

ELEVATED SYSTOLIC BLOOD PRESSURE IN A RURAL POPULATION

RALPH E. WHEELER, M.D.¹

THE factors giving rise to elevated blood pressure have been intensively studied in clinic and laboratory, but seldom in relation to other findings in a general population. It therefore seemed useful to undertake a general study of medical examinations performed in rural Cattaraugus County with a view to ascertaining what the small group with this finding might show in greater or less degree than the total examined sample.

The medical records used for this study were made under the auspices of the Milbank Memorial Fund and the United States Public Health Service at an examining clinic in a rural area of Cattaraugus County, New York. The farm and small village inhabitants of the neighborhood were invited to attend for a health examination, and about a fifth of the population attended. While some undoubtedly came to verify a suspicion of illness, it is felt that a large proportion came in a spirit of cooperation. A more detailed statement of the type of individual examined and of the method of examination will be found elsewhere.²

The most significant limitation of these data lies in the fact that in the majority of instances the blood pressure was taken only at the time of examination and might have been unusually low or high at that time. Blood pressures which were elevated were often taken twice during the course of the examination, however, to make sure that the reading was not merely a result of apprehension on the part of the patient.

Rates for persons whose upper or systolic level of blood pressure exceeded 160 mm. of mercury have been recorded in the more gen-

¹ From the Milbank Memorial Fund.

² Wheeler, Ralph E.: Impairments in a Rural Population. *The Milbank Memorial Fund Quarterly*, July, 1937, xv, No. 3, pp. 248-261.

AGE	NUMBER EXAMINED		SYSTOLIC PRESSURE OF 160 + MM.			
	Male	Female	Number		Per Cent	
			Male	Female	Male	Female
5 +	385	475	38	80	9.9	16.8
5-14	69	68	0	1	0.7	0.5
15-29	81	135	1	0		
30-44	91	118	5	9	5.5	7.6
45-59	83	100	12	35	14.4	35.0
60 +	61	54	20	35	32.8	64.8

Table 1. Number examined, and number and percentage of persons found to have a systolic blood pressure of 160 mm. or more, by age and sex.

eral discussion of findings.³ The essential data are reproduced in Table 1, by age and sex. They show a definite excess among females at ages after 45 years and a tendency in both sexes to increase rather rapidly with age.

Because examination was voluntary, it may well be asked whether this represents a true picture of the prevalence in this population or whether the rather high figures, particularly for elderly women, indicate that the clinic sample was biased by the inclusion of a disproportionate number of cases with high blood pressure. Unfortunately, no definite answer can be given, although there is some evidence supporting the view that these data are biased. There were 422 persons above the age of thirty years who were under observation in a morbidity survey conducted by the United States Public Health Service in the area in question. By the method of periodic house-to-house canvass, this survey collected data on the illnesses, acute and chronic, of more than 5,000 persons in the area where medical examinations were performed. The assembled data were made available for a comparative study through the kindness of Mr. Selwyn D. Collins of the Office of Statistical Investigations of the United States Public Health Service. It was found that 188 of the total of 2,794 persons above thirty years of age in the area, or

³ Wheeler, Ralph E.: Impairments in a Rural Population. IV. The Milbank Memorial Fund *Quarterly*, April, 1938, xvi, No. 2, pp. 192-217.

6.7 per cent, reported "high blood pressure,"⁴ while 39 of the 422 persons examined in the clinic, or 9.2 per cent, reported to the survey that they had "high blood pressure."

This could be interpreted as showing a definite bias in at least that part of the examined group which was included in the survey. However, rates for females reporting "high blood pressure" to the survey workers were 9.4 per cent and 8.4 per cent for the examined and total survey populations, respectively; those for males were 9.1 and 5.2 per cent. Females, therefore, showed an excess of only 10 per cent in the examined group while males showed an excess of 75 per cent.⁵ The excess is clearly of a type which most markedly affects the male rates.

The results of medical examinations, moreover, were often explained to the patients, and it is known that patients sometimes reported these results to the survey workers *after* their examinations so that the excess is not entirely due to a foreknowledge of the ailment. In addition, it is believed that those who cooperated with the medical clinic were also more cooperative in stating their ailments to the survey workers, and this could explain in part the excess.

The available data on blood pressure measurements in population samples are rather limited—perhaps because of doubt as to the validity of presenting figures based on a single measurement. However, age-specific rates for urban male office and industrial workers are available in the Life Conservation Studies,⁶ and these rates are not widely at variance with those for males in the present series.

⁴ In the survey data "high blood pressure" was combined with arteriosclerosis. This is, however, the only category which throws light on this point and it is known that reports were very largely of high blood pressure.

⁵ A correction should properly be made for age as the group of 422 persons examined during the period of the survey showed definite age differences, even among those over the age of thirty years. When this correction is made, females showed a 37 per cent, and males a 93 per cent, excess in the examined group.

⁶ A series of publications, 1929-1930, of the Heart Council of Greater Cincinnati (312 West Ninth Street, Cincinnati). The first two parts cover office workers and industrial workers, respectively. Nearly comparable data are also to be found in Public Health Bulletin No. 162, June, 1926: A report by R. H. Britten and L. R. Thompson on a Health Study of Ten Thousand Industrial Workers.

Although the survey data, therefore, offer some evidence for the view that the sample is biased, there is not a little support for the opinion, of at least one examiner, that the chief limitation of the prevalence figures is the fact that individuals were rated on the basis of a single test.

For the more intensive study of the group of persons with this finding, it was considered advisable to include all those with a blood pressure of 150 mm. or higher. While this figure is 10 mm. lower than that used for the prevalence studies, it was felt that the lower base would include enough individuals with at least potentially elevated blood pressure to make up for the inclusion of a few persons with merely a high normal rating. The term "elevated" systolic pressure is, therefore, used to define the outstanding feature of this group. It was also necessary to exclude ages under thirty years because of the limited number of cases.⁷

The number of persons with systolic pressures of 150 or more after the age of thirty years are shown for broad age groups by sex in Table 2. The figures for males, even on the broader basis of 150, are seen to be limited, and this necessitates the employment of a somewhat indirect method of analysis for the prevalence in this group of other conditions determined by the medical examination—that of applying rates for the given condition in the examined population to the elevated pressure group and comparing the expectancy so obtained with the actually observed number. By this method, when the observed exceeds the expectancy, there is indicated a positive relationship; when the reverse is true, a negative or

⁷ Excluded, therefore, were the following cases:

<i>Age</i>	<i>Male</i>	<i>Female</i>
5-14	0	1
15-29	8	1
5-29	8	2

Only one male, aged 21 years, and one female, aged 11 years, showed systolic blood pressure above 160 mm. These two showed high diastolic pressures also. The remaining cases in these two age groups had elevated systolic pressures only.

inverse relationship is suggested. Age is an important general factor, and because the mean age of the elevated blood pressure group is somewhat higher than that of others above the age of thirty years,⁸ broad age groups of fifteen years are used to minimize errors that may arise from a simple comparison.

Table 2. Number of males and females at ages above 30 years with systolic blood pressures of 150 mm. or higher.

Age	Male	Female	Both Sexes
30+	53	108	161
30-44	8	20	28
45-59	19	48	67
60+	26	40	66

It may be noted that the possibility of a bias in the incidence data does not detract from the validity of this approach. Comparisons of this type may be made with any examined group containing a sufficiently large subgroup with a specified finding. Thus, hospital or outpatient studies could be made from most of the points of view mentioned below, the chief qualification being that all the examinees should have been under comparable types of observation.

The first significant relationship which appears in this group is that with sex. The number of females which might be expected in the total elevated blood pressure group on the basis of the percentage of women in the examined group is shown in Table 3, the expected number being simply obtained by applying the percentage of females in the total examined group (Table 1) at each age to the total for both sexes (Table 2) at that age in the high blood pressure group.

The ratio of observed to expected is 1.3; that is, some 30 per cent more females were found in the elevated group than would have been expected. When it is remembered that the bias, if any, is in the direction of males in this sample, these rural data may be taken as conforming with other observations on the greater prevalence of hypertension among women.

⁸ The mean age of males above the age of thirty years with elevated blood pressure is 59.4 years while that of all examined males above that age is 51.1 years. For females the mean ages are 55.4 and 48.6 years, respectively.

In a more general discussion⁹ it was stated that the relationship between high blood pressure and sex might be an indirect one as overweight is related to both. The solution of this question is beset

Table 3. Observed number of females at ages above 30 years with systolic blood pressures of 150 mm. or more, and expected number based upon percentages of females in total examined group.

Age	Observed Number	Expected Number	Per Cent Examined of Female Sex
30 +	108	83.4	—
30-44	20	15.8	56.4
45-59	48	36.6	54.6
60 +	40	31.0	46.9

with difficulties for neither elevated pressure nor degrees of over or underweight are measured with a high degree of accuracy. However, some significant relationships do appear between relative weight¹⁰ and elevated pressure, as shown in

Table 4. The expected number is uniformly lower than the observed for 20 per cent overweight in the six age samples of the two sexes, and uniformly higher for 10 per cent underweight. In other words, elevated systolic pressure is associated more frequently with overweight, less frequently with underweight, than is to be expected on the basis of the proportions of such individuals in the entire examined group. The relationship appears to be more definite for females than for males but seems to be obscure at ages above 60 years.

The variations of blood pressure with weight have been presented for males by Britten,¹¹ in considerably more detail than the limited data of the present study permit, and useful data are also to be found for employed males in the Life Conservation Studies,⁹ but similar studies for females are not available so that it may be useful to give the weight and blood pressure data in some detail for

⁹ Wheeler, *op. cit.*, 1938.

¹⁰ The difference between observed and standard weight for height, age, and sex, in relation to the standard weight.

¹¹ Britten, Rollo H.: A Study of Medical Examination Records of 3,037 Men Markedly Under or Overweight for Height and Age. *Public Health Reports*, August 4, 1933, xlviii, No. 31, pp. 926-944.

AGE	SYSTOLIC PRESSURE OF 150+ MM. AND KNOWN WEIGHT		20 PER CENT OR MORE OVERWEIGHT				10 PER CENT OR MORE UNDERWEIGHT			
			Male		Female		Male		Female	
	Male	Female	Ob- served	Ex- pected	Ob- served	Ex- pected	Ob- served	Ex- pected	Ob- served	Ex- pected
30+	50	104	7	5.4	50	37.7	6	10.5	4	13.3
30-44	7	18	1	0.6	12	5.8	0	1.1	0	3.1
45-59	18	47	3	2.4	22	16.7	0	2.4	1	4.4
60+	25	39	3	2.4	16	15.2	6	7.0	3	5.8

Table 4. Number with systolic blood pressure of 150 mm. or more and known relative weight record, observed and expected numbers with specified degree of over or underweight, by age and sex.

the entire examined group. This has been done in Table 5 where the percentage of persons with elevated systolic pressure in three weight groups is presented by age and sex. The figures increase quite consistently with age in all weight groups; they increase with relative weight to some extent for males and quite definitely for females, but the oldest age groups for both sexes show this latter much less consistently. The other aspect of the relationship—that lower blood pressures are related to underweight—does not fall

Table 5. Number of examined persons overweight, normal, and underweight, by age and sex, and the percentage of individuals in each weight group with systolic blood pressure of 150 mm. or more.

AGE	MALE			FEMALE		
	20 Per Cent or More Overweight	+19 to -9 Per Cent Normal	10 Per Cent or More Underweight	20 Per Cent or More Overweight	+19 to -9 Per Cent Normal	10 Per Cent or More Underweight
PER CENT WITH SYSTOLIC PRESSURE OF 150 MM. OR MORE						
30-44	12.5	9.2	—	31.6	10.9	—
45-59	27.3	25.4	—	62.8	43.6	11.1
60+	50.0	43.2	37.5	80.0	80.0	37.5
NUMBER EXAMINED						
30-44	8	65	13	38	55	21
45-59	11	59	10	35	55	9
60+	6	37	16	20	25	8

within the limits of the present paper, but it may be stated that there is evidence that this relationship is also quite definite.¹²

These figures, of course, raise the question whether the relationship brought out is an actual one or whether it simply demonstrates an error inherent in clinical methods of testing systolic pressure in persons of varying weight. Such a question cannot be answered by field data of this type except to point out that they hold true when the systolic level for elevated pressure is 160 as well as when it is 150. The limited number of cases in this series makes it difficult to carry the relationship through higher systolic levels, but if there is an error in clinical methods of measurement, it would appear to be of a larger order than 10 mm.

These facts about overweight and elevated pressure, taken together with the fact that an appreciably larger proportion of women than of men were in the overweight group,¹³ help to explain the observed excess among females, even though they do not fully clarify all the issues.

In addition to sex and overweight, there are a number of other medical examination findings which are felt to be associated with elevated blood pressure in some degree. An extensive comparison of several conditions covered by the examination was therefore undertaken. In Table 6 appear the expected, contrasted with the observed,

¹² For the examined population given in Table 5 the percentages of persons with systolic pressure below 120 mm. for the three groups overweight, normal, and underweight, are respectively:

AGE	MALES			FEMALES		
	Overweight	Normal	Underweight	Overweight	Normal	Underweight
30-44	0.0	26.2	38.5	7.9	25.4	52.4
45-59	0.0	15.2	50.0	0.0	3.6	11.1
60 +	0.0	5.4	18.8	0.0	0.0	0.0

The percentages of persons with relatively low systolic pressures are seen to rise as relative weight decreases.

¹³ The prevalence of overweight of 20 per cent or more among women was, for the three age groups used here, from youngest to oldest: 32.2, 35.5, and 38.9 per cent. Corresponding rates for men were 8.7, 13.4, and 9.8 per cent.

MEDICAL EXAMINATION FINDING	MALES		FEMALES		BOTH SEXES		RATIO OF OBSERVED TO EXPECTED
	Observed	Expected	Observed	Expected	Observed	Expected	
1. Chronic Myocarditis	12	7.2	18	10.6	30	17.8	1.7
2. Infected Tonsils, Chronic	9	5.8	13	9.7	22	15.5	1.4
3. Urinary Albumin (All Degrees)	6	2.8	5	5.3	11	8.1	1.4
4. Pulse Pressure Above 50 mm. ²	50	34.1	104	79.3	154	113.4	1.4
5. Temperature 99.0° or Higher	8	6.0	26	21.2	34	27.2	1.2
6. Lumbago and Backache (Current)	6	3.7	8	7.6	14	11.3	1.2
7. Tonsils Enlarged	3	4.0	19	13.9	22	17.9	1.2
8. Shortness of Breath, Symptom	22	17.1	60	52.0	82	69.1	1.2
9. Urinary Sugar, All Degrees	1	2.5	15	11.2	16	13.7	1.2
10. X-ray, Increased Lung Markings	15	11.5	28	25.6	43	37.1	1.2
11. Urinary Specific Gravity 0.0130 +	11	11.0	18	14.4	29	25.4	1.1
12. Dizziness, Symptom	12	12.4	47	41.4	59	53.8	1.1
13. "Rheumatic Pains," Symptom	24	23.6	65	57.1	89	80.7	1.1
14. "Nephritis," Family History	15	14.3	43	38.2	58	52.5	1.1
15. "Heart Trouble," Family History	12	9.3	40	38.3	52	47.6	1.1
16. Teeth, Five or More Missing ²	41	37.2	93	86.4	134	123.6	1.1
17. Headache, Symptom	15	12.8	50	47.3	65	60.1	1.1
18. Pulse 80 + Per Minute	25	22.6	78	75.7	103	98.3	1.0
19. Cardiac Pain, Symptom	10	8.3	30	30.1	40	38.4	1.0
20. Scarlet Fever, Past History	13	9.9	26	27.8	39	37.7	1.0
21. Marital Status—Married	39	39.6	88	85.3	127	124.9	1.0
22. No Prior City Residence	27	28.2	71	68.8	98	97.0	1.0
23. Economic Status Above Average	34	33.8	70	71.5	104	105.3	1.0
24. Rural as Opposed to Village Residence	28	28.5	50	52.4	78	80.9	1.0
25. Chronic Constipation, Symptom	14	13.0	52	56.9	66	69.9	0.9
26. Tonsils Buried	21	18.8	26	31.6	47	50.4	0.9
27. Thyroid, Diffuse or Nodular Enlargement	—	—	10	10.8	—	—	0.9
28. Frequent Coughs or Colds, History	9	11.9	25	27.1	34	39.0	0.9
29. Upper Respiratory Infections, Exclusive of Tonsils	5	7.9	7	6.2	12	14.1	0.8
30. Chronic Bronchitis, Diagnosed	9	8.4	7	10.8	16	19.2	0.8
31. Pneumonia, Past History	11	13.2	11	13.9	22	27.1	0.8
32. Tuberculosis, Active, Arrested, Suspected	7	8.4	14	18.5	21	26.9	0.8

¹ The differences between expected and observed in this series are not in general statistically significant, and conclusions drawn from them are subject to reservations noted in the text.

² Consistent excess in all age groups of both sexes.

Table 6. Observed number of persons found to have systolic blood pressures of 150 mm. or more, with specified finding and expected number (corrected for age) on the basis of rates from the total examined sample.¹

numbers for these other findings by sex. The expected numbers were obtained by applying the age and sex specific rates¹⁴ for the

¹⁴ Many of these age and sex specific rates have been presented in the detailed study of prevalence for the total sample. See Wheeler, *op. cit.*, 1938. The numbers examined for *both* blood pressure and the specified condition were sometimes slightly less than the figures in Table 2.

various findings in the total sample to the smaller number of individuals of the corresponding age and sex in the elevated pressure group. Totals for each sex only are presented in Table 6, and the ratio of observed to expected is shown in the final column. In reference to this table, it is important to keep in mind that small variations in the observed cases, quite within the limits of chance, will cause marked changes in the place of any specified condition in the table. The numerical rating is, therefore, chiefly for convenience in reference. Despite the lack of statistical significance for most of the differences between expected and observed numbers, however, this table suggests a number of relationships, especially where groups of allied conditions are considered. Several well-established relationships are indicated, such as those between high blood pressure and myocarditis (1), elevated pulse pressure (4), and glycosuria (9). The common symptoms of dizziness (12), headache (17), and cardiac pain (19), are relatively low, however, as are also family history of nephritis (14) and heart trouble (15).²⁵ Past or present environmental factors (22 and 24) or economic factors (23) were signally unrelated. Perhaps the most consistent group, however, is that of respiratory conditions (28-32) whose expectancy seems uniformly to exceed the observed.

Tonsillar data are proverbially difficult to interpret and the varying locations of infected (2), enlarged (7), and buried (26) tonsils are cases in point. It may be that these various aspects of tonsillar pathology have varying relations to hypertension but it cannot be overstressed that only very tentative conclusions can be drawn from these and other data in this table.

CONCLUSIONS

Systolic blood pressure readings of 160 mm. or more were en-

²⁵ These data are not, however, conclusive because they relate to such history in siblings, if any, and parents of the examined patient. That a more detailed analysis of actual rates among close relatives might reveal a really significant relationship is indicated by the not uncommon finding of elevated pressure in siblings whose parents died of nephritis, cerebral hemorrhage, or heart trouble and by the occasional finding of elevated systolic pressures among one or more children in families where both parents showed high blood pressure.

countered in nearly 10 per cent of males and in 17 per cent of females above the age of five years in a series of examinations made in a rural area. The figure is considerably higher than the 3.6 per cent finding of Riseman and Weiss¹⁶ for patients seen in an urban hospital outpatient service, and possible selective factors in the examined sample are discussed.

An intensive study of factors associated with "elevated blood pressure" (150 mm. or more) was undertaken, and it was found that the data of the present sample add further evidence for the opinion that this condition is more prevalent among females than among males after the age of thirty years. They also indicate that the difference in prevalence between the two sexes is, in part, related to the more frequent occurrence of overweight among females. This conclusion is, however, based upon the assumption that there is no substantial error in the measurement of blood pressure in overweight persons.

A number of other medical examination findings are shown to be associated to some extent with elevated blood pressure, but the significance of these relationships cannot be determined with the present limited data.

¹⁶ Riseman, J. E. F. and Weiss, Soma: The Age and Sex Incidence of Arterial Hypertension. *American Heart Journal*, December, 1929, v, No. 2, p. 172.