Progress in the Battle Against Hypertension
Changes in Blood Pressure Levels in the United States from 1960 to 1980

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SUMMARY  Intensive efforts by practicing physicians and public health workers to identify and treat persons with hypertension have been underway for many years. In this report, changes in blood pressure levels in the United States are assessed based on nationally representative health (and nutrition) examination surveys conducted by the National Center for Health Statistics in 1960 to 1962, 1971 to 1974, and 1976 to 1980. Analysis of age-adjusted data for adults aged 18 to 74 years (including those on antihypertensive medication) indicates that between the first and third surveys for whites and blacks, respectively, mean systolic blood pressure declined 5 and 10 mm Hg; the proportion of persons with systolic blood pressure of 140 mm Hg or higher fell 18 and 31%; the proportion with undiagnosed hypertension decreased 17 and 59%; and the proportion taking antihypertensive medications rose 71 and 31%. These differences between the first and third surveys were all statistically significant (p < 0.05 or better). Changes in diastolic blood pressure levels were generally not significant among race-sex groups. The proportion of persons with definite hypertension (i.e., systolic blood pressure > 160 mm Hg, and/or diastolic blood pressure > 95 mm Hg, and/or taking antihypertensive medication) declined among blacks but rose slightly among whites. Study results are consistent with the recent decline in cardiovascular disease mortality. (Hypertension 10: 226-233, 1987)

KEY WORDS  • blood pressure • hypertension • health surveys • United States

AFTER many years of substantial efforts to educate the public and health care providers about hypertension and to identify and treat persons with the disease, it is useful to assess the overall impact of such programs on blood pressure levels in the U.S. adult population. This report presents changes in blood pressure levels based on data from three large representative national health surveys conducted in the period 1960 to 1980 by the National Center for Health Statistics.

The implications of the changes observed may be better understood by reviewing briefly the history of hypertension. Although hypertension has been prevalent in the United States for many decades, its importance as a public health problem was not well recognized until the 1960s. Before the use of diuretics beginning in the late 1950s as an effective treatment for hypertension, only very potent antihypertensive drugs were available and their use was often limited to treating malignant hypertension in emergency rooms and hospitals. 1

Large prospective studies in Framingham, Massachusetts and Tecumseh, Michigan demonstrated an increased risk of stroke and myocardial infarction associated with elevated blood pressure. 2-7 The Veterans Administration Cooperative Study showed that the risks of stroke and congestive heart failure could be reduced by lowering blood pressure in persons with moderate or severe hypertension (diastolic blood pressure [DBP] > 105 mm Hg). 8-10

National recognition of hypertension as a public health problem of major importance was substantially enhanced with the initiation of the National High Blood Pressure Education Program (NHBPEP)11 in 1972. Under this program, the NHBPEP Coordinating
Council was formed to coordinate efforts of the many voluntary and professional groups that had become involved in hypertension control. The NHBPEP Coordinating Council currently functions as a forum for consensus and action for these organizations.

The report of the first Joint National Committee on the Detection, Evaluation, and Treatment of High Blood Pressure (JNC) was issued in 1977 and distributed widely to health care providers and organizations. The JNC report recommended treatment of all adults with DBPs of 105 mm Hg or greater as well as those with DBPs of 90 to 104 mm Hg if other risk factors were present, a formalized stepped-care approach to treatment, and avoidance of inappropriate or ineffective medications. By formulating one of the first sets of guidelines for the treatment of hypertension, this report established a standard of care for the disease.

Inadequate treatment regimens, poor patient compliance, and other problems that may follow detection of elevated blood pressure began to receive more attention in the mid-1970s. Improved follow-up as well as detection became an important goal of state hypertension programs, partly in response to federal aid requirements.

In 1979, results were published from the Hypertension Detection and Follow-up Program (HDFP) that demonstrated that systematic treatment of hypertension can reduce all-cause mortality. Following a review of the HDFP results, the second JNC report was published in 1980. This report recommended treatment of persons with DBP of 90 mm Hg or more, offered guidelines for the extent of evaluation of persons with elevated blood pressure, included \( \beta \)-blockers in the stepped-care treatment guidelines, and made guarded recommendations on isolated systolic hypertension. It also suggested weight reduction in obese patients and sodium control as adjunctive therapy for the management of hypertension.

Following the development of new antihypertensive agents and the publication of the results of new clinical trials in the early 1980s, the report of the third JNC was published. It emphasized increased targeting for screening programs and increased use of nonpharmacological methods both initially and during long-term management of hypertension. The report also created new categories for persons with DBPs of 85 through 89 mm Hg (high normal) and for those with isolated systolic hypertension, and it updated the stepped-care recommendations with regard to \( \beta \)-blockers and angiotensin converting enzyme inhibitors. "Step-down" therapy was mentioned for use in selected patients.

Current efforts in hypertension research include basic research into the etiology of hypertension and its effects, exploration of new treatment methods, and examination of the medical significance of mild hypertension and of hypertension in children and the elderly.

**Subjects and Methods**

Data analyzed in this report were obtained from three cross-sectional surveys conducted by the National Center for Health Statistics during the period 1960 to 1980. These surveys were designed to assess various aspects of the health status of the U.S. civilian noninstitutionalized population, based on clinical histories and physical examinations of representative individuals selected by complex probability sampling procedures. The three surveys were the first National Health Examination Survey (NHES I), conducted in 1960 to 1962, the National Health and Nutrition Examination Survey (NHANES I), conducted in 1971 to 1974; and its successor, NHANES II, conducted in 1976 to 1980. Sample sizes and other characteristics of the three surveys are presented in Table 1. The three surveys differ in regard to subject matter covered but generally permit comparisons across time of selected measures.

The findings in this report are national estimates based on weighted observations. The data obtained for each examined person were weighted so that the sum of sampling weights for all persons drawn from a subuniverse is approximately equal to the number of persons in that subuniverse at the midpoint of the survey, as estimated by the Bureau of the Census. The weights take into account the probability with which persons were drawn into the samples and certain adjustments, based on the known demographic characteristics of interviewed or examined persons versus all eligible persons, to minimize the effects of nonresponse and bias.

Most of the analyses presented are based on \( t \) tests comparing means or prevalence rates in two population subgroups. Unless otherwise specified, statistical significance was based on the 5% significance level. The standard errors used in these tests were calculated by a balanced replication technique that is appropriate to the complex survey design and estimation procedure. These standard errors are presented in Reference 27. Where comparisons are made between surveys, the age-standardized means have been calculated by the direct method for the 1960 to 1962 and 1971 to 1974 surveys using the reference population estimates at the midpoint of the 1976 to 1980 survey as the standard population.

The first blood pressure determination in each survey was the most comparable among the three surveys and was used in our analyses. In all three surveys a

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<tbody>
<tr>
<td>Age range of sample population (yr)</td>
<td>18–79</td>
<td>18–74</td>
<td>18–74</td>
</tr>
<tr>
<td>Total sample size*</td>
<td>7,710</td>
<td>19,572</td>
<td>18,209</td>
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<tr>
<td>Total number of examined persons*</td>
<td>6,672</td>
<td>13,645</td>
<td>12,504</td>
</tr>
<tr>
<td>White men</td>
<td>2,669</td>
<td>4,334</td>
<td>5,148</td>
</tr>
<tr>
<td>White women</td>
<td>3,050</td>
<td>6,750</td>
<td>5,686</td>
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<td>Black men</td>
<td>352</td>
<td>845</td>
<td>649</td>
</tr>
<tr>
<td>Black women</td>
<td>469</td>
<td>1,550</td>
<td>782</td>
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<tr>
<td>Response rate (%)</td>
<td>86.5</td>
<td>69.7</td>
<td>68.7</td>
</tr>
</tbody>
</table>

*Includes all other races not shown separately.
blood pressure reading was taken by the physician at the beginning of the physician's examination with the examinee seated. Second and third blood pressure readings were taken from some (but not all) examinees in the three surveys and differed from the first readings in terms of posture (supine vs sitting) and type of examiner (physician vs nurse). For clarity, this report focuses on changes across the three surveys for the four race-sex groups, especially on the differences between the first and third surveys. Data showing much greater detail with regard to age-specific rates and to differences between the second survey and the other two surveys were recently published in a monograph available from the National Center for Health Statistics.

An examinee was considered to have definite hypertension if the systolic blood pressure (SBP) was greater than or equal to 160 mm Hg, and/or the DBP was greater than or equal to 95 mm Hg, and/or he or she was currently taking antihypertensive medication. Those examinees who had definite hypertension according to their pressure measurements but were neither taking antihypertensive medication nor had ever been told by a physician that they had high blood pressure were considered to have undiagnosed hypertension. Examinees deemed hypertensive were considered to have controlled hypertension if their SBP was less than 140 mm Hg and their DBP less than 90 mm Hg if they were taking antihypertensive medication and/or had been previously diagnosed as hypertensive by a physician.

In NHANES I, subjects were asked about use of antihypertensive medication in the past 6 months; in the other two surveys, current usage was ascertained. This difference may result in a small upward bias in the number of persons taking medications in the 1971 to 1974 estimates, although it was not possible to quantitatively assess the amount of this bias.

### Results

Over the period spanned by the three surveys, mean SBP significantly decreased for both white and black persons and for both men and women across the three surveys (Table 2). When values for NHES I (1960 to 1962) and NHANES I (1976 to 1980) were compared, the age-adjusted mean SBP for adults aged 18 to 74 years fell from 133 to 129 mm Hg for white men, from 129 to 123 mm Hg for white women, from 138 to 130 mm Hg for black men, and from 138 to 126 mm Hg for black women. These differences were significant for each of the four race-sex groups (p < 0.01). The age-adjusted mean SBP declined significantly more in women than in men and more in black adults than in white adults over the period studied (p < 0.01 in each case). Similar declines were noted for both median and 95th percentile SBP levels for each race-sex group (see Table 2).

Age-specific mean SBP declined for each age group in the range studied (Figure 1). For example, the mean SBP declined 7.6% (from 157 to 145 mm Hg) among white adults aged 65 to 74 years (p < 0.01), whereas it fell only 0.8% (from 118 to 117 mm Hg) among white adults aged 18 to 24 years.

The age-adjusted proportions of persons with SBP of 140 mm Hg or greater decreased over the 20 years (see Table 2). The magnitude of the decline was 12% (p < 0.01) for black men and women combined (from 40 to 28%), and 5% (p < 0.01) for white men and women combined (from 29 to 24%), thus narrowing...
the differences between the races for these proportions.

In contrast to the significant improvements noted for SBP from 1960 to 1980, the results for DBP did not demonstrate any consistent changes for any race-sex group over the three surveys (Table 3). Age-adjusted mean DBP levels all showed variable fluctuations over time for all race-sex groups except white men (Table 3). Among white men, the age-adjusted mean DBP increased from 79 mm Hg in NHES I to 83 mm Hg in NHANES II, and the difference was statistically significant (p<0.05). Consistent with the race and sex relationships observed with mean SBP measurements, white adults had lower mean DBP than black adults and women had lower mean DBP values than men.

A general increase in mean DBP between the first and third surveys was observed within age groups (Figure 2). No consistent changes were evident in the proportion of the population with DBP of 90 mm Hg or greater (see Table 3).

From 1960 to 1980, the age-adjusted proportion of the population with definite hypertension (as defined earlier) increased for white men and women and decreased for black men and women; only the increase for white men was statistically significant (Figure 3). The decrease among black adults was similar for men (-16%) and women (-15%), while the increase among white adults was more evident in men (+27%) than in women (+8%). In general, these age-specific proportions rose slightly in whites and decreased in blacks over the three surveys.

From 1960 to 1980, the proportion of persons with undiagnosed hypertension declined (Figure 4). Although minor increases were noted for some race-sex groups between the 1960 to 1962 and 1971 to 1974 surveys, the downward tendency between the 1960 to 1962 and 1976 to 1980 surveys was significant for each race-sex group except white men (p<0.05). The decline in the age-adjusted proportion of persons with undiagnosed hypertension was especially notable among black adults: It decreased from 21.1 to 9.9% among black men and from 13.2 to 4.5% among black women over the span of the three surveys. In comparison, this proportion declined from 10.7 to 9.8% among white men and from 7.7 to 5.6% among white women (see Figure 4).

The declines in age-specific proportions of persons with undiagnosed hypertension were substantially larger among black adults than among white adults in most age groups. Although some of the age-specific proportions for black adults were twice as high as those for white adults in the 1960 to 1962 study, most of the age-specific proportions for black adults were very close to those for white adults in the 1976 to 1980 survey. In fact, for black women aged 55 to 74 years, the proportions with undiagnosed hypertension were actually lower than those for white women in the same age group.

As presented in Figure 5, the proportion of persons taking antihypertensive medications increased for each race-sex group over the 20 years studied. During this period, the age-adjusted proportion of persons taking such medications rose from 3.8 to 7.6% among white men, from 7.0 to 11.1% among white women, from 6.0 to 9.2% for black men and for 15.9 to 19.3% among black women. The absolute increase over the period studied was similar for each of the four race-sex groups, although the age-adjusted proportion of per-

![Figure 2](http://hyper.ahajournals.org/)

sons taking antihypertensive medications was generally higher among women than among men and among black adults than among white adults. The increases in this proportion were generally larger for the older age groups (aged 45–64 years) than for the younger age groups (aged 18–34 years). Similarly, when only hypertensive persons were considered in each survey, the proportion of hypertensive persons who were medicated was higher among women than among men and was higher among black adults than among white adults.27

The proportion of the U.S. population with controlled hypertension increased over the span of the three surveys (Figure 6). These increases were statistically significant for whites (from 0.6 to 1.5% for white men and from 1.3 to 2.8% for white women; \( p<0.001 \)), but not for blacks (from 0.6 to 2.0% for black men and from 4.6 to 4.8% for black women). The age-specific proportions of persons with controlled hypertension changed the least among adults aged 18 to 34 years, and increased the most among the
older age groups. During 1960 to 1962, 4.1% of hypertensive adults in the age range of 45–74 years were controlled; this proportion increased to 11.5% in 1976 to 1980 (p < 0.001). Among all medicated hypertensive adults aged 45 to 74 years, the proportion with blood pressures less than 140/90 mm Hg increased from 12.2% in 1960 to 1962 to 21.7% in 1976 to 1980 (p < 0.001).

Discussion
Changes in blood pressure levels over the 20-year period studied may be due to factors that affected only those persons at highest risk, such as screening and medical treatment of persons with elevated blood pressure. Such factors would be expected to substantially affect the mean and 95th percentile of the blood pressure distribution curve but to have little effect on the median because only the upper tail of the curve is influenced. Alternatively, the changes in blood pressure levels may be due to factors that affected the entire U.S. population, such as improved diet and exercise patterns. Such factors would be expected to decrease both the mean and median of the blood pressure distribution curve similarly because the entire curve is affected.

Our results suggest that both types of factors are involved. The most important factor appears to be an increased identification and treatment of persons with elevated blood pressure, as evidenced by the substantial decline in SBP noted for the 95th percentile (see Table 2). Over the same period, a smaller but not inconsequential decrease in median SBP occurred that may have been caused by societywide changes in lifestyle patterns, resulting at least in part from increasing awareness of cardiovascular risk factors.

Consistent with previous reports, these surveys show that black adults experience a higher prevalence of elevated blood pressure than do white adults. However, greater improvement in both mean SBP and proportion of persons with SBP of 140 mm Hg or greater was observed for black adults than for white adults; thus, the difference between the races in prevalence of elevated blood pressure decreased between the first and third surveys.

Similarly consistent with previous studies, persons in the older age groups had higher mean SBP and higher proportions of persons with SBP of 140 mm Hg or greater in all three surveys. The extent to which this difference represents a widespread preventable form of pathology among the elderly rather than a natural aging process (such as progressive loss of arterial elasticity) is uncertain. However, the finding that older age groups experienced a greater decline in SBP levels than younger age groups is encouraging.

SBP and DBP measurements are highly correlated, and most regimens for treating hypertension tend to focus on lowering the DBP to an acceptable level. In view of the strong decline evident for SBP levels and the significant 2 to 3 mm Hg decrease in mean DBP observed from 1973 to 1980 in the Minnesota Heart Study, the absence of a decline in DBP levels over the 20 years studied is unexplained.

Only the first blood pressure determination was used in our analyses. It is possible that the first blood pressure determination may have been slightly elevated due to examinee anxiety; however, the degree of such elevation is likely to be similar in each of the surveys. Although blood pressure levels used in this study may be somewhat higher than if an average of several blood pressures had been used, comparisons between race-sex groups or between surveys should not be affected.

The variable results for proportion of adults with definite hypertension may reflect two competing trends. As more persons became aware of cardiovascular risk factors and as life-style practices improved over the last several decades, one might have expected a decrease in definite hypertension. However, the combination of more frequent blood pressure screening, which will identify more persons with labile hypertension at a high level, and an increased tendency to treat those in the modestly elevated range over these 20 years would result in an increase in definite hypertension. In addition, according to a recent report, the proportion of the population considered overweight based on body mass index has increased for each race-sex group during the period studied.

From 1960 to 1980, the proportion of persons taking antihypertensive medications increased substantially;
this rise would tend to increase the number of subjects with definite hypertension by definition. The proportion of adults under age 35 years taking blood pressure medications is relatively low. Such persons experience a low prevalence of hypertension, have fewer physician contacts and thus have fewer blood pressure readings taken, and may be more likely to be treated for hypertension with nonpharmacological methods than are adults in older age groups.

Consistent with the increasing prevalence of elevated blood pressure with age, the proportion of adults aged 35 years and older who take antihypertensive medication increased directly with age. Persons aged 35 to 74 years were more likely to take such medications in 1976 to 1980 than in 1960 to 1962, as would be expected given the increasing awareness and diagnosis of hypertension during the period studied. The availability to clinicians of new antihypertensive drugs that are less toxic and more effective and recent interest in treating persons with mildly elevated blood pressure probably have contributed to the increased use of antihypertensive medications since 1960.

In summary, the changes in blood pressure levels and prevalence of hypertension are generally in the anticipated directions during the years studied and are consistent with previous reports. Overall, there were decreases in mean and median SBP and in the proportion of persons with SBP of 140 mm Hg or greater. There were no consistent changes for any of the DBP measurements, for reasons that are not fully understood. Although competing trends appear to have affected the results for definite hypertension, there were decreases in undiagnosed hypertension and increases in the use of blood pressure medications and in the proportion of persons whose hypertension was under control. In general, these improvements were most marked among black adults, who were most at risk at the beginning of the study period.

The improvements observed in the diagnosis and control of elevated blood pressure in the United States represent a major achievement by practicing physicians and public health workers. New drug development and other research, public education, and screening and treatment programs have led to more effective treatment regimens, greater public awareness of the risks inherent in elevated blood pressure, increased knowledge about the life-style patterns that influence blood pressure, and greater recognition by physicians of the importance of treating even mildly elevated blood pressure.

The recent decline in cardiovascular disease mortality in the United States has been well documented. As demonstrated by these analyses, identification and control of hypertension markedly increased during the period of the decline. Although the magnitude of the contribution of these improvements to the falling rates of cardiovascular disease morbidity and mortality is unclear, it is likely that the improved control of hypertension played an important role. While the data in these surveys have provided useful benchmarks for measuring progress in the battle against hypertension, they also reveal that there is substantial room for improvement in the proportion of hypertensive persons still in need of having their blood pressure controlled. Continuation of vigorous efforts by practicing physicians and public health workers to identify and treat persons with hypertension and support for research seeking to clarify the linkage between life-style and health appear to be justified.

References
14. Five-year findings of the Hypertension Detection and Follow-up Program: I. Reduction in mortality of persons with high blood pressure, including mild hypertension. JAMA 1979;242:2562–2571
15. Five-year findings of the Hypertension Detection and Follow-up Program: II. Mortality by race-sex and age. JAMA 1979;242:2572–2577
19. Origin, program, and operation of the U.S. National Health Survey. Hyattsville, MD: National Center for Health Statistics, 1963; PHS publication no 1000 (Vital and health statistics; series 1; no 1). 41 pp


25. Replication: an approach to the analysis of data from complex surveys. Hyattsville, MD: National Center for Health Statistics, 1966; PHS publication no 1000 (Vital and health statistics; series 2; no 14). 38 pp

26. Pseudoreplication: further evaluation and application of the balanced half-sample techniques. Hyattsville, MD: National Center for Health Statistics, 1969; PHS publication no 1000 (Vital and health statistics; series 2; no 31). 24 pp


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*Hypertension*. 1987;10:226-233
doi: 10.1161/01.HYP.10.2.226

*Hypertension* is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
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Print ISSN: 0194-911X. Online ISSN: 1524-4563

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