23% of white women, 21% of black men, and 13% of black women were within the normal range for this age group.

Data were available at the follow-up examination to study not only the age group 65 to 74 years but also persons aged 75 years and older. The proportions of persons aged 65 to 74 years within the normal range at follow-up were higher than those seen at baseline, but the proportions decreased for persons aged 75 years and older, with approximately one third of the white men, one quarter of the white women, one quarter of the black men, and 12% of the black women within the normal range. The decrease in the

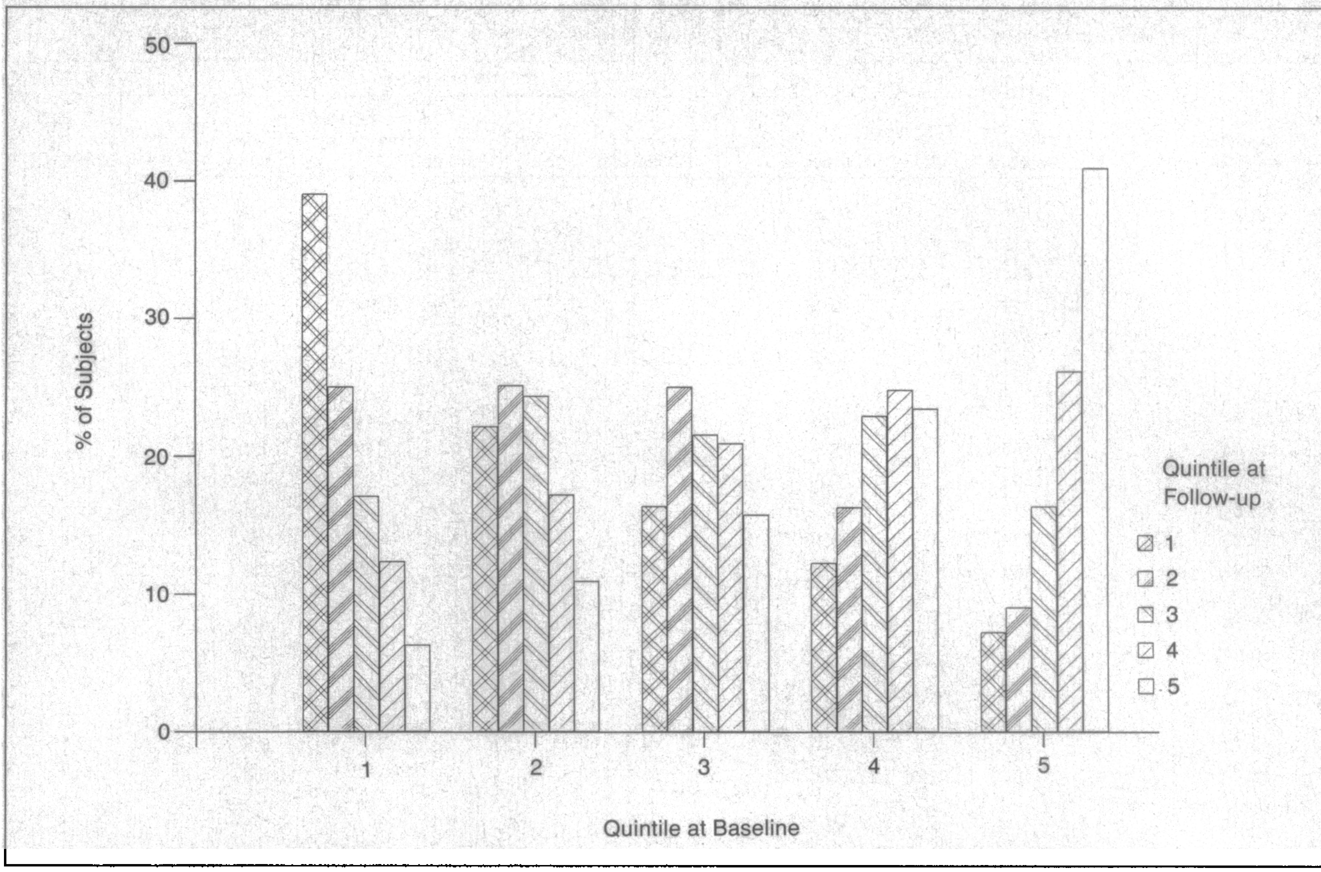

Fig 3.—Quintiles of systolic blood pressure distribution for white men at follow-up (National Health Epidemiologic Follow-up Study [NHEFS]) according to quintiles of distribution at baseline (National Health and Nutrition Examination Survey [NHANES I]).

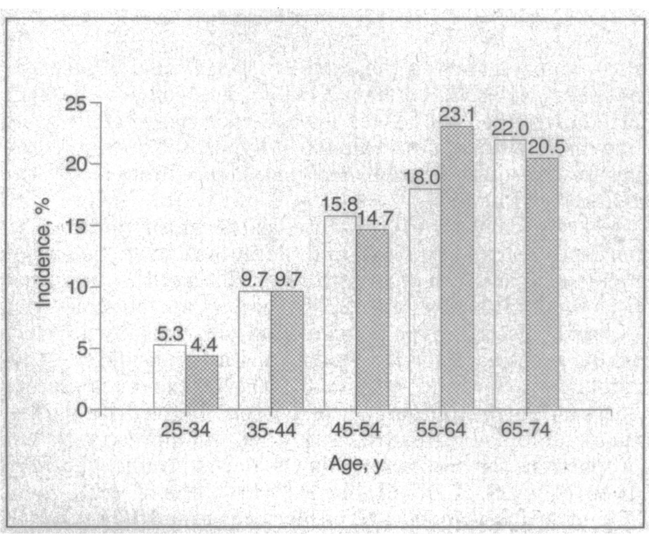

Fig 4.—Incidence rates of hypertension for white men (open bars) and women (cross-hatched bars) with average follow-up of 9.5 years (follow-up study National Health Epidemiologic Follow-up Study [NHEFS]).

[redacted]

Sex, Race, and Age, y	No. of Persons	% of Participants: Normal	Hypertension: Borderline	Hypertension: Definite
White, men				
25-34	548	88.1	6.6	5.3
35-54	725	73.2	14.3	12.4
55+	442	58.1	21.7	20.1
Total	**1715**	74.1	13.8	12.1
White, women				
25-34	1260	91.8	3.7	4.4
35-54	1486	78.5	10.2	11.3
55+	477	56.6	21.6	21.8
Total	**3223**	80.4	9.4	10.2
Black, men				
25-34	55	72.7	16.4	10.9
35-54	69	59.4	10.1	30.4
55+	48	54.2	18.8	27.1
Total	**172**	62.2	14.5	23.3
Black, women				
25-34	174	76.4	6.9	16.7
35-54	174	60.9	15.5	23.6
55+	39	56.4	5.1	38.5
Total	**387**	67.4	10.6	22.0

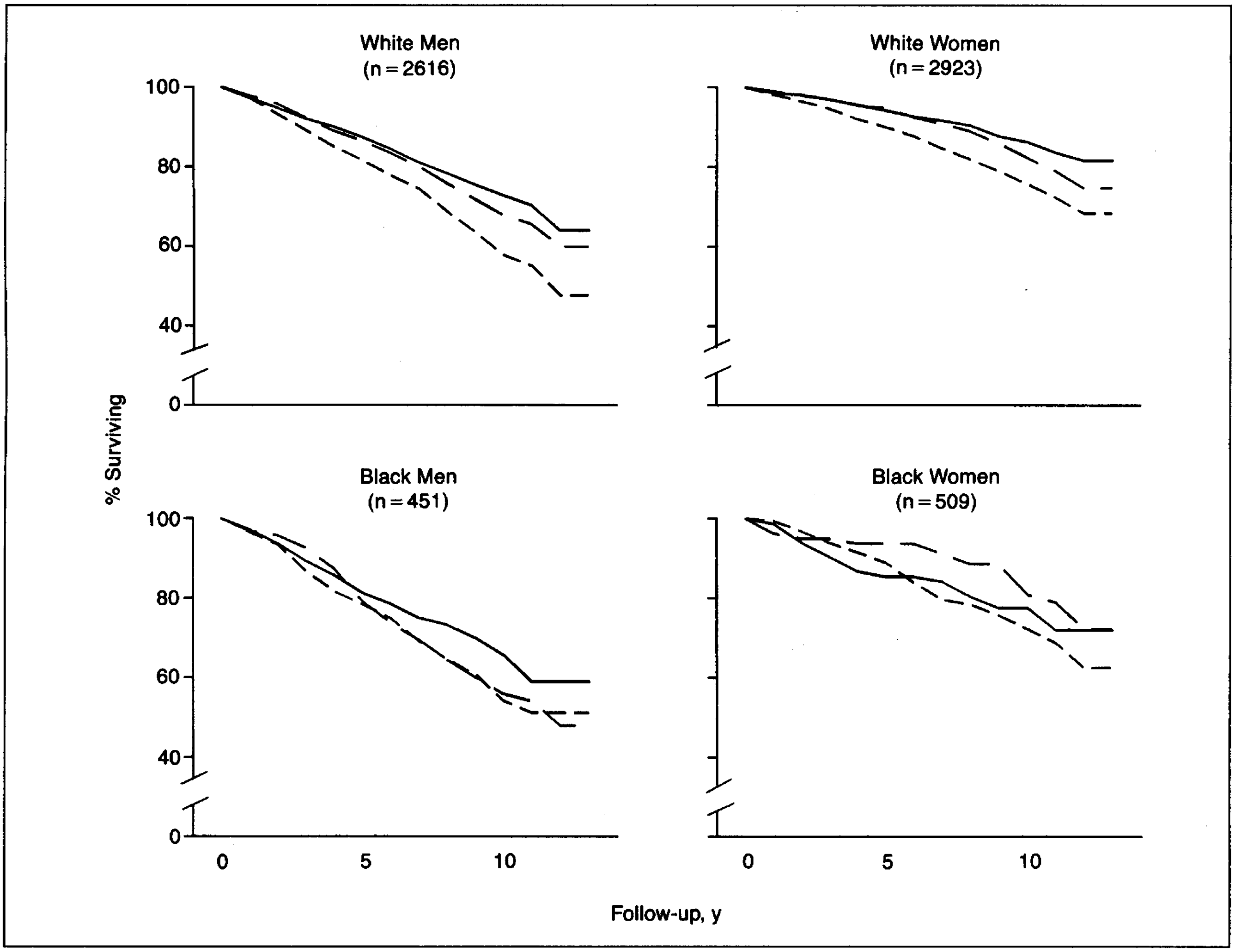

Fig 5.—Probability of survival according to blood pressure category (normal [solid line], borderline hypertension [long dashes], and definite hypertension [short dashes]) among persons aged 50 years and over (follow-up study [National Health Epidemiologic Follow-up Study (NHEFS)]).

proportion of persons in the normal range results in different patterns of increase in the other categories. At baseline (NHANES I), the borderline and definite categories increased with age to about age 55 years, but there was little change or a slight decline in the rates in the older age groups. The percentage treated increased consistently with age.

The impact of a larger number of persons being treated for hypertension was seen on prevalence rates at the time of the follow-up (NHEFS) (Table 2). For example, at baseline the prevalence of definite untreated hypertension for white men was 17% with 9% treated for hypertension, but at the NHEFS only 5% had untreated hypertension and 22% were receiving treatment for hypertension. For all race and sex groups, the prevalence rates of borderline hypertension at follow-up continued to increase from the younger to the older age groups, and, in conjunction with these trends, the rates for those persons receiving treatment increased considerably with age. Definite untreated hypertension was unrelated to age. In the interpretation of the prevalence rates, it should be noted that the clinical setting vs the household location of the measurement may influence these rates. Since the household measurement at the follow-up has been shown to be lower than the clinic measurement, some persons who may be classified as having definite hypertension at a clinic setting could be classified as borderline for a household measurement. Also, the rates may be influenced by selective survival, that is, those persons who have died may have had higher blood pressure than those who survived.

Although the number of persons diagnosed as having isolated systolic hypertension was small, the rate increased dramatically across age groups, approximately doubling at each ten-year age interval, for all the race and sex groups at both examinations.

Change in Blood Pressure

The proportions of persons in each quintile of the systolic blood pressure distribution at follow-up according to baseline quintile is shown for white men in Fig 3. About 40% of those persons whose baseline systolic blood pressures were in the lowest or highest quintile remained in the same quintile at follow-up. Adding in the proportion in the adjacent quintile, about two thirds of those in the two extreme quintiles at baseline were in the same or the immediately adjacent quintile at follow-up. The same proportion, about two thirds, of persons whose baseline systolic blood pressure was in the second, third, and fourth quintiles remained in the same or the two adjacent quintiles at follow-up. Only about 30% to 35% of white men had a follow-up blood pressure moving more than one quintile from their baseline position. Patterns similar to the one seen in Fig 3 were observed for the other race-sex groups, and for all race-sex groups when diastolic blood pressures were similarly considered. Thus, some tracking is clearly observable in these data despite the considerable methodologic limitations of this comparison, such as the use of a single casual blood pressure measurement at each time point, the lengthy and variable time interval between measurements (seven to 12 years), and the differing location of the blood pressure measurement at baseline (in the clinic) and at follow-up (in the home).

Incidence of Hypertension

Incidence rates for white men and women with an average follow-up of 9.5 years are presented in Fig 4. The rates for Fig 4 and for Table 3 are given according to the age of the participants at baseline (NHANES I). For white men and women, the incidence of definite hypertension increased approximately 5% for each ten-year interval of age. The rates for men and women were equal for all ages with the exception of the age group 55 to 64 years.

Table 3 presents the incidence rates of borderline and definite hypertension for the four race and sex groups and three age intervals. An increase in the incidence of hypertension with age for both borderline and definite hypertension, as seen in Fig 4, existed for all race and sex groups. As seen in Fig 4, the rates for white men and women were virtually the same. For white men there was a total incidence (definite and borderline) of 12% for those persons who were in the youngest age group (25 to 34 years) at baseline and 49% for those in the oldest age group (65 years and older) at baseline. For white women the incidence rates were 8% for those 25 to 34 years old and 47% for the oldest group.

Black participants had incidence rates at least twice those of the white participants. The age-adjusted relative risk comparing incidence rates for black men and white men was 1.95 (with 95% confidence interval of 1.45 to 2.62) and for black women compared with white women, 2.33 (with 95% confidence interval of 1.88 to 2.88). These differences were particularly large for the younger age groups. The total incidence rate for black women less than 35 years of age was 24% compared with 8% for white women. For men the rates were 28% for blacks and 12% for whites.

Survival Associated With Baseline Hypertension

The Kaplan-Meier survival curves for persons aged 50 years and older according to their baseline hypertension classification are shown in Fig 5 for each race-sex group. For this analysis, the definite hypertension category included subjects taking antihypertensive drugs and those with isolated systolic hypertension. Among white men and women, the proportion of persons surviving was highest among normotensive subjects at baseline, lowest among definite hypertensive subjects, and intermediate among those with borderline hypertension. Among men, the proportions surviving at 12 years were 64%, 60%, and 48% of normotensive, borderline hypertensive, and definite hypertensive subjects, respectively. The corresponding proportions for white women were 82%, 75%, and 68%. The differences between these curves were statistically significant with the use of a log-rank test for both sexes. Among black men and women, the proportion of persons surviving was lower among those with definite hypertension than among normotensive subjects (51% vs 59% for men and 63% vs 72% for women, respectively); however, the survival experience of the borderline hypertensive group differed for men and women. Among black men, those with borderline hypertension had a survival experience similar to that of subjects with definite hypertension, particularly after the fourth year of follow-up, leaving 48% alive by the end of follow-up. Among black women, the survival experience of the borderline group was more like that of the normotensive subjects than those with definite hypertension, with 72% remaining alive at the end of follow-up. The small sample size of black persons in the NHANES I baseline makes these comparisons less precise and, therefore, difficult to interpret. The survival curves were not significantly different between the hypertensive groups for black women or for black men.

COMMENT

Prevalence rates of hypertension have been the guide for determination of treatment and norms for the development of research and clinical trials. Most studies have reported higher prevalence rates for men than for women to the age of 45 years. At the age of 45 years the rates are similar, and there actually is a crossover resulting in women having higher rates than men beyond the age of 55 years. The same relationship was evident in the prevalence rates for the participants in the NHANES I and the NHEFS. But the age- and sex-specific incidence rates of hypertension from the follow-up study (NHEFS) did not exhibit the same relationship seen for the prevalence rates. There were minimal differences in the incidence rates of hypertension between men and women for all of the age groups studied. In the Framingham Offspring Study, eight-year incidence of hypertension was higher in men aged 20 to 39 years than in women of comparable ages. It is possible that excess incident cases do occur in men at younger ages and this results in a higher prevalence of hypertension in men than women until middle age. After that time, other factors, such as selective survival, may play a role in the female excess at older ages. This is evident in the better survival experience in women compared with men, regardless of hypertension status at baseline. However, the number of deaths at younger ages was inadequate to document the presence of a sex difference in this study.

Although few epidemiologic community studies of hypertension have included adequate numbers of black persons to produce stable estimates, those that have been completed consistently report a higher prevalence of hypertension among black persons than white, with black women having the highest rates.[11,12] The level of these rates and the magnitude of the race difference have been used as indicators of the level and race difference of the incidence of hypertension. Incidence rates of hypertension calculated from the NHEFS data emphasized dramatically what was implied in the previously reported prevalence rates. The incidence rates for blacks were at least twice the rates for whites for every age group. This impressive difference was true for both men and women. The only exception to this finding was for men aged 55 to 64 years, in whom the rates were slightly less than double. A 2:1 black-white ratio was evident in an incidence study of persons screened for the Hypertension Detection and Follow-up Study.

When the two examinations of the cohort were considered as separate cross-sectional estimates of hypertension prevalence at different points in time, comparable age-sex-race subgroups showed major differences in mean systolic blood pressure levels (Fig 1). These decreases in systolic blood pressure were consistent with similar trends seen among the three Health Examination Surveys over the period 1960 to 1980.[10] However, in the NHEFS the later diastolic blood pressures were also lower than at the previous survey. This decrease in blood pressure may have resulted from the confluence of three major factors. First, this may reflect the fact that the NHEFS cohort consisted of persons who were survivors from the original NHANES I examined sample. In fact, hypertension status at baseline was strongly related to mortality in the next ten years. Second, the frequency of treatment of individuals in the population was approximately two times higher in the later period than in the earlier one. For example, in white men aged 65 to 74 years at each of the surveys, the proportion of the total population being medicated for hypertension increased from about 15% to 30%. The highest percentage being treated was in black women, aged 65 to 74 years in 1982 to 1984, with almost 60% of the population being treated. This dramatic increase in treatment probably reflects the result of continued efforts by the High Blood Pressure Education Program and by individual physicians to identify and treat hypertensive patients.[13] Similar increases in treatment have been seen in regional studies.[14] The effect of treatment is likely to be one of the major reasons for the decrease in blood pressure.

Third, and more complicated to interpret, is the effect of the difference in methods used for measuring blood pressures in the two surveys. The home blood pressures obtained at the follow-up examinations resulted in a downward bias in blood pressure level when compared with the earlier blood pressures obtained in the Mobile Examination Center. When blood pressures in comparable age-sex-race subgroups not receiving medication at either examination were compared, there was a uniform decrease in blood pressure level (Fig 2). The absolute decreases were comparable for systolic and diastolic blood pressure, with some increase in differences at older ages. Blood pressure distributions for those aged 65 years and older found in the NHEFS were similar to the levels in the Iowa location of the Established Population for Epidemiologic Studies of the Elderly but lower than those found in East Boston and New Haven, Conn.[15] These studies were done contemporaneously with the NHEFS and used home blood pressures and similar measurement methods. Because of various factors, such as population selection and different treatment patterns, such variability is not unexpected.

Most studies suggest that home blood pressures are lower than clinic ones.[16,17] However, it appears that a precise quantification of expected home-clinic differences in population-based studies has not been made. There are some data from local studies. As part of the Pawtucket Heart Health Program, a random subsample of 133 subjects aged 25 to 64 years had blood pressures measured first in the home and subsequently in the clincic.[18] On preliminary analysis, the average systolic blood pressure was 1.6 mm Hg lower and the diastolic blood pressure was 4.5 mm Hg lower.[18] A significant technician effect was found in an analysis of variance components analysis of the data. The data were reanalyzed with over 500 individuals, and the previously indicated home-clinic differences were still present (Sonja M. McKinley, PhD, unpublished data, 1987). This finding was consistent with that of another study of men with mild to moderate hypertension examined in the clinic and at home over a four-week period.[16]

The determination of hypertension incidence in a longitudinal study has certain advantages. For example, the definition of an incident case that includes those being treated might provide a better description of relationships in the situation of frequent drug treatment. At follow-up, approximately 70% of men and 85% of women with definite hypertension were being treated with medication. The percentage being treated was generally higher with age. As a result, the upper end of the blood pressure distribution at the follow-up examination was distorted by the treatment effect. As indicated, this was one of the reasons for the decreased mean blood pressures, especially at older ages. Previous reports have presented hypertension incidence data,[19,20] including investigations of etiologic factors in hypertension.[21] A major problem for interpreting an incidence study of hypertension is the inherent variability of blood pressure and its effects on case definition. Since a blood pressure cutoff point is necessary, the number of new cases will vary depending on the definition. The effect of blood pressure variability may be especially evident in this study, since a single determination was used for classification at two separate times. In an analysis of the Multiple Risk Factor Intervention Trial data from one of the participating centers, various definitions of a case and a baseline noncase were used.[22] Depending on the definition, two differing estimates were found. These incidence rates ranged from 6.2 to 15.5 per 1000 person-years, depending on the definition of hypertension. In fact, the case definition varied considerably among the various hypertension studies.[19-21,23] The definition selected for this study was consistent with previous National Center for Health Statistics (Hyattsville, Md) surveys and based on the World Health Organization (Geneva) definition.[24] Besides the treated individuals, it included those with isolated systolic hypertension, an important group of older persons, and those with only elevated diastolic blood pressure. The latter subgroup, defined by diastolic blood pressure, was emphasized in the Joint National Committee III definition of hypertension.[13]

Another issue related to blood pressure variability and incident case definition is regression to the mean. When certain blood pressure levels by virtue of being extremely high or low are used to classify individuals at baseline, the subsequent case rate will be affected by purely statistical considerations.[25] Statistical adjustments have been proposed to correct for this effect of blood pressure change due to variability and classification. It was judged to be a conservative strategy in this study to minimize this effect by restricting the population at risk for the development of hypertension to individuals with normal blood pressure (below 140 mm Hg systolic and 90 mm Hg diastolic) at baseline. The groups excluded from these analyses would be more likely affected by the regression to the mean. The follow-up case definition was higher (160 mm Hg systolic and/or 95 mm Hg diastolic). Again, this would tend to minimize the effect of regression to the mean. Because of this analytic approach, a certain number of cases were eliminated, and the rates were lower than those estimated from some other studies. In the present study, the location of the follow-up blood pressure determination in the home rather than in the examination trailer, as at baseline, complicates both incidence estimates and trends in the blood pressure distribution. Because of the apparent effect of different methods causing a lower follow-up blood pressure than would have been expected, the incidence levels are conservative estimates.

A number of community-based studies have identified a relationship between baseline blood pressure and total mortality.[26-28] This is consistent with this national study, which demonstrates the negative impact of definite hypertension on the nation's health. The present study provides an integrated, broad, and contemporaneous view of hypertension. Hypertension detection and control efforts should continue on a national basis.

The NHANES Epidemiologic Follow-up Study was jointly initiated by the National Institute on Aging (Bethesda, Md) and the National Center for Health Statistics, Hyattsville, Md, and has been developed and funded by the National Institute on Aging; National Center for Health Statistics; National Cancer Institute; National Heart, Lung, and Blood Institute; National Institute of Arthritis, Diabetes, and Digestive and Kidney Diseases; National Institute of Mental Health; National Institute of Alcohol Abuse and Alcoholism; National Institute of Allergy and Infectious Diseases; and National Institute of Neurological Disorders and Stroke (National Institutes of Health, Bethesda, Md).

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