

VITAL and HEALTH STATISTICS

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**Blood Pressure
of Adults
by Age and Sex**

United States - 1960 - 1962

Blood pressure measurement, and distributions and mean levels by age and sex.

Washington, D.C.

June 1964

U.S. DEPARTMENT OF
HEALTH, EDUCATION, AND WELFARE

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Public Health Service
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In accordance with specifications established by the National Health Survey, the Bureau of the Census, under a contractual agreement, participated in the design and selection of the sample, and carried out the first stage of the field interviewing and certain parts of the statistical processing.

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	Page
Introduction -----	1
Blood Pressure Measurement-----	1
Blood Pressure Variation-----	3
Special Sources of Variation-----	3
Blood Pressure by Age and Sex-----	6
Comparisons and Analysis-----	9
Discussion -----	12
Summary-----	15
Detailed Tables-----	17
Appendix I. Blood Pressure Measurement-----	35
Appendix II. Survey Design, Missing Data, and Variance-----	36
The Survey Design-----	36
Reliability in Probability Surveys-----	36
Sampling and Measurement Error-----	36
Small Numbers-----	37
Appendix III. Observer Variability in Blood Pressure Measurement-----	38

SYMBOLS

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BLOOD PRESSURE OF ADULTS

BY AGE AND SEX

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INTRODUCTION

The first cycle of the Health Examination Survey was undertaken to obtain information on the prevalence of certain chronic diseases, on dental health, and on the distribution of a number of anthropometric and sensory characteristics in the civilian, noninstitutional population of the United States. A sample of 7,710 persons aged 18-79 years was drawn, and of these 6,672 were examined. Each person received a standard examination, lasting about 2 hours, performed by medical and other staff members of the Survey in specially designed mobile clinics. The study design and execution have been previously described,¹ and a description of the sample and response has been published.²

This report presents data on blood pressure by age and sex. It describes the pertinent parts of the examination, specifies the techniques used, and compares the information obtained in this Survey with that obtained in other surveys. The relationship of blood pressure with other findings of the examination or with demographic variables other than age and sex is not dealt with in this report.

BLOOD PRESSURE MEASUREMENT

The measurement of blood pressure was part of a cardiovascular examination, which included, in addition to a medical history, an electrocardiogram, a chest X-ray, auscultation of the heart, examination of the peripheral arteries, and funduscopy. Some details of this examination have

been described in a previous report.¹ Upon entering the Mobile Examination Center the examinee was greeted by a receptionist-interviewer, who obtained a limited number of personal and medical particulars from him. The examinee then completed a self-administered medical history. Since this routine was invariant, at least 45 minutes passed, in most cases, before the examinee saw a physician. In some instances he had already completed part, or all, of the other examination procedures and had been in the Center more than an hour and a half before receiving his physical examination.

The blood pressure of each examinee was measured three times during the course of the physical examination. The first measurement was taken just after the physician met the examinee. The second was taken midway in the examination, after auscultation of the heart in the sitting position and before the arthritis examination. The examinee had just had an electrocardiogram taken by the nurse and had been allowed a few moments after sitting up for the effects of postural hypotension to disappear. The third measurement was taken at the end of the physical examination.

A venipuncture was usually made during the physical examination, although the specific point at which it was taken varied from one examinee to another.

Blood pressure measurements were taken on the left arm with the examinee sitting on the examining table. The nurse placed the middle of the cuff over the bulge in the upper left arm. The cuff was left on the arm between the first and second measurements, was removed after the

second, and returned for the third. The physician held the arm at the level of the atrium, with the nurse raising the Baumanometer to the physician's eye level. Using the bell of his stethoscope, the physician noted the pressure when the sound was first heard, when it first became muffled, and when it disappeared, recording all three measurements. In this report, the point at which the Korotkoff sounds disappeared is given as the diastolic pressure. If the sounds did not disappear, the point of muffling, if distinctly heard, is given. Since the Baumanometer is scaled in intervals of 2 mm., measurements were so recorded. The background of these procedures is discussed briefly in Appendix I.

There is a tendency to choose certain end digits in measurement, with particular preference for 0 or 5. Table A gives the distribution of end digits used in reporting systolic and diastolic pressures on the first blood pressure measurement. The preference for numbers ending in 0 is quite marked, and a comparable preference for the end digit 5 is strong enough in some cases to overcome the instruction to use only even

numbers in recording. If all three blood pressures are averaged, a set of artificial end digits results which are more uniformly distributed, although the averaging of three even numbers results in more odd than even quotients. At least it is possible to group blood pressures ending in digits 0 through 4 and those ending in digits 5 through 9 without great irregularity in the resulting distributions.

The preference for certain end digits would merely be an item of human frailty were it not also associated with disease judgments. The lower limit for definite hypertension often used is 160, and it will be noted that on the first blood pressure measurement there was definite preference for a reading of 160 over a reading of 158 (table B). A similar situation can be observed in reading diastolic pressures around 90 mm.hg., which is frequently used as a lower bound for borderline hypertension. On the second and third measurements these strong preferences seemed to diminish. Averaging all three values, of course, tends to transform these reading preferences and to obscure them.

Table A. Distribution of end digits on blood pressure measurement: Health Examination Survey, 1960-62

End digit	First measurement		Average of 3 measurements	
	Sys-tolic	Dia-stolic	Sys-tolic	Dia-stolic
	Number of examinees			
0-----	2,169	2,299	560	652
1-----	-	1	894	836
2-----	1,073	895	444	480
3-----	-	2	885	829
4-----	1,200	933	440	429
5-----	66	69	856	814
6-----	1,005	1,109	409	393
7-----	2	-	910	828
8-----	1,153	1,289	455	484
9-----	2	1	819	927
Missing---	2	174	-	-

¹5th phase.

Table B. Number of blood pressure measurements at specified levels, by order of measurement: Health Examination Survey, 1960-62

Blood pressure (mm. hg.)	Measurement		
	First	Second	Third
<u>Systolic</u>			
144-----	126	120	100
146-----	84	94	97
148-----	98	79	77
158-----	56	53	59
160-----	124	116	88
162-----	50	32	41
<u>Diastolic</u>			
88-----	277	284	253
90-----	390	348	341
92-----	124	154	128
94-----	106	116	117
96-----	115	133	109
98-----	107	105	90

BLOOD PRESSURE VARIATION

Blood pressure may vary considerably over a short period of time even under relatively standard conditions. For half the persons examined during this cycle of the Health Examination Survey the difference between the highest and lowest systolic readings was 10 mm. hg. or more. In half the cases the difference between the highest and lowest diastolic readings was at least 6 mm. hg. Similar variation has been noted in other studies. In the measurements made by the Health Examination Survey, variation was about the same for men and women, but both for men and for women it increased with age. These observations refer, of course, only to variation observed during a single physical examination. If variation is measured over a longer period of time the median range becomes greater. In one study where subjects had determinations of resting blood pressure made six times every weekday for 3 weeks, the median range over the 3-week period was 30 mm. hg. for systolic and 22 mm. hg. for diastolic pressures.³ Even in hospital studies where an effort is made to obtain basal blood pressures under carefully controlled conditions, blood pressures for an individual vary from one time to another, although less than with casual pressures.⁴

Because blood pressure fluctuates it seemed reasonable to average the three blood pressure measurements obtained for each individual and to use this average as the best measure of his blood pressure. It is these average measurements that are tabulated in this paper (excluding those in tables A and B). Such average figures do not necessarily eliminate the recording problems, even though they probably reduce the effect of reading preferences. A distribution of average values is shown in figure 1. It covers only the range from 130 to 199 mm. hg. systolic and 80 to 109 mm. hg. diastolic. The averaging procedure leads to an excess of odd-end digits, which produces a sawtooth effect in the figure, but in addition some irregularity is probably introduced by a tendency to shift readings as boundary values are approached, that is, values which traditionally are regarded as those separating hypertensive from normotensive levels.

SPECIAL SOURCES OF VARIATION

Two characteristics of the Health Examination Survey merit special attention because of their possible effect on the blood pressure data. The first is that during the physical examination a venipuncture was made. The second is that persons were examined at different times of the day.

A venipuncture is disturbing to many people, and although a blood pressure measurement was never taken immediately after a venipuncture, it is possible that some delayed reaction to the venipuncture might alter the blood pressure level. If this occurred with sufficient frequency and if the changes were large enough and tended to be in the same direction, the mean blood pressure level would be discernibly altered by the venipuncture. Even if this did not happen it is still possible that the venipuncture increased the variability of measurement to some extent.

It must be emphasized that no direct measurement of the effect of venipuncture on blood pressure was undertaken during the Health Examination Survey. However, the three successive blood pressure measurements on each individual were recorded, as was the time of the venipuncture, and it should be possible to discern the effect of venipuncture from these data—if the effect is marked. The problem may be approached in the following way. On the average, systolic pressure tended to decrease slightly from the first to the third measurements, whereas the diastolic pressure remained about the same on successive measurements. For some persons a venipuncture was made before the first blood pressure measurement, for others between the first and second, and so on. The question is whether the relationship among successive blood pressure measurements differed in some consistent fashion according to the time of venipuncture.

The answer to this question is complicated by the fact that younger persons, who have lower and less variable blood pressures, proceeded through the examination more rapidly than older persons. Since the venipuncture was timed to occur a little more than 1 hour after the beginning of the examination, regardless of age, younger persons were more apt than older to be further advanced in the examination at the time

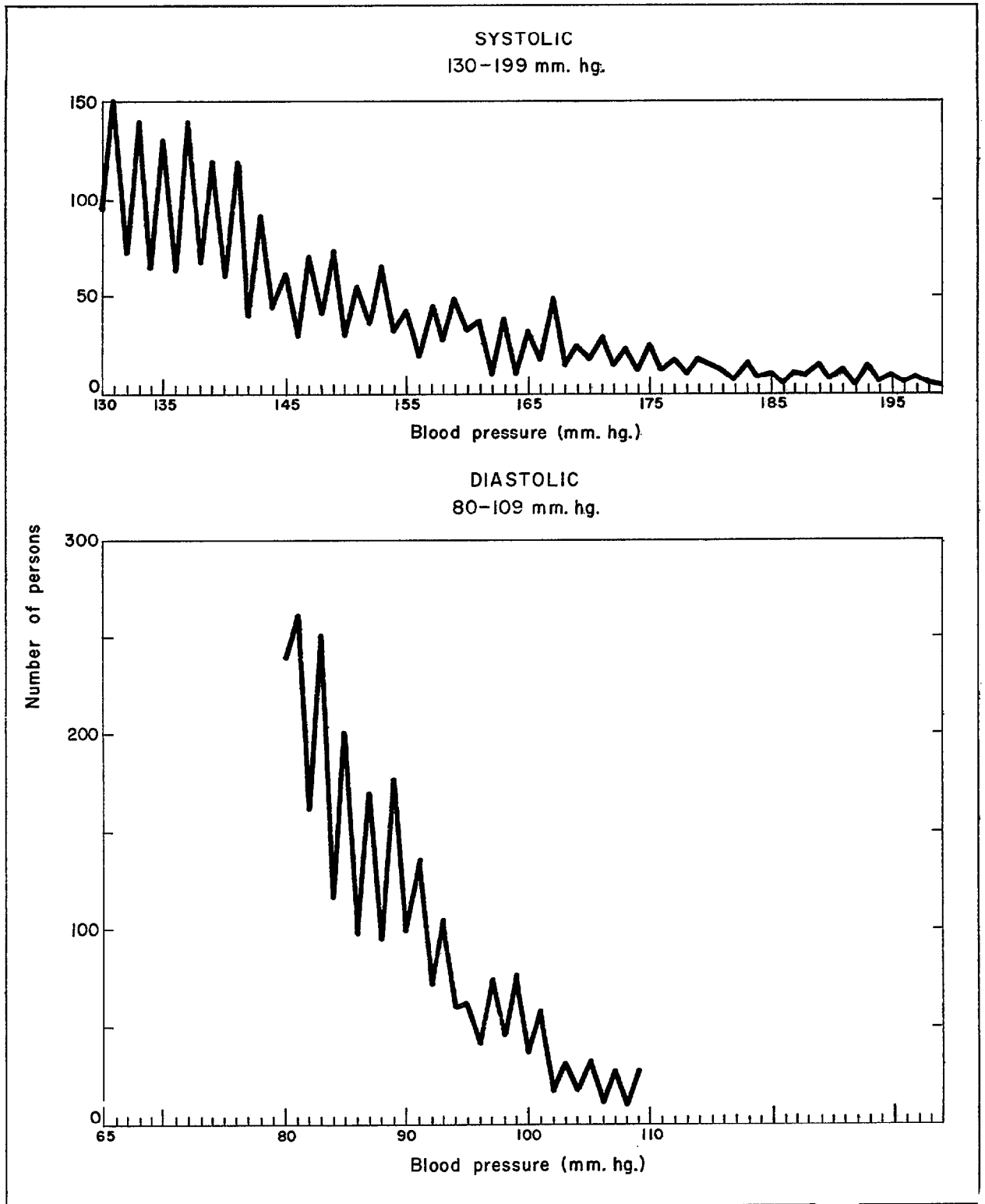


Figure 1. Distribution of specified blood pressures: Health Examination Survey.

of venipuncture. Therefore, it is necessary to compute differences between successive blood pressures that are age specific. In table C these are summarized as age-adjusted differences.

If blood pressure were affected in a consistent manner by venipuncture, the three numbers in any column of table C would vary in the same pattern as the three numbers in any other column. The data do not suggest this; in fact, what variation there is in each column is trivial. It can therefore be assumed that the venipuncture had no discernible effect on the blood pressure levels reported by this Survey.

A possible diurnal variation in blood pressure is another concern because sample persons came for examination at their convenience rather than at random. Older people were more likely to come early in the day than younger.² This difference, while definite enough, would be important only if mean blood pressure had a marked diurnal variation and the data from the Health Examination Survey do not indicate this.

Table D presents age-adjusted blood pressure levels according to the time of day at which persons arrived for the examination. Blood pressures were taken approximately an hour later. These calculations are for the age range 18-74 years, as data for the age group 75-79 years were too scanty to be included. The tabled values do not constitute estimates for the population of the United States.

Table D. Age-adjusted blood pressure, by time of day: Health Examination Survey, 1960-62

Time of day ¹	Systolic	Diastolic
	Blood pressure in mm. hg.	
8 a.m-----	128.7	78.7
9 a.m-----	129.6	79.5
10 a.m-----	127.6	78.0
11 a.m-----	129.8	78.2
12 p.m-----	130.6	78.7
1 p.m-----	130.1	78.5
2 p.m-----	129.8	79.5
3 p.m-----	131.6	79.9
4 p.m-----	132.0	80.4
5 p.m-----	133.2	81.1
6 p.m-----	132.1	78.8
7 p.m-----	131.1	79.2

¹"Time of day" is the time the examinee began his examination. Blood pressures were usually measured about an hour later.

NOTE: These values are obtained by weighting mean values by age and sex for each time of day by the age-sex distribution of the total U.S. population. They do not constitute estimates for the United States.

The data are consistent with a slight tendency for blood pressures to rise in the afternoon and it is possible that a test of significance (which was not undertaken) would demonstrate this in statistical terms. However that may be, it is unlikely that this variation is great or that it constitutes

Table C. Changes in blood pressure associated with time of venipuncture: Health Examination Survey, 1960-62

Time of venipuncture	Difference in mm. hg. between			
	First and second measurements		Second and third measurements	
	Systolic	Diastolic	Systolic	Diastolic
Before either measurement-----	2.62	0.40	0.67	-0.28
Between the two measurements-----	3.01	-0.05	1.10	-0.39
After both measurements-----	2.96	0.29	0.75	-0.19

Table E. Mean blood pressure in adults, by age and sex: United States, 1960-62

Age	Systolic			Diastolic		
	Both sexes	Men	Women	Both sexes	Men	Women
Mean blood pressure in mm. hg.						
All ages-18-79 years----	130.9	132.1	129.9	78.7	79.4	78.1
18-24 years-----	116.4	121.7	111.8	70.4	71.6	69.4
25-34 years-----	119.9	124.7	115.6	74.6	76.4	72.9
35-44 years-----	125.6	128.6	122.8	79.3	80.7	78.0
45-54 years-----	133.8	133.8	133.8	82.6	83.2	82.0
55-64 years-----	143.6	140.3	146.6	84.0	83.1	84.9
65-74 years-----	154.8	148.0	160.2	82.5	81.0	83.7
75-79 years-----	155.5	154.3	156.6	79.4	79.4	79.3

a complicating feature in the analysis of the data; it is obviously only a minor source, if any, of variation.

BLOOD PRESSURE BY AGE AND SEX

Mean blood pressures by age and sex are given in table E and figure 2. These show a tendency for systolic blood pressures to rise with age over the age range 18-79 years, while diastolic blood pressures rise until age 45-54 years for men and age 55-64 years for women, after which they decline. At younger ages blood pressures are higher for men than for women; at older ages this is reversed.

With increasing age there is a tendency for the distribution of blood pressures to be displaced toward higher values (figs. 3, 4). Concurrently, the relationship between systolic and diastolic blood pressures is altered. Distributions of systolic and diastolic blood pressures are given in tables 1-17 for each age-sex group. Many of the numbers presented in these tables have high sampling variability, but when considered overall, they present a consistent picture of the relation between systolic and diastolic pressures. Estimating

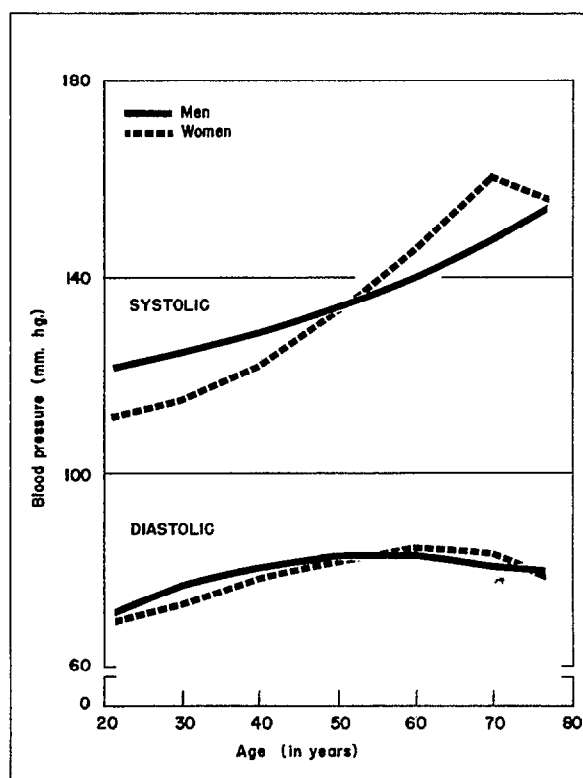


Figure 2. Mean blood pressure in adults, by age and sex: United States.

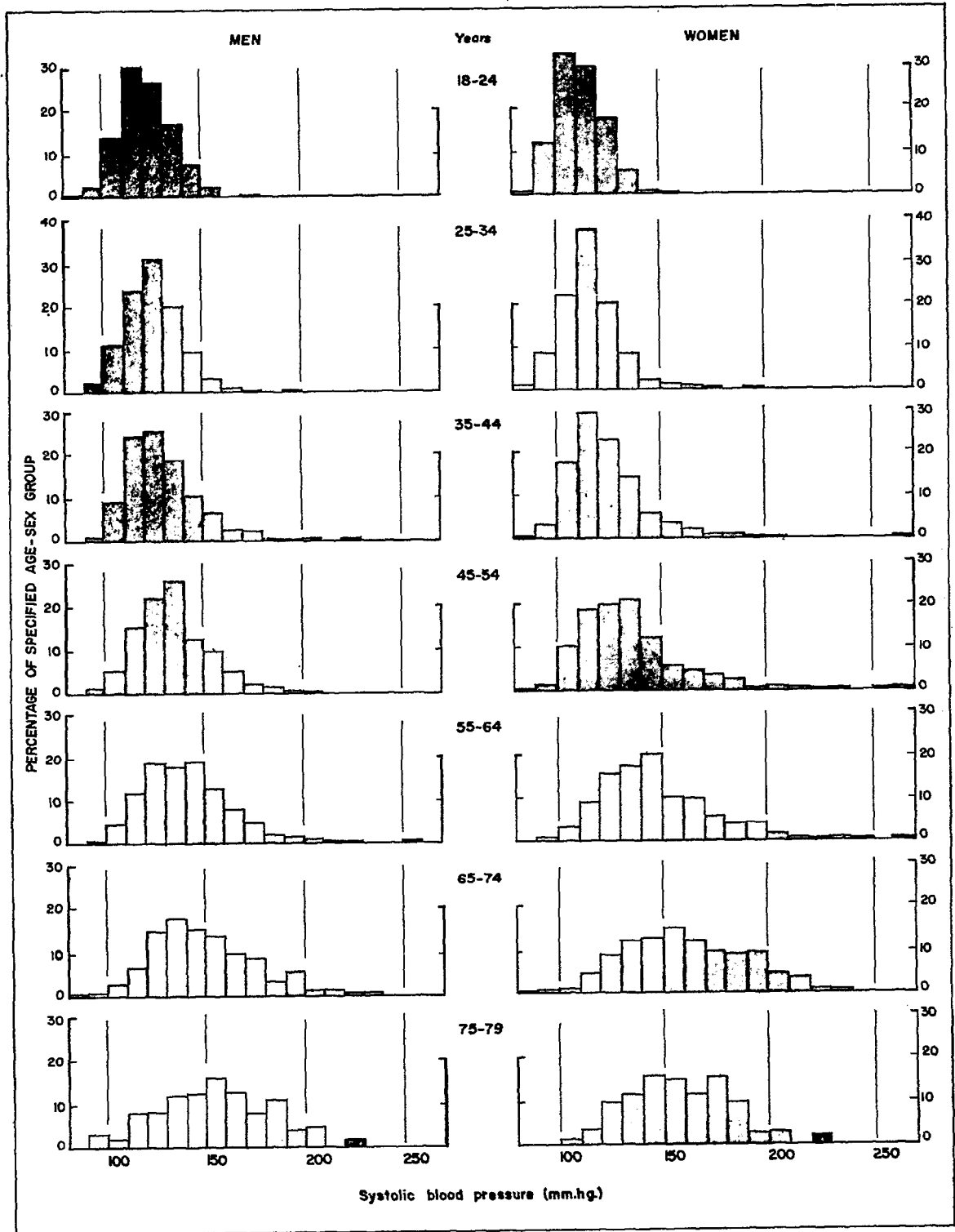


Figure 3. Distribution of systolic blood pressure of adults, by age and sex: United States.

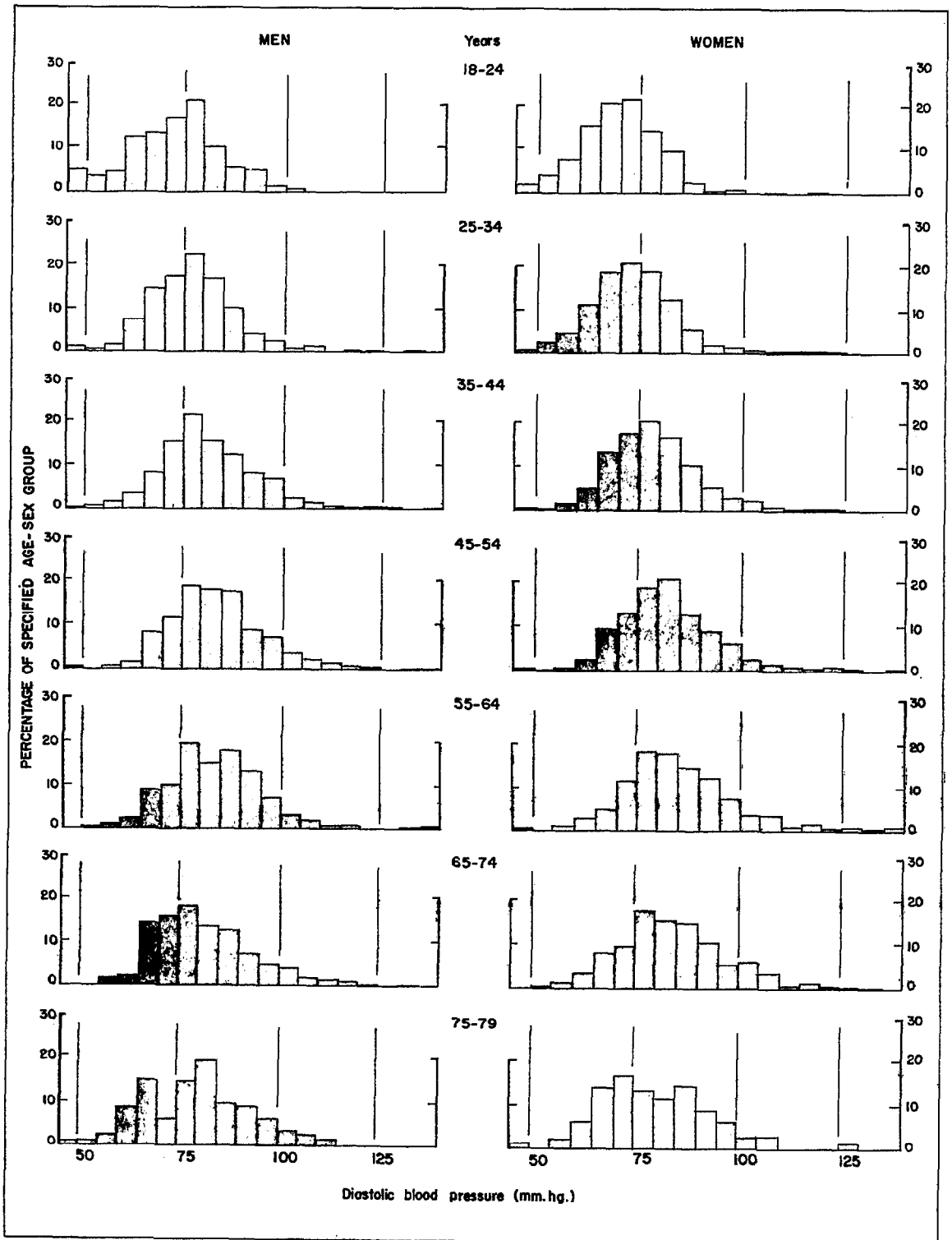


Figure 4. Distribution of diastolic blood pressure of adults, by age and sex: United States.

techniques and reliability are discussed in Appendix II.

Differences in mean values, of course, are only part of the story. The mean blood pressures for adults aged 18-79 years were 130.9 systolic and 78.7 diastolic. However, 16 percent had blood pressures below both 120 systolic and 70 diastolic, while the same percentage had either a systolic pressure of at least 160 or a diastolic pressure of at least 95. For young men aged 18-24 years the proportions were much greater at the lower end of the scale and smaller at the upper end: 26 percent had blood pressures below 120/70 while only about 2 percent were as high as 160 systolic or 95 diastolic. For women 75-79 years of age the distribution was reversed, 2 percent with blood pressures less than 120/70 and 46 percent with at least 160 systolic or 95 diastolic. The percentage of persons with high blood pressures by sex and age is given in table F.

COMPARISONS AND ANALYSIS

If HES findings for the United States are compared with findings from other surveys, the salient features may be more obvious. Three surveys of general populations were chosen for comparison. One was a survey of a sample of the adult population aged 29-62 years in Framingham, Massachusetts, in which 4,469 persons were examined.⁵ The second was a survey made of the population aged 15 years and over of the town of Bergen, Norway, in which some 68,000 persons were examined.⁶ The third was a survey of two districts in Taipeh, Formosa, in which about 9,700 Taiwanese and "mainland" Chinese were examined.⁷ The measurement techniques in all three surveys were essentially the same as those used by the Health Examination Survey, although in the Formosan survey blood pressure measurements were obtained at home rather than at a clinic.

Table F. Percent of adults with blood pressure of at least 160 systolic or 95 diastolic, by sex and age: United States, 1960-62

Sex and age	Systolic at least 160 mm. hg.	Diastolic at least 95 mm. hg.	Systolic at least 160 mm. hg. or diastolic 95 mm. hg.
	Percent of adults		
Both sexes-18-79 years-----	11.3	10.0	15.9
<u>Men</u>			
Total-18-79 years-----	9.3	10.5	15.0
18-24 years-----	0.2	1.6	1.6
25-34 years-----	1.0	4.5	4.8
35-44 years-----	5.2	12.6	13.4
45-54 years-----	8.9	15.7	18.9
55-64 years-----	17.1	13.6	23.3
65-74 years-----	29.0	14.5	30.3
75-79 years-----	40.7	13.8	41.6
<u>Women</u>			
Total-18-79 years-----	13.0	9.6	16.7
18-24 years-----	0.1	1.1	1.1
25-34 years-----	1.1	3.0	3.1
35-44 years-----	3.8	7.5	8.4
45-54 years-----	12.8	13.4	18.2
55-64 years-----	26.1	18.3	31.8
65-74 years-----	46.9	18.9	49.9
75-79 years-----	44.0	13.0	45.9

The trends by age reported by the three surveys were similar to those reported for the United States by the Health Examination Survey (figs. 5, 6). The resemblance to the Bergen findings is especially striking. Figure 7 shows the percentage increase in mean blood pressures from one age group to the next; these changes, especially for systolic pressure, are nearly the same for the two populations. The one exception arises from a reported drop in the systolic pressure for women in the United States between the age groups 65-74 and 75-79 years; it is entirely possible that this discordance is a result of the small number of persons aged 75-79 years examined by the Health Examination Survey. The 95 percent confidence interval for the mean systolic pressure for women aged 75-79 years has as its upper bound a value consistent with a rise in blood pressure from ages

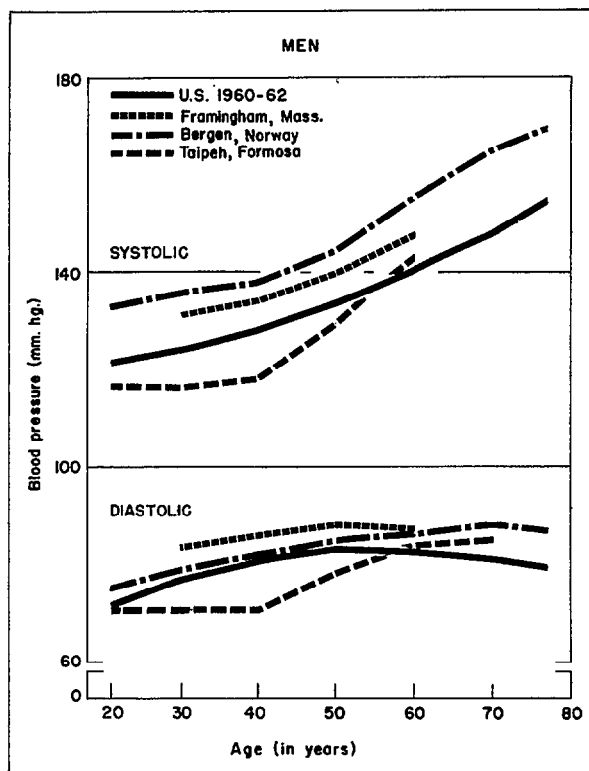


Figure 5. Mean blood pressure, by age for men, 18-79 years: four surveys.

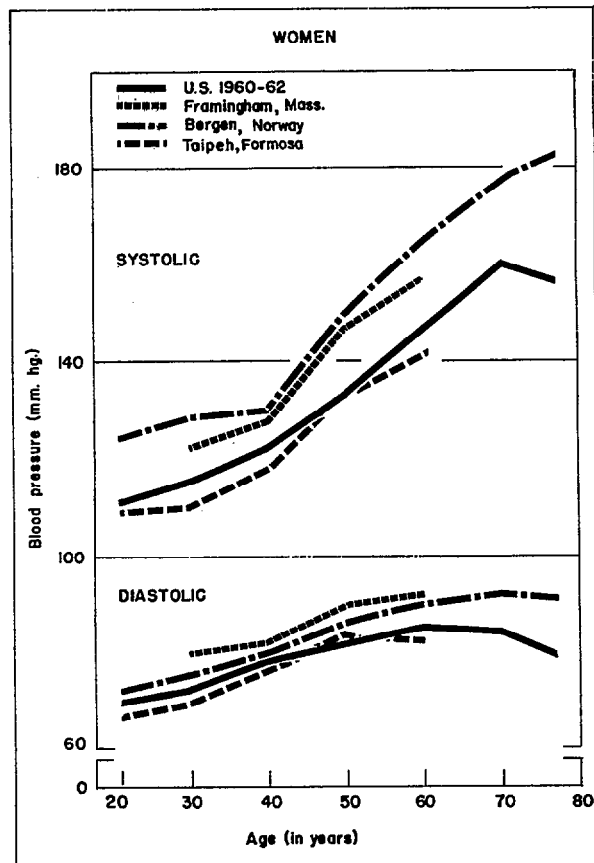


Figure 6. Mean blood pressure, by age for women, 18-79 years: four surveys.

65-74 to 75-79 years. Although it would be rash to assert that this is, indeed, the fact for the population of the United States, it would be equally rash to accept without question the finding that systolic blood pressure for women begins to decrease after 75 years of age.

Not only did systolic pressure increase with age for persons 18-79 years but for most of the age span the rate of increase was greater the older the person (fig. 7). Whether this applies to the entire age range or whether it is true only until age 60 for men and age 50 for women, as the Bergen data suggest, is impossible to determine, in view of the sample size used in the Health Examination Survey. With diastolic pressure the rate of increase was less the older the individual, and

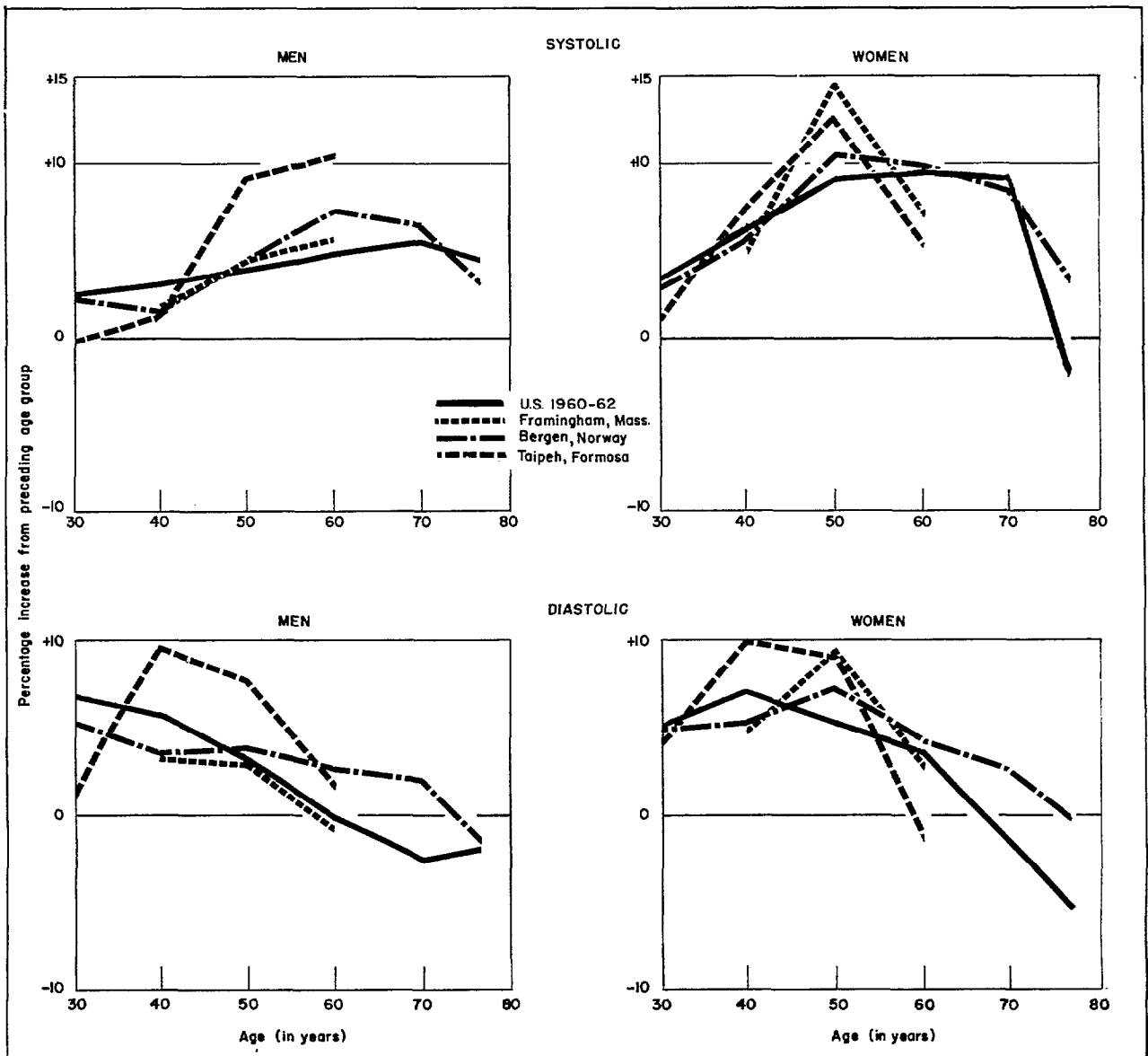


Figure 7. Percentage increase in mean blood pressure, by age for men and women: four surveys.

after age 64 for men and 74 for women diastolic pressure began to decrease with age.

It must be emphasized that what are reported here as changes associated with age are not derived from observation of individuals as they get older. The Health Examination Survey undertook only to examine persons at one point in time and the data reported here are cross-sectional. It is conceivable that data from one-time surveys understate the tendency of blood pressure to in-

crease as people get older, since young persons with high blood pressure are less apt to survive to an older age than young persons with low blood pressure.

Neither is it argued that parallel findings in different populations demonstrate that the phenomenon of higher blood pressures at older ages is an essential human characteristic. It has been argued on the basis of findings in certain primitive groups that there is no inherent tendency of blood

pressure to rise with age.^{8, 9} For a number of reasons—the small number of persons in primitive groups, the difficulty of ascertaining age, and the strong selective factor of a high mortality—such evidence must be regarded with considerable reservation. However, the Health Examination Survey has not collected any evidence to distinguish between biological and cultural factors related to blood pressure differences.

With respect to sex differences, all four surveys indicate higher blood pressures among young men than among young women, whereas older men have lower blood pressures than older women (fig. 8). The age at which the reversal occurs varies somewhat. According to the findings of the

Health Examination Survey, blood pressures are higher for women in the United States than for men only in age groups 55-64 years and older. The Bergen and Framingham surveys show this shift to be a decade earlier. The broad age groups used in this report somewhat exaggerate the difference between these surveys. However, if the shift arose as the function of some relatively fixed event, such as the onset of menopause in women, one would expect greater agreement.

DISCUSSION

Data in this report are based on casual blood pressures measured indirectly, primarily because this is the blood pressure determination most easily made. Although this is no trivial advantage, there are others. For one thing, this measurement is readily accepted by examinees, with the result that a blood pressure measurement was obtained for every person examined by the Health Examination Survey with the exception of one woman who was too obese to be measured with the apparatus in use. Any attempt to measure blood pressure directly—by inserting a catheter into an artery—would surely have entailed some sample loss because of refusal or technical failure, as would have an effort to obtain blood pressures involving hospital confinement.

Another advantage of casual blood pressures is that they are immediately referable to clinical experience. As part of an effort by the Health Examination Survey to evaluate the possibility of bias arising from nonresponse, inquiries were sent to the physicians of nonexamined persons asking, among other things, for a report of blood pressure measurements, if available. Similar inquiries were sent to the physicians of a matching set of examined persons. Not only was the average blood pressure measurement reported for each of these two groups similar—134/80 for examined and 135/81 for nonexamined—but for examined persons the average measurement reported by their physicians agreed exactly with their average measurement obtained by the Health Examination Survey—134/80 in both instances.

While the advantages of indirect pressures are numerous, it is necessary to note one of the disadvantages. This is the possibility (not definitely proved) that such measurements are affected by differences in upper arm girth. Ragan

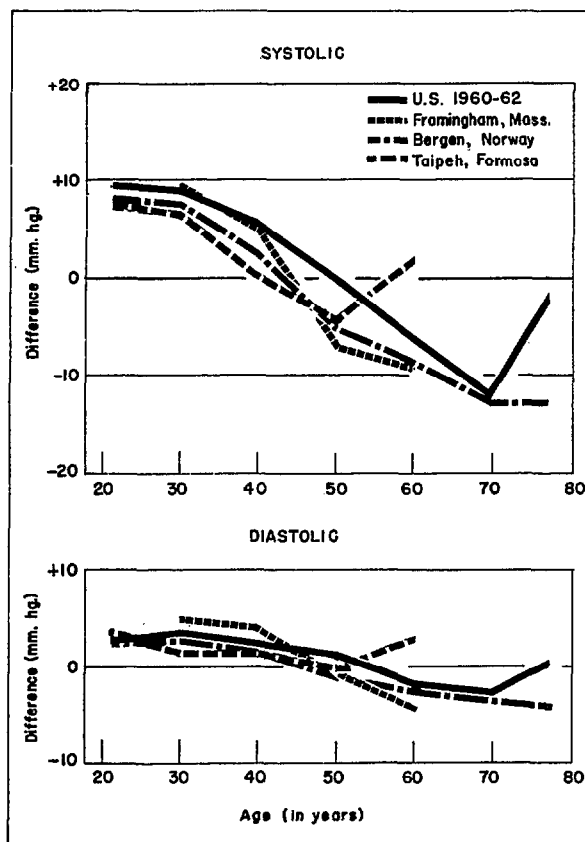


Figure 8. Mean difference between blood pressures for men and women: four surveys.

NOTE: Mean blood pressure for men minus mean blood pressure for women.

and Bordley in a study of 51 young adults found that for persons with arm girths of about 28 cm. the direct and indirect systolic pressures were nearly the same.¹⁰ With smaller arms the indirect pressure tended to be too low; with larger it tended to be too high. In the measurement of diastolic pressures (fourth phase) the indirect method tended to give results slightly too great even with small arm girths, and the disparity became greater as the arm girth increased. Since the majority of American adults have upper arm girths in excess of 28 cm. it would follow that the absolute levels reported for the U.S. population are higher than a set of direct measurements of blood pressure would show them to be.

Arm girths tend to increase with age. It might therefore be surmised that indirect blood pressure measurements would exaggerate the true rate at which mean blood pressures increase with age, and some studies have introduced "corrections" for this effect. Figure 9 suggests that these efforts are hardly justified. While mean blood pressures are higher for larger arm girths than for smaller, the rate of increase of blood pressure with age seems practically the same for persons of any specified arm girth as for all persons combined. Obviously this cannot be completely so, but it does suggest that survey data hardly lend themselves to such refined analysis.

What makes this measurement artifact especially unfortunate is that fatter people tend to have larger arm girths. To what extent the higher blood pressure associated with a greater arm girth really is a consequence of a positive association of blood pressure with obesity has never been accurately determined. The data from Ragan and Bordley¹⁰ and from other studies, while suggesting that for a given direct blood pressure the indirect blood pressure tends to rise as arm girth increases, are still too scanty to provide accurate estimates of the numerical extent of this effect, or indeed to prove that such an effect exists.

For this and other reasons, differences between surveys in the absolute levels of blood pressure reported are very difficult to interpret. The difficulty is clearly delineated by Bøe *et al.* in reporting the data from the Bergen survey.⁶ This was a complete survey of the population of Bergen done in conjunction with a compulsory X-ray examination. Some 68,000 persons were

measured. Between January and June 1950 the Northern District of Bergen was surveyed, and from January to May 1951 the Southern District was surveyed. The Southern District had systolic pressures for the various age groups 5 to 7 per cent lower than the Northern and diastolic pressures for most age groups 1 to 2 per cent higher. (The data from the Northern District are used in figures 5 and 6. Had data from the Southern District been used instead, the systolic pressures would have been close to those reported by the Health Examination Survey, while the diastolic would have been slightly higher.) Since the populations in these two areas differed relatively little by any of the usual indices, the most logical explanation for the reported difference in blood pressure levels was some minor difference in the circumstances of the examination or the measurement technique. Bøe *et al.* concluded: "The results seem to emphasize that one should not attach too much importance to absolute figures and give warning that it may be dangerous to compare investigations . . ."

The point that emerged from the examination of the Bergen data was that despite differences in absolute levels, the trend of blood pressure levels with increasing age and the sex differentials were practically identical in the two districts.⁶ This basic agreement is not surprising since, for all practical purposes, both groups were large samples of the same population. When this is not the case, and particularly when the populations are special groups—such as employed groups, military personnel, or insured persons—it becomes difficult to judge whether the reported differences reflect selective factors or are produced by some other means.

Nor can the effects of selectivity be assessed on an *a priori* basis. A standard reference for clinicians for many years has been the data on blood pressure reported by Master *et al.*¹¹ These were obtained from a sample of industrial populations and civilian employees at military bases during World War II and appear to derive largely from pre-employment physical examinations. Despite the ostensible peculiarities of this sample, the findings correspond closely to those from the Health Examination Survey.

Another factor to consider in judging survey results is the setting in which the blood pressure was observed. There is some evidence that blood

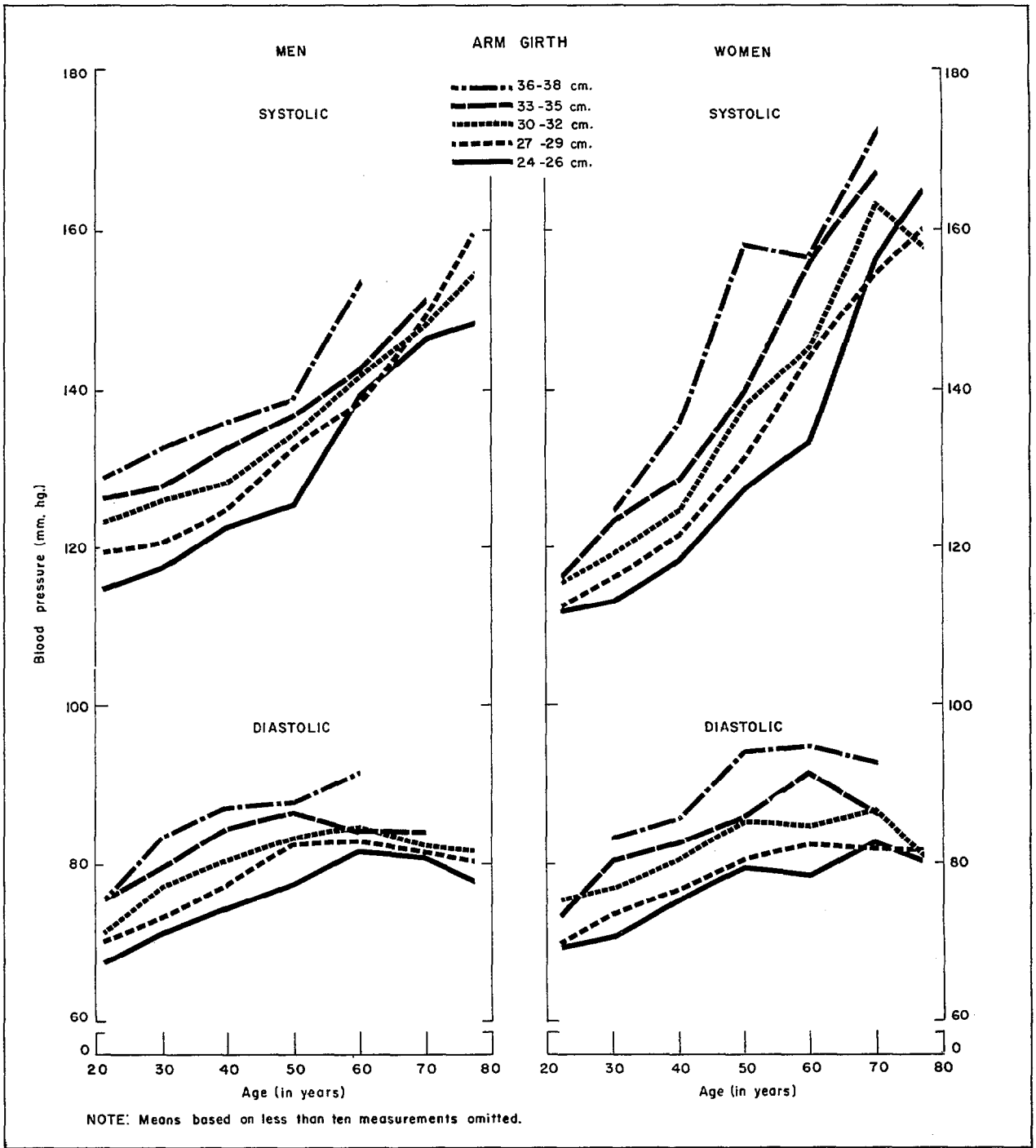


Figure 9. Mean blood pressure, by age for men and women with specified arm girths: Health Examination Survey.

pressure measurements taken in a clinical setting tend to be higher than measurements taken at home.^{12,13} Of the four surveys cited in this report only one was conducted at home and this survey reported generally lower blood pressures than the others.

Re-examination may partly dissipate the effect of a clinic setting. In one study, blood pressures measured 3 weeks to 4 months after the initial survey were less by 3.9 mm.hg. for systolic pressures and 3.6 mm.hg. for diastolic.¹⁴ In another study pressures measured 40 to 80 hours later averaged 5.2 mm.hg. lower for systolic and 1.5 mm.hg. lower for diastolic pressures.¹³ In the Framingham Heart Study⁵ blood pressure levels in the sample group were less by 3.8 mm.hg. systolic and 2.9 mm.hg. diastolic when measured 2 years after the initial survey and the level decreased again (although by a lesser amount) at the next biennial examination. A group of volunteers who were included in the same survey, and examined in exactly the same fashion as the sample persons, did not exhibit this trend. Since the Health Examination Survey performed only a single examination and did not accept volunteers for examination, it is reasonable to assume that in terms of the circumstances under which they were obtained the blood pressure data from the Health Examination Survey are comparable with those from the first examination at Framingham.

Still another factor influencing the blood pressure data from the Health Examination Survey was the use of a large number of physicians. Altogether 62 physicians were employed, each examining about 80 persons. It is clear that there was a measurable difference among physicians in their blood pressure determinations. This difference presumably has two causes. The first is what Ayman and Goldshine¹⁵ called "the pressor effect of the physician's presence" on the

patient, an effect which may be assumed to vary from one physician to another. The second arises from differences in measurement technique. When a measurement depends upon one's hearing changes in sound while simultaneously observing the level of a rapidly moving column of mercury, it must be taken for granted that, other things being equal, different observers will make different determinations. The extent of such differences is discussed in Appendix III. There is little indication that this observer variation has biased the blood pressure findings of the Health Examination Survey, but it does decrease their precision.

SUMMARY

1. Mean systolic pressure in the U.S. population rises over the age range 18-79 years, the rate of rise tending to increase with age. Mean diastolic pressure rises until 45-54 years of age for men and 55-64 years for women; at older ages it declines.
2. Under age 45 blood pressures are higher for men than for women; over age 54 blood pressures are higher for women than for men.
3. Findings for other population groups are generally similar to those for the United States.
4. A larger arm girth is associated with higher blood pressures. For any specified arm girth, however, mean blood pressures rise with age. There is little diurnal variation in mean blood pressure.
5. Blood pressure levels presented in this report seem comparable with those obtained in the usual clinical situation and are similar to the standards presently in use in the United States.

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DETAILED TABLES

		Page
Table 1.	Number of adults aged 18-79 years, by specified systolic and diastolic blood pressures: United States, 1960-62-----	18
2.	Number of men aged 18-79 years, by specified systolic and diastolic blood pressures: United States, 1960-62-----	19
3.	Number of women aged 18-79 years, by specified systolic and diastolic blood pressures: United States, 1960-62-----	20
4.	Number of men aged 18-24 years, by specified systolic and diastolic blood pressures: United States, 1960-62-----	21
5.	Number of men aged 25-34 years, by specified systolic and diastolic blood pressures: United States, 1960-62-----	22
6.	Number of men aged 35-44 years, by specified systolic and diastolic blood pressures: United States, 1960-62-----	23
7.	Number of men aged 45-54 years, by specified systolic and diastolic blood pressures: United States, 1960-62-----	24
8.	Number of men aged 55-64 years, by specified systolic and diastolic blood pressures: United States, 1960-62-----	25
9.	Number of men aged 65-74 years, by specified systolic and diastolic blood pressures: United States, 1960-62-----	26
10.	Number of men aged 75-79 years, by specified systolic and diastolic blood pressures: United States, 1960-62-----	27
11.	Number of women aged 18-24 years, by specified systolic and diastolic blood pressures: United States, 1960-62-----	28
12.	Number of women aged 25-34 years, by specified systolic and diastolic blood pressures: United States, 1960-62-----	29
13.	Number of women aged 35-44 years, by specified systolic and diastolic blood pressures: United States, 1960-62-----	30
14.	Number of women aged 45-54 years, by specified systolic and diastolic blood pressures: United States, 1960-62-----	31
15.	Number of women aged 55-64 years, by specified systolic and diastolic blood pressures: United States, 1960-62-----	32
16.	Number of women aged 65-74 years, by specified systolic and diastolic blood pressures: United States, 1960-62-----	33
17.	Number of women aged 75-79 years, by specified systolic and diastolic blood pressures: United States, 1960-62-----	34

Table 1. Number of adults aged 18-79 years, by specified systolic and diastolic blood pressures: United States, 1960-62

Systolic blood pressure (mm. hg.)	Diastolic blood pressure (mm. hg.)									
	Total	Under 50	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-89
Number of adults in thousands										
Total-----	111,087	898	1,124	2,661	6,664	13,290	16,984	21,078	16,977	12,453
Under 90-----	259	43	52	102	12	18	24	9	-	-
90-99-----	3,248	160	239	537	1,006	843	280	127	56	-
100-109-----	12,849	254	374	1,006	2,153	3,651	3,187	1,769	384	71
110-119-----	23,321	184	266	644	1,947	4,216	6,510	5,831	2,775	835
120-129-----	22,883	80	125	291	1,019	2,448	3,869	6,243	5,206	2,667
130-139-----	17,844	30	55	14	242	1,114	1,693	3,906	4,369	3,604
140-149-----	11,073	-	-	25	133	417	494	1,665	2,210	2,435
150-159-----	7,076	45	14	27	60	212	505	767	814	1,209
160-169-----	4,499	58	-	15	34	211	142	397	690	586
170-179-----	3,021	44	-	-	16	143	62	165	222	424
180-189-----	1,926	-	-	-	41	-	72	56	219	286
190-199-----	1,472	-	-	-	-	-	105	80	32	218
200-209-----	774	-	-	-	-	-	26	26	-	60
210-219-----	399	-	-	-	-	18	-	21	-	26
220-229-----	194	-	-	-	-	-	16	-	-	32
230-239-----	135	-	-	-	-	-	-	16	-	-
240-249-----	11	-	-	-	-	-	-	-	-	-
250-259-----	32	-	-	-	-	-	-	-	-	-
260+-----	73	-	-	-	-	-	-	-	-	-
Diastolic blood pressure (mm. hg.)—Con.										
Systolic blood pressure (mm. hg.)	90-94	95-99	100-104	105-109	110-114	115-119	120-124	125-129	130-134	135+
Number of adults in thousands—Con.										
Total-----	7,764	4,995	2,597	1,654	665	607	268	171	81	154
Under 90-----	-	-	-	-	-	-	-	-	-	-
90-99-----	-	-	-	-	-	-	-	-	-	-
100-109-----	-	-	-	-	-	-	-	-	-	-
110-119-----	98	14	-	-	-	-	-	-	-	-
120-129-----	757	177	-	-	-	-	-	-	-	-
130-139-----	1,758	771	210	46	32	-	-	-	-	-
140-149-----	2,002	1,094	430	139	29	-	-	-	-	-
150-159-----	1,202	1,330	511	271	56	52	-	-	-	-
160-169-----	799	640	413	303	118	66	29	-	-	-
170-179-----	515	462	398	312	90	131	38	-	-	-
180-189-----	351	221	256	163	130	99	31	-	-	-
190-199-----	149	218	198	223	68	67	93	-	21	-
200-209-----	101	67	137	43	74	74	52	66	18	29
210-219-----	16	-	44	48	54	91	16	32	32	-
220-229-----	16	-	-	43	16	-	-	60	-	11
230-239-----	-	-	-	63	-	-	8	12	10	25
240-249-----	-	-	-	-	-	-	-	-	-	11
250-259-----	-	-	-	-	-	13	-	-	-	18
260+-----	-	-	-	-	-	13	-	-	-	60

Table 2. Number of men aged 18-79 years, by specified systolic and diastolic blood pressures: United States, 1960-62

Systolic blood pressure (mm.hg.)	Diastolic blood pressure (mm. hg.)									
	Total	Under 50	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-89
Number of men in thousands										
Total-----	52,744	546	423	986	2,614	5,748	7,491	10,640	8,044	6,642
Under 90-----	43	21	-	23	-	-	-	-	-	-
90-99-----	696	59	34	92	187	143	99	44	39	-
100-109-----	4,137	133	111	300	743	911	1,087	690	90	71
110-119-----	10,157	150	141	349	791	1,912	2,644	2,568	1,165	407
120-129-----	12,375	80	89	208	559	1,588	1,934	3,476	2,588	1,328
130-139-----	10,268	30	47	-	154	674	967	2,313	2,110	2,071
140-149-----	6,194	-	-	14	95	288	311	800	1,131	1,456
150-159-----	3,960	30	-	-	37	114	315	549	355	721
160-169-----	2,053	44	-	-	15	75	53	133	400	286
170-179-----	1,309	-	-	-	16	44	20	66	152	178
180-189-----	604	-	-	-	17	-	30	-	14	125
190-199-----	501	-	-	-	-	-	-	-	-	-
200-209-----	248	-	-	-	-	-	14	-	-	-
210-219-----	74	-	-	-	-	-	-	-	-	-
220-229-----	77	-	-	-	-	-	16	-	-	-
230-239-----	27	-	-	-	-	-	-	-	-	-
240-249-----	-	-	-	-	-	-	-	-	-	-
250-259-----	18	-	-	-	-	-	-	-	-	-
Diastolic blood pressure (mm. hg.)—Con.										
Systolic blood pressure (mm.hg.)	90-94	95-99	100-104	105-109	110-114	115-119	120-124	125-129	130-134	135+
Number of men in thousands —Con.										
Total-----	4,050	2,695	1,222	800	375	228	107	25	49	58
Under 90-----	-	-	-	-	-	-	-	-	-	-
90-99-----	-	-	-	-	-	-	-	-	-	-
100-109-----	-	-	-	-	-	-	-	-	-	-
110-119-----	31	-	-	-	-	-	-	-	-	-
120-129-----	383	141	-	-	-	-	-	-	-	-
130-139-----	1,181	558	134	28	-	-	-	-	-	-
140-149-----	1,128	558	279	107	29	-	-	-	-	-
150-159-----	658	751	221	130	43	36	-	-	-	-
160-169-----	298	307	167	139	98	26	13	-	-	-
170-179-----	134	198	152	200	72	49	28	-	-	-
180-189-----	105	54	70	70	47	54	16	-	-	-
190-199-----	77	104	153	69	20	34	24	-	21	-
200-209-----	56	24	47	14	25	29	10	-	-	29
210-219-----	-	-	-	-	40	-	16	-	18	-
220-229-----	-	-	-	26	-	-	-	25	-	11
230-239-----	-	-	-	17	-	-	-	-	10	-
240-249-----	-	-	-	-	-	-	-	-	-	-
250-259-----	-	-	-	-	-	-	-	-	-	18

Table 3. Number of women aged 18-79 years, by specified systolic and diastolic blood pressures: United States, 1960-62

Systolic blood pressure (mm. hg.)	Diastolic blood pressure (mm. hg.)									
	Total	Under 50	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-89
Number of women in thousands										
Total-----	58,343	352	701	1,675	4,050	7,542	9,493	10,439	8,934	5,811
Under 90-----	216	22	52	79	12	18	24	9	-	-
90-99-----	2,551	102	205	446	819	700	181	82	17	-
100-109-----	8,712	121	262	706	1,409	2,740	2,100	1,079	294	-
110-119-----	13,163	34	125	295	1,156	2,304	3,866	3,263	1,610	428
120-129-----	10,508	-	36	83	460	861	1,934	2,767	2,619	1,339
130-139-----	7,576	-	7	14	88	441	726	1,594	2,259	1,533
140-149-----	4,879	-	-	10	39	129	183	865	1,079	979
150-159-----	3,116	15	14	27	24	98	190	218	460	488
160-169-----	2,446	14	-	15	19	136	88	264	290	300
170-179-----	1,713	44	-	-	-	99	41	98	70	247
180-189-----	1,322	-	-	-	24	-	42	56	204	161
190-199-----	971	-	-	-	-	-	105	80	32	218
200-209-----	526	-	-	-	-	-	12	26	-	60
210-219-----	324	-	-	-	-	18	-	21	-	26
220-229-----	116	-	-	-	-	-	-	-	-	32
230-239-----	108	-	-	-	-	-	-	16	-	-
240-249-----	11	-	-	-	-	-	-	-	-	-
250-259-----	13	-	-	-	-	-	-	-	-	-
260+-----	73	-	-	-	-	-	-	-	-	-
Diastolic blood pressure (mm. hg.)—Con.										
Systolic blood pressure (mm. hg.)	90-94	95-99	100-104	105-109	110-114	115-119	120-124	125-129	130-134	135+
Number of women in thousands—Con.										
Total-----	3,714	2,299	1,375	854	290	379	161	146	33	96
Under 90-----	-	-	-	-	-	-	-	-	-	-
90-99-----	-	-	-	-	-	-	-	-	-	-
100-109-----	-	-	-	-	-	-	-	-	-	-
110-119-----	67	14	-	-	-	-	-	-	-	-
120-129-----	374	36	-	-	-	-	-	-	-	-
130-139-----	577	213	76	17	32	-	-	-	-	-
140-149-----	875	536	151	32	-	-	-	-	-	-
150-159-----	545	578	290	141	12	16	-	-	-	-
160-169-----	501	333	246	164	20	41	16	-	-	-
170-179-----	381	264	246	112	17	82	10	-	-	-
180-189-----	246	167	187	93	82	44	15	-	-	-
190-199-----	72	114	45	153	48	33	69	-	-	-
200-209-----	45	43	90	29	49	45	42	66	18	-
210-219-----	16	-	44	48	13	91	-	32	14	-
220-229-----	16	-	-	18	16	-	-	35	-	-
230-239-----	-	-	-	46	-	-	8	12	-	25
240-249-----	-	-	-	-	-	-	-	-	-	11
250-259-----	-	-	-	-	-	13	-	-	-	-
260+-----	-	-	-	-	-	13	-	-	-	60

Table 4. Number of men aged 18-24 years, by specified systolic and diastolic blood pressures: United States, 1960-62

Systolic blood pressure (mm.hg.)	Diastolic blood pressure (mm. hg.)						
	Total	Under 50	50-54	55-59	60-64	65-69	70-74
Number of men in thousands							
Total-----	7,139	358	256	336	914	957	1,205
Under 90-----	21	21	-	-	-	-	-
90-99-----	155	31	34	48	-	-	16
100-109-----	999	82	39	112	254	197	144
110-119-----	2,178	95	108	122	316	431	495
120-129-----	1,896	68	61	54	174	199	346
130-139-----	1,197	30	13	-	107	117	130
140-149-----	521	-	-	-	26	13	34
150-159-----	156	30	-	-	37	-	38
160+-----	15	-	-	-	-	-	-
Diastolic blood pressure (mm. hg.)--Con.							
Systolic blood pressure (mm. hg.)	75-79	80-84	85-89	90-94	95-99	100-104	
Number of men in thousands--Con.							
Total-----	1,494	726	400	371	96	25	
Under 90-----	-	-	-	-	-	-	
90-99-----	-	26	-	-	-	-	
100-109-----	105	10	57	-	-	-	
110-119-----	416	149	46	-	-	-	
120-129-----	648	255	90	-	-	-	
130-139-----	246	241	55	193	63	-	
140-149-----	42	45	139	178	33	10	
150-159-----	37	-	14	-	-	-	
160+-----	-	-	-	-	-	15	

Table 5. Number of men aged 25-34 years, by specified systolic and diastolic blood pressures: United States, 1960-62

Systolic blood pressure (mm. hg.)	Diastolic blood pressure (mm. hg.)							
	Total	Under 50	50-54	55-59	60-64	65-69	70-74	75-79
Number of men in thousands								
Total-----	10,281	129	51	165	768	1,494	1,773	2,275
Under 90-----	-	-	-	-	-	-	-	-
90-99-----	203	28	-	-	113	62	-	-
100-109-----	1,129	50	7	76	152	289	258	283
110-119-----	2,390	24	14	89	217	506	602	571
120-129-----	3,187	12	13	-	257	440	489	958
130-139-----	2,025	-	17	-	28	156	327	354
140-149-----	927	-	-	-	-	40	55	54
150-159-----	311	-	-	-	-	-	42	56
160-169-----	88	14	-	-	-	-	-	-
170-179-----	8	-	-	-	-	-	-	-
180+-----	13	-	-	-	-	-	-	-
Diastolic blood pressure (mm. hg.)--Con.								
Systolic blood pressure (mm. hg.)	80-84	85-89	90-94	95-99	100-104	105-109	110-114	115+
Number of men in thousands--Con.								
Total-----	1,706	1,029	424	250	65	116	-	37
Under 90-----	-	-	-	-	-	-	-	-
90-99-----	-	-	-	-	-	-	-	-
100-109-----	14	-	-	-	-	-	-	-
110-119-----	318	48	-	-	-	-	-	-
120-129-----	630	260	116	11	-	-	-	-
130-139-----	453	421	129	133	7	-	-	-
140-149-----	252	255	147	52	13	60	-	-
150-159-----	26	38	31	53	11	43	-	11
160-169-----	13	8	-	-	26	13	-	13
170-179-----	-	-	-	-	8	-	-	-
180+-----	-	-	-	-	-	-	-	13

Table 6. Number of men aged 35-44 years, by specified systolic and diastolic blood pressures: United States, 1960-62

Systolic blood pressure (mm. hg.)	Diastolic blood pressure (mm. hg.)								
	Total	Under 50	50-54	55-59	60-64	65-69	70-74	75-79	
Number of men in thousands									
Total-----	11,373	14	86	205	408	922	1,736	2,449	
Under 90-----	-	-	-	-	-	-	-	-	
90-99-----	95	-	-	18	34	-	31	11	
100-109-----	1,012	-	52	76	175	127	373	142	
110-119-----	2,755	14	19	56	122	344	771	901	
120-129-----	2,894	-	15	55	77	346	380	700	
130-139-----	2,153	-	-	-	-	84	115	497	
140-149-----	1,171	-	-	-	-	-	14	148	
150-159-----	703	-	-	-	-	21	20	39	
160-169-----	267	-	-	-	-	-	31	12	
170-179-----	240	-	-	-	-	-	-	-	
180-189-----	21	-	-	-	-	-	-	-	
190-199-----	12	-	-	-	-	-	-	-	
200+-----	50	-	-	-	-	-	-	-	
Diastolic blood pressure (mm. hg.)—Cbn.									
Systolic blood pressure (mm. hg.)	80-84	85-89	90-94	95-99	100-104	105-109	110-114	115-119	120+
Number of men in thousands—Con.									
Total-----	1,756	1,426	929	797	295	175	94	13	67
Under 90-----	-	-	-	-	-	-	-	-	-
90-99-----	-	-	-	-	-	-	-	-	-
100-109-----	52	15	-	-	-	-	-	-	-
110-119-----	360	138	31	-	-	-	-	-	-
120-129-----	711	417	130	63	-	-	-	-	-
130-139-----	400	525	298	181	41	11	-	-	-
140-149-----	206	248	252	161	118	24	-	-	-
150-159-----	13	69	194	216	74	13	43	-	-
160-169-----	13	-	7	79	32	52	41	-	-
170-179-----	-	15	17	97	9	62	9	13	17
180-189-----	-	-	-	-	21	-	-	-	-
190-199-----	-	-	-	-	-	12	-	-	-
200+-----	-	-	-	-	-	-	-	-	50

Table 7. Number of men aged 45-54 years, by specified systolic and diastolic blood pressures: United States, 1960-62

Systolic blood pressure (mm. hg.)	Diastolic blood pressure (mm. hg.)									
	Total	Under 50	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-89
Number of men in thousands										
Total-----	10,034	30	-	70	139	798	1,176	1,871	1,794	1,726
90-99-----	120	-	-	17	12	21	24	33	13	-
100-109-----	526	-	-	37	56	175	203	42	14	-
110-119-----	1,523	-	-	-	54	380	401	383	219	85
120-129-----	2,200	-	-	17	-	90	398	566	593	381
130-139-----	2,575	-	-	-	-	30	107	626	658	626
140-149-----	1,258	-	-	-	17	88	17	125	183	304
150-159-----	941	-	-	-	-	15	27	95	56	205
160-169-----	467	30	-	-	-	-	-	-	59	88
170-179-----	197	-	-	-	-	-	-	-	-	14
180-189-----	133	-	-	-	-	-	-	-	-	23
190-199-----	56	-	-	-	-	-	-	-	-	-
200-209-----	38	-	-	-	-	-	-	-	-	-
Diastolic blood pressure (mm. hg.)—Con.										
Systolic blood pressure (mm. hg.)	90-94	95-99	100-104	105-109	110-114	115-119	120-124	125-129	130-134	135+
Number of men in thousands—Con.										
Total-----	847	701	358	223	133	95	51	-	8	13
90-99-----	-	-	-	-	-	-	-	-	-	-
100-109-----	-	-	-	-	-	-	-	-	-	-
110-119-----	-	-	-	-	-	-	-	-	-	-
120-129-----	110	46	-	-	-	-	-	-	-	-
130-139-----	298	167	46	17	-	-	-	-	-	-
140-149-----	220	158	108	9	29	-	-	-	-	-
150-159-----	108	258	104	48	-	25	-	-	-	-
160-169-----	111	53	24	41	47	16	-	-	-	-
170-179-----	-	20	42	51	32	28	11	-	-	-
180-189-----	-	-	20	57	-	17	16	-	-	-
190-199-----	-	-	15	-	-	8	24	-	8	-
200-209-----	-	-	-	-	25	-	-	-	-	13

Table 8. Number of men aged 55-64 years, by specified systolic and diastolic blood pressures: United States, 1960-62

Systolic blood pressure (mm. hg.)	Diastolic blood pressure (mm. hg.)									
	Total	Under 50	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-89
Number of men in thousands										
Total-----	7,517	-	13	80	161	652	726	1,444	1,111	1,305
90-99-----	41	-	-	9	-	32	-	-	-	-
100-109-----	307	-	13	-	63	78	73	81	-	-
110-119-----	893	-	-	23	28	184	288	223	88	59
120-129-----	1,361	-	-	33	36	267	162	380	278	157
130-139-----	1,291	-	-	-	-	80	91	347	209	307
140-149-----	1,394	-	-	14	19	12	80	180	240	374
150-159-----	945	-	-	-	-	-	18	172	100	233
160-169-----	580	-	-	-	15	-	-	61	133	126
170-179-----	327	-	-	-	-	-	-	-	63	18
180-189-----	149	-	-	-	-	-	14	-	-	31
190-199-----	115	-	-	-	-	-	-	-	-	-
200-209-----	66	-	-	-	-	-	-	-	-	-
210-219-----	18	-	-	-	-	-	-	-	-	-
220-229-----	29	-	-	-	-	-	-	-	-	-
230-239-----	-	-	-	-	-	-	-	-	-	-
240-249-----	-	-	-	-	-	-	-	-	-	-
250-259-----	-	-	-	-	-	-	-	-	-	-
Diastolic blood pressure (mm. hg.)—Con.										
Systolic blood pressure (mm. hg.)	90-94	95-99	100-104	105-109	110-114	115-119	120-124	125-129	130-134	135+
Number of men in thousands—Con.										
Total-----	999	513	226	146	47	47	-	-	18	29
90-99-----	-	-	-	-	-	-	-	-	-	-
100-109-----	-	-	-	-	-	-	-	-	-	-
110-119-----	-	-	-	-	-	-	-	-	-	-
120-129-----	27	21	-	-	-	-	-	-	-	-
130-139-----	204	14	40	-	-	-	-	-	-	-
140-149-----	309	121	30	14	-	-	-	-	-	-
150-159-----	187	188	32	14	-	-	-	-	-	-
160-169-----	117	85	33	-	-	9	-	-	-	-
170-179-----	79	-	42	86	31	8	-	-	-	-
180-189-----	35	37	-	-	16	16	-	-	-	-
190-199-----	-	46	37	32	-	-	-	-	-	-
200-209-----	40	-	11	-	-	14	-	-	-	-
210-219-----	-	-	-	-	-	-	-	-	18	-
220-229-----	-	-	-	-	-	-	-	-	-	11
230-239-----	-	-	-	-	-	-	-	-	-	-
240-249-----	-	-	-	-	-	-	-	-	-	-
250-259-----	-	-	-	-	-	-	-	-	-	18

Table 9. Number of men aged 65-74 years, by specified systolic and diastolic blood pressures: United States, 1960-62

Systolic blood pressure (mm. hg.)	Diastolic blood pressure (mm. hg.)								
	Total	55-59	60-64	65-69	70-74	75-79	80-84	85-89	
Number of men in thousands									
Total-----	4,972	93	102	710	789	898	677	623	
Under 90-----	23	23	-	-	-	-	-	-	
90-99-----	42	-	-	15	27	-	-	-	
100-109-----	141	-	23	45	35	38	-	-	
110-119-----	309	41	14	67	86	52	17	32	
120-129-----	726	29	15	232	159	201	65	24	
130-139-----	858	-	18	94	198	223	149	118	
140-149-----	749	-	16	108	111	198	150	113	
150-159-----	681	-	-	78	85	101	124	139	
160-169-----	474	-	-	49	23	38	103	44	
170-179-----	414	-	16	22	20	46	69	115	
180-189-----	150	-	-	-	16	-	-	39	
190-199-----	253	-	-	-	-	-	-	-	
200-209-----	53	-	-	-	14	-	-	-	
210-219-----	56	-	-	-	-	-	-	-	
220-229-----	16	-	-	-	16	-	-	-	
230-239-----	27	-	-	-	-	-	-	-	
Diastolic blood pressure (mm. hg.)—Con.									
Systolic blood pressure (mm. hg.)	90-94	95-99	100-104	105-109	110-114	115-119	120-124	125-129	130-134
Number of men in thousands—Con.									
Total-----	357	250	205	99	81	62	16		10
Under 90-----	-	-	-	-	-	-	-	-	-
90-99-----	-	-	-	-	-	-	-	-	-
100-109-----	-	-	-	-	-	-	-	-	-
110-119-----	-	-	-	-	-	-	-	-	-
120-129-----	-	-	-	-	-	-	-	-	-
130-139-----	58	-	-	-	-	-	-	-	-
140-149-----	21	32	-	-	-	-	-	-	-
150-159-----	120	23	-	11	-	-	-	-	-
160-169-----	63	76	37	33	9	-	-	-	-
170-179-----	38	52	36	-	-	-	-	-	-
180-189-----	-	-	30	13	31	22	-	-	-
190-199-----	56	58	88	25	-	25	-	-	-
200-209-----	-	9	14	-	-	15	-	-	-
210-219-----	-	-	-	-	40	-	16	-	-
220-229-----	-	-	-	-	-	-	-	-	-
230-239-----	-	-	-	17	-	-	-	-	10

Table 10. Number of men aged 75-79 years, by specified systolic and diastolic blood pressures: United States, 1960-62

Systolic blood pressure (mm. hg.)	Diastolic blood pressure (mm. hg.)							
	Total	Under 50	50-54	55-59	60-64	65-69	70-74	75-79
Number of men in thousands								
Total-----	1,428	16	17	38	121	214	86	209
90-99-----	40	-	-	-	28	13	-	-
100-109-----	21	-	-	-	21	-	-	-
110-119-----	109	16	-	18	38	-	-	22
120-129-----	111	-	-	19	-	14	-	23
130-139-----	168	-	17	-	-	113	-	19
140-149-----	174	-	-	-	17	27	-	53
150-159-----	223	-	-	-	-	-	86	49
160-169-----	178	-	-	-	-	26	-	23
170-179-----	107	-	-	-	-	21	-	20
180-189-----	151	-	-	-	17	-	-	-
190-199-----	53	-	-	-	-	-	-	-
200-209-----	66	-	-	-	-	-	-	-
210-219-----	-	-	-	-	-	-	-	-
220-229-----	26	-	-	-	-	-	-	-
Diastolic blood pressure (mm. hg.)—Con.								
Systolic blood pressure (mm. hg.)	80-84	85-89	90-94	95-99	100-104	105-109	110-114	
Number of men in thousands—Con.								
Total-----	274	132	122	89	49	40	20	
90-99-----	-	-	-	-	-	-	-	
100-109-----	-	-	-	-	-	-	-	
110-119-----	15	-	-	-	-	-	-	
120-129-----	54	-	-	-	-	-	-	
130-139-----	-	19	-	-	-	-	-	
140-149-----	55	22	-	-	-	-	-	
150-159-----	35	23	16	15	-	-	-	
160-169-----	80	20	-	14	15	-	-	
170-179-----	20	16	-	29	-	-	-	
180-189-----	14	32	71	17	-	-	-	
190-199-----	-	-	20	-	13	-	20	
200-209-----	-	-	16	15	21	14	-	
210-219-----	-	-	-	-	-	-	-	
220-229-----	-	-	-	-	-	26	-	

Table 11. Number of women aged 18-24 years, by specified systolic and diastolic blood pressures: United States, 1960-62

Systolic blood pressure (mm. hg.)	Diastolic blood pressure (mm. hg.)						
	Total	Under 50	50-54	55-59	60-64	65-69	70-74
Number of women in thousands							
Total-----	8,430	177	357	656	1,316	1,728	1,804
Under 90-----	67	10	18	30	-	-	-
90-99-----	1,031	75	75	186	409	194	57
100-109-----	2,773	93	113	276	493	868	676
110-119-----	2,508	-	109	147	323	448	686
120-129-----	1,497	-	36	17	61	185	346
130-139-----	448	-	7	-	29	34	40
140-149-----	64	-	-	-	-	-	-
150-159-----	34	-	-	-	-	-	-
160-169-----	7	-	-	-	-	-	-
Diastolic blood pressure (mm. hg.)--Con.							
Systolic blood pressure (mm. hg.)	75-79	80-84	85-89	90-94	95-99	100+	
Number of women in thousands--Con.							
Total-----	1,202	798	219	75	79	19	
Under 90-----	9	-	-	-	-	-	
90-99-----	37	-	-	-	-	-	
100-109-----	177	78	-	-	-	-	
110-119-----	458	234	84	19	-	-	
120-129-----	423	304	73	38	15	-	
130-139-----	99	164	39	-	35	-	
140-149-----	-	17	-	7	28	12	
150-159-----	-	-	23	11	-	-	
160-169-----	-	-	-	-	-	7	

Table 12. Number of women aged 25-34 years, by specified systolic and diastolic blood pressures: United States, 1960-62

Systolic blood pressure (mm. hg.)	Diastolic blood pressure (mm. hg.)							
	Total	Under 50	50-54	55-59	60-64	65-69	70-74	75-79
Number of women in thousands								
Total-----	11,291	74	275	529	1,286	2,098	2,327	2,052
Under 90-----	102	13	12	49	12	-	16	-
90-99-----	928	27	110	168	253	326	29	16
100-109-----	2,440	-	136	216	503	697	537	259
110-119-----	4,174	34	16	75	389	787	1,289	1,028
120-129-----	2,255	-	-	21	112	234	427	497
130-139-----	935	-	-	-	17	54	30	202
140-149-----	222	-	-	-	-	-	-	51
150-159-----	116	-	-	-	-	-	-	-
160-169-----	73	-	-	-	-	-	-	-
170-179-----	34	-	-	-	-	-	-	-
180+-----	14	-	-	-	-	-	-	-
Diastolic blood pressure (mm. hg.)--Con.								
Systolic blood pressure (mm. hg.)	80-84	85-89	90-94	95-99	100-104	105-109	110-114	115+
Number of women in thousands--Con.								
Total-----	1,399	670	241	163	106	18	17	37
Under 90-----	-	-	-	-	-	-	-	-
90-99-----	-	-	-	-	-	-	-	-
100-109-----	90	-	-	-	-	-	-	-
110-119-----	447	88	7	14	-	-	-	-
120-129-----	582	300	70	12	-	-	-	-
130-139-----	263	215	108	20	-	9	17	-
140-149-----	-	66	31	73	-	-	-	-
150-159-----	16	-	14	43	17	9	-	16
160-169-----	-	-	11	-	62	-	-	-
170-179-----	-	-	-	-	27	-	-	7
180+-----	-	-	-	-	-	-	-	14

Table 13. Number of women aged 35-44 years, by specified systolic and diastolic blood pressures: United States, 1960-62

Systolic blood pressure (mm. hg.)	Diastolic blood pressure (mm. hg.)								
	Total	Under 50	50-54	55-59	60-64	65-69	70-74	75-79	80-84
Number of women in thousands									
Total-----	12,325	44	33	233	652	1,666	2,199	2,509	2,061
Under 90-----	16	-	8	-	-	-	8	-	-
90-99-----	391	-	12	37	118	97	89	30	8
100-109-----	2,134	28	13	137	270	609	593	387	97
110-119-----	3,571	-	-	59	210	706	973	1,031	452
120-129-----	2,794	-	-	-	55	206	351	747	822
130-139-----	1,761	-	-	-	-	48	164	269	513
140-149-----	747	-	-	-	-	-	21	12	103
150-159-----	436	-	-	-	-	-	-	34	66
160-169-----	245	-	-	-	-	-	-	-	-
170-179-----	87	16	-	-	-	-	-	-	-
180-189-----	102	-	-	-	-	-	-	-	-
190-199-----	21	-	-	-	-	-	-	-	-
200+-----	20	-	-	-	-	-	-	-	-
Diastolic blood pressure (mm. hg.)--Con.									
Systolic blood pressure (mm. hg.)	85-89	90-94	95-99	100-104	105-109	110-114	115-119	120-124	
Number of women in thousands--Con.									
Total-----	1,271	727	386	280	124	59	64	16	
Under 90-----	-	-	-	-	-	-	-	-	-
90-99-----	-	-	-	-	-	-	-	-	-
100-109-----	-	-	-	-	-	-	-	-	-
110-119-----	117	22	-	-	-	-	-	-	-
120-129-----	434	180	-	-	-	-	-	-	-
130-139-----	472	174	76	24	8	15	-	-	-
140-149-----	175	233	133	70	-	-	-	-	-
150-159-----	56	36	104	98	42	-	-	-	-
160-169-----	10	47	66	39	53	-	14	16	-
170-179-----	8	13	-	14	-	7	29	-	-
180-189-----	-	22	7	36	-	38	-	-	-
190-199-----	-	-	-	-	21	-	-	-	-
200+-----	-	-	-	-	-	-	20	-	-

Table 15. Number of women aged 55-64 years, by specified systolic and diastolic blood pressures: United States, 1960-62

Systolic blood pressure (mm. hg.)	Diastolic blood pressure (mm. hg.)									
	Total	Under 50	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-89
Number of women in thousands										
Total-----	8,121	15	-	70	231	394	950	1,431	1,403	1,154
90-99-----	42	-	-	-	28	14	-	-	-	-
100-109-----	250	-	-	-	34	100	86	23	8	-
110-119-----	714	-	-	-	87	99	216	179	105	10
120-129-----	1,242	-	-	45	63	44	285	419	233	133
130-139-----	1,370	-	-	-	-	80	196	329	385	278
140-149-----	1,587	-	-	-	-	21	47	423	337	368
150-159-----	794	15	-	10	-	21	33	-	112	199
160-169-----	757	-	-	15	19	-	60	23	106	92
170-179-----	454	-	-	-	-	17	-	-	70	30
180-189-----	306	-	-	-	-	-	-	21	15	42
190-199-----	314	-	-	-	-	-	28	15	32	-
200-209-----	113	-	-	-	-	-	-	-	-	-
210-219-----	56	-	-	-	-	-	-	-	-	-
220-229-----	25	-	-	-	-	-	-	-	-	-
230-239-----	50	-	-	-	-	-	-	-	-	-
240-249-----	11	-	-	-	-	-	-	-	-	-
250-259-----	-	-	-	-	-	-	-	-	-	-
260+-----	36	-	-	-	-	-	-	-	-	-
Diastolic blood pressure (mm. hg.)—Con.										
Systolic blood pressure (mm. hg.)	90-94	95-99	100-104	105-109	110-114	115-119	120-124	125-129	130-134	135+
Number of women in thousands—Con.										
Total-----	987	578	276	273	69	113	19	68	18	72
90-99-----	-	-	-	-	-	-	-	-	-	-
100-109-----	-	-	-	-	-	-	-	-	-	-
110-119-----	19	-	-	-	-	-	-	-	-	-
120-129-----	20	-	-	-	-	-	-	-	-	-
130-139-----	63	10	28	-	-	-	-	-	-	-
140-149-----	238	135	18	-	-	-	-	-	-	-
150-159-----	131	175	45	54	-	-	-	-	-	-
160-169-----	203	121	54	45	-	19	-	-	-	-
170-179-----	147	62	70	43	-	15	-	-	-	-
180-189-----	109	18	19	25	38	19	-	-	-	-
190-199-----	56	56	-	64	31	20	11	-	-	-
200-209-----	-	-	42	-	-	28	-	25	18	-
210-219-----	-	-	-	25	-	12	-	18	-	-
220-229-----	-	-	-	-	-	-	-	25	-	-
230-239-----	-	-	-	17	-	-	8	-	-	25
240-249-----	-	-	-	-	-	-	-	-	-	11
250-259-----	-	-	-	-	-	-	-	-	-	-
260+-----	-	-	-	-	-	-	-	-	-	36

Table 16. Number of women aged 65-74 years, by specified systolic and diastolic blood pressures: United States, 1960-62

Systolic blood pressure (mm. hg.)	Diastolic blood pressure (mm. hg.)								
	Total	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-89
Number of women in thousands									
Total-----	6,192	28	81	219	500	597	1,078	949	930
Under 90-----	14	14	-	-	-	-	-	-	-
90-99-----	42	-	30	11	-	-	-	-	-
100-109-----	52	-	40	-	11	-	-	-	-
110-119-----	252	-	-	25	39	122	66	-	-
120-129-----	506	-	-	62	47	136	87	72	101
130-139-----	755	-	-	41	88	61	250	201	73
140-149-----	767	-	10	39	78	83	176	235	73
150-159-----	897	14	-	24	46	63	123	233	140
160-169-----	733	-	-	-	110	-	190	108	100
170-179-----	566	-	-	-	62	-	22	-	106
180-189-----	518	-	-	17	-	42	35	99	57
190-199-----	533	-	-	-	-	78	65	-	208
200-209-----	267	-	-	-	-	12	26	-	46
210-219-----	196	-	-	-	18	-	21	-	26
220-229-----	50	-	-	-	-	-	-	-	-
230-239-----	45	-	-	-	-	-	16	-	-
Diastolic blood pressure (mm. hg.)--Con.									
Systolic blood pressure (mm. hg.)	90-94	95-99	100-104	105-109	110-114	115-119	120-124	125-129	130-134
Number of women in thousands--Con.									
Total-----	639	349	387	214	59	94	32	23	14
Under 90-----	-	-	-	-	-	-	-	-	-
90-99-----	-	-	-	-	-	-	-	-	-
100-109-----	-	-	-	-	-	-	-	-	-
110-119-----	-	-	-	-	-	-	-	-	-
120-129-----	-	-	-	-	-	-	-	-	-
130-139-----	16	24	-	-	-	-	-	-	-
140-149-----	43	-	29	-	-	-	-	-	-
150-159-----	119	42	75	18	-	-	-	-	-
160-169-----	145	37	25	18	-	-	-	-	-
170-179-----	167	87	76	24	-	22	-	-	-
180-189-----	57	73	76	36	-	26	-	-	-
190-199-----	16	59	38	38	-	-	32	-	-
200-209-----	45	27	24	22	43	-	-	23	-
210-219-----	16	-	44	10	-	46	-	-	14
220-229-----	16	-	-	18	16	-	-	-	-
230-239-----	-	-	-	29	-	-	-	-	-

Table 17. Number of women aged 75-79 years, by specified systolic and diastolic blood pressures: United States, 1960-62

Systolic blood pressure (mm. hg.)	Diastolic blood pressure (mm. hg.)									
	Total	Under 50	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85-89
	Number of women in thousands									
Total-----	1,443	14	-	32	86	200	237	191	168	206
100-109-----	17	-	-	-	-	-	-	17	-	-
110-119-----	49	-	-	-	25	-	25	-	-	-
120-129-----	136	-	-	-	62	22	18	20	-	14
130-139-----	164	-	-	14	-	71	25	-	-	32
140-149-----	229	-	-	-	-	30	32	51	94	-
150-159-----	213	-	-	17	-	30	80	26	18	14
160-169-----	165	14	-	-	-	26	18	28	10	22
170-179-----	219	-	-	-	-	21	41	48	-	57
180-189-----	136	-	-	-	-	-	-	-	47	26
190-199-----	41	-	-	-	-	-	-	-	-	10
200-209-----	42	-	-	-	-	-	-	-	-	-
210-219-----	-	-	-	-	-	-	-	-	-	-
220-229-----	32	-	-	-	-	-	-	-	-	32
	Diastolic blood pressure (mm. hg.)--Con.									
Systolic blood pressure (mm. hg.)	90-94		95-99		100-104		105-109		110+	
	Number of women in thousands--Con.									
Total-----	120		91		38		40		19	
100-109-----	-		-		-		-		-	
110-119-----	-		-		-		-		-	
120-129-----	-		-		-		-		-	
130-139-----	22		-		-		-		-	
140-149-----	21		-		-		-		-	
150-159-----	-		28		-		-		-	
160-169-----	22		25		-		-		-	
170-179-----	10		18		14		10		-	
180-189-----	43		21		-		-		-	
190-199-----	-		-		-		30		-	
200-209-----	-		-		24		-		19	
210-219-----	-		-		-		-		-	
220-229-----	-		-		-		-		-	

APPENDIX I

BLOOD PRESSURE MEASUREMENT

The techniques for measuring blood pressure used by the Health Examination Survey follow procedures suggested in the Report of the Conference on Longitudinal Cardiovascular Studies, National Heart Institute, Bethesda, Maryland, 1957 (the "Beaconsfield Report") which essentially follows the lines of the American Heart Association recommendations. This does not constitute a definitive specification, however, since in a number of particulars alternative suggestions are offered, and there is no really satisfactory basis for choosing between them. For example, in the recording of diastolic pressure some investigators prefer to use the fourth phase and some the fifth. It would have been possible for the Health Examination Survey to have reported both diastolic pressures, since both were tabulated, but this would simply have complicated the presentation without any apparent gain in utility.

The sphygmomanometers used in this Survey were standard instruments (Baumanometer). They are very durable and relatively trouble-free. There is some reason to believe, however, that occasionally these instruments—usually through unnoticed spillage of mercury—were slightly out of calibration, and it would have been desirable to have checked the instruments more frequently than was done.

In this report the average of the three readings was tabulated. Although the report of the Beaconsfield Conference permits this procedure, many persons with clinical training think it an unwarranted innovation. The fact is, of course, that the blood pressure for any individual is a constantly altering value, with periods when it is low and occasions when it is unusually high. Presumably if only one figure is to be used to characterize the blood pressure of an individual it should ideally integrate his total experience. If this cannot be ob-

tained, an average of several readings probably serves better than a single casual pressure, however standardized the circumstances of measurement for that single measure seem to be. Certainly for describing population groups it seems that an average of several blood pressure measurements is the preferable statistic, among the various possible alternatives, despite the obvious reluctance to use it.

There is no standard environment for taking a blood pressure measurement. The usual procedure is to try to have the examinee calm and rested before measurement but the specific program for arriving at this state is highly variable. Essentially, the procedure used in the Health Examination Survey might be considered as approximating the usual situation in clinical practice, with the blood pressure being measured, without special preparation, during the course of a physical examination. Other investigators, arguing that the home is a person's usual environment, prefer taking the blood pressure measurement there. Whatever the possible advantages to this technique, the difficulty of conducting an extended medical examination in a standardized fashion at home ruled this out for the Health Examination Survey.

The efforts that have been made to standardize blood pressure measurement, while highly useful, must ultimately be limited by the great lability of this measure. For survey purposes there is little real difference between the various acceptable alternative procedures. However, if the results of one survey are to be compared with those from another, it would be desirable to make the circumstances and techniques of measurement of both as similar as possible. In any case, there is a remarkable resemblance among the blood pressure findings of various surveys, despite recognized and unrecognized differences in procedure.



APPENDIX II

SURVEY DESIGN, MISSING DATA, AND VARIANCE

The Survey Design

The Health Examination Survey is designed as a highly stratified multistage sampling of the civilian, non-institutional population (aged 18-79 years) of the conterminous United States. The first stage of the plan is a sample of 42 primary sampling units (PSU's) from the 1,900 geographic units into which the United States has been divided. A PSU is a county, two or three contiguous counties, or a standard metropolitan statistical area. Later stages result in the random selection of clusters of about four persons from a small neighborhood within the PSU. The total sample included 7,710 persons in the 42 PSU's in 29 States. The detailed structure of the design and the conduct of the Survey have been described in previous reports.^{1, 2}

Reliability in Probability Surveys

The Survey draws strength from the fact that it is a probability sample of its total target population, and from the fact that the measurement processes which were employed were highly standardized and closely controlled. This does not mean, of course, that the correspondence between the real world and survey results is exact. Data from the Survey are imperfect for three important reasons: (1) results are subject to sampling error, (2) the actual conduct of a survey never agrees perfectly with the design, and (3) the measurement process itself is inexact, even when standardized and controlled. The faithfulness with which the study design was carried out has been analyzed in a previous report.²

Of the 7,710 sample persons, the 6,672 who were examined—a response rate of over 86 percent—give evidence that they are a highly representative sample of the adult civilian, noninstitutional population of the United States. Imputation for the nonrespondents was accomplished by attributing to nonexamined persons the characteristics of comparable examined persons. The specific procedure used² consisted of inflating the sample weight for each examined person to compensate

for sample persons at that stand and of the same age-sex group who were not examined.

While it is impossible to be certain that the blood pressures are the same in the examined and the non-examined groups, the available evidence indicates that it is. One source of information on this question is a special inquiry sent to the physicians of nonexamined persons and to the physicians of a matching set of examined persons. The mean blood pressures reported for the examined and nonexamined groups were in exact agreement. Further details on this subject appear in a previous report.²

Sampling and Measurement Error

In this report and its appendices, several references have been made to efforts to evaluate both bias and variability of the measurement techniques. The probability design of the Survey makes possible the calculation of sampling errors. Traditionally the role of the sampling error has been the determination of how imprecise the survey results may be because they come from a sample rather than from measurement of all elements in the universe.

The task of presenting sampling errors for a study of the type of the Health Examination Survey is difficult for at least three reasons. (1) Measurement error and "pure" sampling error are confounded in the data; it is not easy to find a procedure which will either completely include both or treat one or the other separately. (2) The survey design and estimation procedure are complex and accordingly require computationally involved techniques for calculation of variances. (3) Thousands of statistics come from the survey, many for subclasses of the population for which there are small numbers of sample cases. Estimates of sampling error are obtained from the sample data and are themselves subject to sampling error, which may be large when the number of cases in a cell is small, or even occasionally when the number of cases is substantial.

As variances are estimated for larger numbers of statistics from the Health Examination Survey, it is

hoped that an increasing amount of information can be presented in published reports. In this report, estimates of approximate sampling variability for selected statistics are presented in tables I and II. These estimates have been prepared by a replication technique which yields overall variability through observation of variability among random subsamples of the total sample. The method reflects both "pure" sampling variance and a part of measurement variance.

Table I. Relative standard error of the mean blood pressure of adults, by age and sex: United States, 1960-62

Age	Systolic		Diastolic	
	Men	Women	Men	Women
	Relative standard error in percent			
Total-18-79 years-	0.3	0.5	0.7	0.6
18-24 years-----	1.0	1.0	1.0	1.0
25-34 years-----	1.0	1.0	1.0	1.0
35-44 years-----	1.0	1.0	1.0	1.0
45-54 years-----	1.0	1.0	1.0	1.0
55-64 years-----	1.0	1.5	1.0	1.0
65-74 years-----	1.5	1.5	1.5	2.0
75-79 years-----	2.0	1.5	1.5	2.0

In accordance with usual practice a 68 percent confidence interval may be considered that range within one standard error of the tabulated statistic and a 95 percent confidence interval that range within two standard errors. An overestimate of the standard error of a difference $d = x - y$ of two statistics x and y is given by the formula $s_d = [x^2V_x^2 + y^2V_y^2]^{1/2}$, where V_x^2 and V_y^2 are relvariances respectively of x and y , or the squares of the relative errors shown in table I. For example, table E shows systolic $x = 132.1$ for men and $y = 129.9$ for women, while from table I relvariances are found to be $V_x^2 = 0.00001$ and $V_y^2 = 0.00002$. The formula yields the estimate of standard error of the difference ($d = 3.0$) as $s_d = 0.71$. Thus, as the observed difference is more than four times its sampling error, it can be concluded with near certainty that the evidence from this Survey is that systolic blood pressure is higher among men than among women.

Small Numbers

In some tables magnitudes are shown for cells for which sample size is so small that the sampling error may be several times as great as the statistic itself. Obviously in such instances the statistic has no meaning in itself except to indicate that the true quantity is small. Such numbers, if shown, have been included to convey an impression of the overall story of the table.

Table II. Relative standard error of number of adults with blood pressure of at least 160 systolic or 95 diastolic, per 100 persons, by sex and age: United States, 1960-62

Sex and age	Systolic at least 160 mm. hg.	Diastolic at least 95 mm. hg.	Systolic at least 160 mm. hg. or diastolic 95 mm. hg.
	Relative standard error in percent		
Both sexes-18-79 years-----	7	8	4
<u>Men</u>			
Total-18-79 years-----	10	9	5
18-24 years-----	*	*	*
25-34 years-----	*	20	25
35-44 years-----	20	15	10
45-54 years-----	20	15	10
55-64 years-----	15	15	10
65-74 years-----	10	20	10
75-79 years-----	20	*	20
<u>Women</u>			
Total-18-79 years-----	6	8	5
18-24 years-----	*	*	*
25-34 years-----	*	25	25
35-44 years-----	25	15	15
45-54 years-----	15	15	15
55-64 years-----	10	15	10
65-74 years-----	10	15	10
75-79 years-----	15	*	15

APPENDIX III

OBSERVER VARIABILITY IN BLOOD PRESSURE MEASUREMENT

Blood pressure measurement is subject to considerable variation from observer to observer. Part of this may be considered technical, arising from differences in the method of inflating and deflating the cuff, uncertainties in recognizing the Korotkoff sounds, the problems of reading scales, and so forth. Part may arise from the reaction to the observer of the person being measured, and this may vary according to the age, sex, race, or income of the person being measured.

The Health Examination Survey can be considered to have obtained an unbiased clinical measure of blood pressure. It has been shown for a subsample of the examinees that the average of blood pressure measurements reported by their private physicians was identical with the average measurement obtained by the Health Examination Survey physicians. In individual cases, however, there frequently were large divergences between measurements from these two sources, but then it is equally true that there were large divergences among the three blood pressure measurements taken by a single physician from an individual during his examination. The essentially unbiased clinical measure obtained by the Survey as a whole may be considered to reflect the averaging effect arising from the use of a large number of physicians.

For individual physicians, there is ample internal evidence from the Survey of significant differences in levels of measurement. Table III shows the extent that the average blood pressure measurement for each physician differs from the average for all physicians. Since the persons examined by a given physician may differ considerably from the general population in their distribution among the various age-sex groups, the mean of the blood pressure measurements for a given physician is compared with an expected value obtained by weighting the age-sex specific blood pressures for the total sample by the percentages in the various age-sex groups examined by that physician. Specifically, for a given examiner,

Let N_i be the number of persons in the i th age-sex group examined by the examiner (sum of $N_i = N$)

Let \bar{X}_i be the mean blood pressure obtained by that examiner for age-sex group i .

Let $\bar{\bar{X}}_i$ be the mean blood pressure for the i th age-sex group as measured by all examiners. Then

$$D = \frac{1}{N} \sum_i N_i (\bar{X}_i - \bar{\bar{X}}_i)$$

D is a summary measure of the deviation of this physician from the average physician and is the statistic tabulated.

There were 42 stands at which examinations were conducted. At most stands there were two physicians who took examinees alternately. On the average there were about 160 examinees at a stand, with roughly half being examined by each physician. While the persons at a specific stand may have blood pressures which deviate from the average for the United States, two physicians at the same stand should have examined a random sample of the population at that stand, and these physician samples should not be expected to differ from each other more than chance. Hence, it is appropriate to compare the deviation at the stand for each of the two physicians there.

Table III presents statistics for systolic and diastolic deviations, specific for stand and for physician. The presentation is slightly simplified. Data for the physicians at one stand where the assignment of examinees was clearly not random are omitted. This eliminated 160 examinees. All cases where the physician examined fewer than 32 persons at a stand were also omitted. This accounts for an additional 135 omissions. Four quasi-stands were constructed to replace four of the 42 actual stands. This was done in such a way as to retain a random assignment of the stand populations together with a pairing of physicians.

While a full analysis of these data is not undertaken in this report, the tabular material suggests the scale of the physician's impact on results. Physician differences are, of course, linked with place differences. A formal separation of the components of variation would be an involved matter. It would have to take into account the complex sample design and estimation pro-

Table III. Deviation of actual from expected mean blood pressure, by stand number and physician: Health Examination Survey, 1960-62

Stand number	Systolic blood pressure		Diastolic blood pressure	
	Physician A	Physician B	Physician A	Physician B
	Mean deviation from expected (mm. hg.)			
1-----	-3.67	4.56	2.17	3.35
2-----	-4.98	3.78	-2.00	² 3.09
3-----	² -0.38	² -3.12	² -6.67	² -5.03
4-----	² -2.02	³ 1.15	² -9.34	³ 0.96
5-----	³ 5.53	⁴ -1.08	³ 3.77	⁴ -7.25
6-----	² -5.03	⁵ 2.24	² -8.34	⁵ -2.30
7-----	⁴ -8.77	⁵ -2.88	⁴ -6.73	⁹ -0.37
8-----	⁶ -3.03	⁹ -0.25	⁶ -5.23	⁹ -0.03
9-----	⁶ 0.34	-8.02	⁶ -5.66	-5.94
10-----	⁷ -2.71	-3.64	⁷ -1.21	4.65
11-----	⁷ 1.02	-0.22	⁷ -0.34	-2.69
12-----	¹⁹ 0.53	2.79	¹⁹ 4.40	1.98
13-----	-2.81	-5.04	-2.93	1.21
14-----	5.61	¹⁵ 0.82	1.60	¹⁵ 4.42
15-----	8.95	-0.31	2.25	-2.55
16-----	⁸ -1.25	-7.02	⁸ 3.67	-1.54
17-----	⁸ 4.09	-0.62	⁸ 1.16	1.04
18-----	⁸ 6.26	3.96	⁸ -0.69	4.42
19-----	1.97	2.70	¹⁵ -2.25	-2.13
¹ 20-----	¹⁵ -3.92	11.56	¹⁵ -8.68	¹⁷ 10.35
¹ 21-----	¹⁶ 3.59	¹⁷ 17.20	¹⁶ 6.35	¹⁷ 10.49
23-----	⁹ -0.13	¹⁰ -1.96	⁹ 1.66	¹⁰ 3.04
24-----	²¹ -1.26	²¹ -5.23	²¹ 2.53	²¹ 4.55
25-----	¹⁰ 2.16	²¹ 0.60	¹⁰ 4.63	3.53
26-----	¹¹ 5.24	¹⁶ 3.56	¹¹ 2.52	¹⁶ 6.50
27-----	5.27	²² 2.38	2.61	²² 3.88
28-----	¹¹ 7.97	¹² 6.61	¹¹ 3.89	¹² 4.88
29-----	¹² 8.99	¹³ -3.73	¹² 7.08	¹³ -0.63
30-----	0.70	-3.91	0.06	2.10
31-----	¹³ 6.12	¹⁴ -2.31	¹³ 4.27	¹⁴ -3.18
32-----	¹⁹ -7.38	-5.42	¹⁹ -0.35	-4.63
33-----	¹⁴ -2.29	3.18	¹⁴ -0.05	-1.23
34-----	¹⁷ 6.60	10.85	¹⁷ 2.03	6.39
36-----	¹⁶ 2.66	-1.36	¹⁶ 4.14	-0.11
37-----	²⁰ 2.92	1.31	²⁰ 3.01	0.73
38-----	¹⁸ -7.93	-0.17	¹⁸ -0.73	²² 1.53
40-----	⁹ 4.10	²² -1.59	⁹ 4.32	2.56
41-----	1.28	2.69	-2.35	0.65
42-----	-6.11	-5.91	1.53	¹⁸ 1.07
¹ 98-----	-4.61	¹⁸ 5.00	²⁰ -5.46	¹⁸ 5.90
¹ 99-----	²⁰ -2.95	-4.45	-0.85	0.58

¹Pseudo stands.

²⁻²²Same physician. For example, one physician conducted examinations at stands 3, 4, and 6 and his deviation are indicated by the superscript 2.

cedure used in the Health Examination Survey. It would have to allow for deep primary stratification, ratio estimation, poststratification, multistage selection, and other departures from simple random sampling. Preliminary investigations indicate that such an analysis would show that between-physician variation is by no means trivial and indeed contributes a substantial proportion of overall total survey variance. Since this component decreases directly with an increasing number of physicians taking measurements, it is much smaller in the Health Examination Survey than it would be in a survey with only a few persons taking the blood pressure measurements.

A more serious concern than increased variability from interphysician differences is the possibility that interphysician differences complicate the analysis of blood pressure data from the Health Examination Survey. Granting a slight attenuation introduced into compari-

sons between subgroups of the population, what is the risk of bias being introduced into such comparisons? The answer to this question must be that such a risk is practically nonexistent. For studies in which only a few observers measure the blood pressure such risks are obviously present, particularly if examinees are not assigned randomly to observers. In the HES, however, the large number of examiners and the relatively small number of persons examined by any one physician reduce this risk to an indiscernible level.

Finally, while there is a general interest in the magnitude of physician differences, and while observer variance is a significant part of total variability, total variability is small for most estimates in this report. For most categories the relative standard error is only a fraction of what a physician would accept as a substantive tolerance.



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