FACTORS INFLUENCING ARTERIAL PRESSURE IN THE GENERAL POPULATION IN JAMAICA

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Though there is evidence that racial factors are important in determining blood-pressure levels in different populations, little is known of the nature of these factors, and the relative contributions of environment and genetics have still to be defined. The evidence from all available epidemiological studies suggests that the arterial pressure in negro populations in the United States is higher than that for white populations there (Adams, 1932; Gover, 1948; Comstock, 1957). Blood-pressure in the negro population of the West Indies is also high (Saunders and Bancroft, 1942; Moser *et al.*, 1959; Johnson and Remington, 1961; Schneckloth *et al.*, 1962). Whereas in the white population in the United States death rates for hypertension and hypertensive heart disease are consistently higher in the male than in the female, in negroes the rates are consistently greater for females than for males (Lennard and Glock, 1957; Stamler *et al.*, 1960).

The ancestors of most American and West Indian negroes came from West Africa in the second half of the seventeenth century and throughout the eighteenth century. No data concerning the blood-pressure levels in the general populations of West Africans are available for comparison, and the lack of accurate knowledge of their ages is likely to make such studies unrewarding at present, so the influence on blood-pressure of the different environments in which negroes live in Africa and in the West remains unexplored.

The epidemiological studies of rural and urban communities carried out in Jamaica and reported here were undertaken to determine some of the factors influencing arterial pressure in West Indians: as similar studies had previously been carried out in Wales (Miall and Oldham, 1955, 1958) a comparison of the magnitude of genetic and environmental influences on arterial pressure in the two races was possible. At the same time the surveys were designed to determine the magnitude of the differences in blood-pressures between negroes in Jamaica and whites in South Wales, using the same observer, the same techniques of examination, and representative populations in both the countries. We thus hoped to determine whether such racial differences in arterial pressure as might be found were explicable in terms of differences in the nature or the magnitude of environmental or genetic factors.

This paper deals with the results of the Jamaican surveys; they will be compared with the Welsh results in another paper.

Methods

The Populations

Two populations were defined geographically and enumerated by private census. The rural population inhabited a rugged inland area surrounding the village of Lawrence Tavern, in upper St. Andrew, about 20 miles (32 km.) north of the capital, Kingston. This population had been chosen by the Departments of Medicine and Preventive Medicine at the University College of the West Indies as typical of inland rural populations in the island. For both sexes the main occupation is agricultural—the cultivation of produce for home consumption and for sale in Kingston and local markets. Housing conditions are poor by Western standards but are ameliorated by a favourable climate; the terrain is such that all except those people confined to the house and yard must lead lives which are physically very active. The diet is low in calories and particularly deficient in proteins and animal fats (Gourlay, 1961, personal communication). Conditions are such that one would expect a low prevalence of those diseases which are characteristically associated with high living standards.

The urban population was chosen with the intention of providing a population with socio-economic standards comparable with those of the rural area, and with

FIG. 1.—Population structures—Lawrence Tavern (rural) and Greenwich Town (urban), Jamaica.

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sufficient stability to allow this type of survey to be undertaken. Greenwich Town, part of Kingston, was selected. The age-and-sex structure of the population in Kingston was found to be very different from that of the rural area (Fig. 1). In most urban populations there is an excess of young adult females, and this is very marked in Kingston, perhaps exaggerated by recent emigration of young adult males and perhaps falsely accentuated in our census by the instability of family life in a city where males are more prone than females to have no fixed abode. Occupations were varied and typical of urban populations elsewhere. The population, though unstable and constantly recruited from migrants to the city from rural areas, was racially as homogeneous as that in the country, the overwhelming majority of the population being negroes. An attempt was made to examine all subjects over the age of 15 years in both populations.

Techniques

The surveys were carried out from March to July, 1959, in the rural community and from August to December in the urban community, and each followed its census within a few weeks. Seasonal variation in arterial pressure has not been studied in Jamaica, but the seasonal differences in the climate are small and the higher altitude of the rural area would tend to compensate for the somewhat higher summer midday temperatures. Measurements were made at any time between 9 a.m. and 5 p.m. in each population, and no special study of diurnal variation in pressure was made.

As in the studies carried out in South Wales (Miall and Oldham, 1955, 1958), with which comparisons are made later, each subject was seen in his or her own home surroundings. Personal, medical, and occupational histories were obtained. An assessment of salt intake, using the type of questionnaire developed by Dahl and Love (1954), was found to be valueless. Arterial pressure measurements were made by two observers who had previously standardized their techniques. Readings were taken with a standard mercury manometer with a cuff size of 13 by 25 cm. after the subjects had been seated for at least 10 minutes. Diastolic pressure was taken as that at which muffling of sounds occurred and readings were recorded as at the nearest 5-mm. or 10-mm. gradation below the observed figure. Measurements of pulse rate, height, weight, and arm girth were also made. Urine was analysed for protein and sugar, and quantitative bacteriological investigations of specimens of clean-voided urine were made. The detailed results of the latter are reported separately (Kass *et al.*, 1962).

Population Response Rates

In the rural population 97.9% of females and 95.2% of males were investigated; in the urban population the figures were 97.8% and 86.7% respectively. The surveys included those who were bedridden at home or in hospital as well as the healthy. The populations are shown in Table I.

Accuracy of Age Statements

In the rural population age statements were verified against their birth certificates for 76.5% of the females and 79.1% of the males. The corresponding rates in the urban population were only 64.4% and 66.3%

respectively. A number of factors contributed to the failures in checking age statements: gross errors in stated age, errors in stated birthplace, and subjects using a different name from that registered probably account for the majority, but in both populations there were people who were not born on the island and therefore not registered there.

Many of the older Jamaicans have little idea of their age and either offer some optimistic guess or charmingly invite your opinion. Stated ages therefore tend to be underestimated, as was shown in those subjects whose dates of birth were checked against their birth certificates. In both sexes there was a slight overall bias towards underestimation of age (not exceeding 2 years in any 5-year age-group); we cannot assume that the errors in those whose age statements we were unable to check were not larger, and as arterial pressure is very sensitive to age we have limited the following comparisons of frequency distributions in the two populations to those subjects whose accurate age was known. Errors introduced by inaccurate age data are probably more important in a survey of arterial pressure than of most other medical indices; when age is underestimated the pressures of older subjects are recorded against falsely young ages and therefore appear to be exaggeratedly high. We believe that the errors introduced by using inaccurate ages are probably of greater importance than the possible errors introduced by omitting subjects whose ages could not be verified.

TABLE I.—Population Samples

Age	Rural Population				Urban Population			
	Subjects whose Ages were Checked	Subjects whose Ages were Not Checked	Lapses	Total	Subjects whose Ages were Checked	Subjects whose Ages were Not Checked	Lapses	Total
<i>Females</i>								
15-	147	15	2	164	107	41	3	151
20-	98	18	1	117	119	66	3	188
25-	111	21	3	135	102	60	7	169
30-	88	17	2	107	90	43	1	134
35-	95	25	2	122	54	33	1	88
40-	74	20	—	94	60	28	1	89
45-	80	16	5	101	43	17	—	60
50-	65	24	3	92	28	20	2	50
55-	46	34	1	81	23	13	1	37
60-	33	24	3	60	13	12	—	25
65-	40	20	3	63	10	10	1	21
70-	14	18	—	32	5	10	—	15
75-	8	11	—	19	4	6	—	10
80-	6	10	—	16	1	2	—	3
85-	1	6	—	7	—	3	—	3
90-	—	—	—	—	—	—	—	—
95-	—	—	—	—	—	—	—	—
100+	1	—	—	1	—	—	—	—
Unknown	—	—	—	—	—	—	3	3
Total	907	279	25	1,211	659	364	23	1,046
<i>Males</i>								
15-	114	11	9	134	56	21	9	86
20-	94	12	3	109	61	19	16	96
25-	63	10	9	82	44	32	9	85
30-	83	11	3	97	54	26	9	89
35-	68	11	5	84	34	11	7	52
40-	70	22	6	98	33	21	3	57
45-	81	14	2	97	34	14	3	51
50-	68	15	4	87	29	16	4	49
55-	45	33	2	80	8	13	2	23
60-	28	18	1	47	8	3	—	11
65-	30	16	1	47	3	2	1	6
70-	14	7	—	21	3	4	—	7
75-	3	11	2	16	4	6	—	10
80-	2	8	—	10	—	—	—	—
85-	—	—	—	—	—	—	—	—
90-	—	2	—	2	—	1	—	1
95-	—	—	—	—	—	—	—	—
100+	1	—	—	1	—	—	—	—
Unknown	—	—	2	2	—	—	23	23
Total	763	202	49	1,014	371	189	86	646

Observer Difference in Sphygmomanometer Readings

Some digit preference in recording arterial pressure measurements is almost invariably found in such surveys. The extent of the digit preference in our readings was small. Observer A had no digit preference in systolic readings, but in every 100 diastolic readings 54% ended in 0, 46% in 5; Observer B showed preference, favouring readings ending in 0 to the extent of 55% and 52% of systolic and diastolic readings respectively.

Fig. 2 shows the magnitude of the differences in mean pressures found in the rural population by the two observers. The numbers of subjects seen in each age-group by each observer are indicated. These differences presumably result from a combination of sampling error, technique, and the circumstances under which measurements were made. Similar but no greater differences were found in the urban surveys.

FIG. 2.—Observer differences in arterial pressure found in randomly selected samples of a Jamaican rural population.

Results

(1) Distribution of Arterial Pressure in Rural and Urban Populations

The distributions of arterial pressure by age for females aged 15–54 years are shown in Fig. 3, and mean values and standard deviations for all females aged 15 and more in Table II.* At almost all ages the females from the rural area have higher mean systolic and diastolic pressures than those from the town (Table III). Their higher standard deviations for both pressures are largely due to a greater proportion of subjects with greatly elevated pressures. The prevalence of diastolic hypertension, using 100 mm., 115 mm., or 130 mm. Hg as the criteria of abnormality, is higher at all ages except that for subjects aged 75 years and more, where the numbers with verified ages are small (Table IV). Furthermore, the difference in the prevalence of hypertension between these two groups of females increases at the higher values; severe hypertension is very much more

common in rural females. Systolic pressures show the same difference with some irregularity in the 45–54-year age-group.

Among the males the distributions (Fig. 4), the means and standard deviations (Tables II and III), and the prevalence of hypertension (Table IV) show no similar consistent difference between the two groups.

The inclusion of subjects in whom ages were not checked increases the numbers in the older age-groups

FIG. 3.—Frequency distributions of arterial pressure in Jamaican females.

TABLE II.—Mean Systolic and Diastolic Pressures. Rural and Urban Populations, Jamaica

Age	Rural Population				Urban Population					
	No.	Systolic		Diastolic		No.	Systolic		Diastolic	
		Mean	S.D.	Mean	S.D.		Mean	S.D.	Mean	S.D.
Females										
15–	147	124.2	13.9	76.2	121	119.1	12.2	73.8	9.5	
20–	98	123.5	12.2	78.4	106	117.5	12.7	72.5	9.9	
25–	111	122.8	15.8	77.3	123	116.8	10.8	74.5	9.8	
30–	88	125.5	14.1	78.2	117	122.1	17.5	78.7	13.1	
35–	95	131.0	23.0	82.4	144	125.4	15.9	80.9	12.2	
40–	74	138.6	24.0	87.6	60	134.5	17.9	85.0	10.4	
45–	80	147.9	29.8	91.4	15.9	43	147.2	28.4	88.0	
50–	65	161.8	31.5	94.7	17.9	28	163.0	37.5	94.1	
55–	46	175.3	40.1	102.0	20.4	23	147.1	23.3	87.1	
60–	33	172.5	38.0	97.7	22.3	13	167.9	24.7	94.8	
65–	40	172.4	30.1	95.5	15.2	10	162.0	18.3	92.5	
70–	14	183.9	45.4	101.1	16.7	5	159.5	13.5	94.5	
75+	16	171.6	32.3	91.6	12.3	5	173.5	24.8	84.5	
Total	907					659				
Males										
15–	114	122.9	12.2	74.6	10.7	56	120.1	11.8	73.2	
20–	94	129.9	13.9	79.9	10.8	61	124.5	13.2	76.5	
25–	63	132.2	16.1	80.6	13.8	44	125.2	11.9	79.8	
30–	83	128.5	16.6	78.8	12.4	54	130.6	17.5	83.0	
35–	68	131.0	18.1	80.8	14.3	34	133.7	15.6	85.6	
40–	70	134.1	15.3	84.8	11.7	33	131.1	13.7	85.7	
45–	81	136.5	22.1	86.3	12.8	34	136.6	23.2	87.6	
50–	68	141.1	22.5	89.0	15.6	29	144.7	30.0	92.0	
55–	45	144.4	27.5	85.9	15.9	8	151.3	34.6	90.0	
60–	28	149.8	27.6	92.0	16.4	8	157.5	28.7	95.6	
65–	30	161.5	29.8	94.3	18.9	3	147.5	21.8	77.5	
70–	14	152.9	21.6	90.7	14.1	3	172.5	43.6	89.2	
75+	5	148.5	23.8	87.5	15.5	4	158.8	11.3	93.8	
Total	763					371				

*In all tables and figures the means have been corrected. Recordings were made at the nearest 5-mm. or 10-mm. gradation below the observed figure; 2.5 mm. has been added to the recorded values to correct for this.

particularly, and confirms the higher rates for hypertension among females in the rural area.

Table V shows the proportion of subjects in these two populations who have had cerebrovascular accidents;

TABLE III.—Differences in Mean Pressures and Standard Deviations Between Jamaican Rural and Urban Populations

Age	Differences between Mean Pressures and between S.D.s (Rural-Urban)							
	Females				Males			
	Sys-tolic	S.D.	Dias-tolic	S.D.	Sys-tolic	S.D.	Dias-tolic	S.D.
15-	+5.1	+1.7	+2.4	+2.6	+2.8	+0.4	+1.4	+0.8
20-	+6.0	-0.5	+5.9	-0.7	+5.4	+0.7	+3.4	+0.9
25-	+6.0	+5.0	+2.8	+2.5	+7.0	+4.2	+0.8	+4.6
30-	+3.4	-3.4	-0.5	-1.4	-2.1	-0.9	-4.2	+0.1
35-	+6.2	+7.1	+1.5	+2.2	-2.6	+2.5	-4.8	+1.1
40-	+4.1	+5.9	+2.6	+4.3	+3.0	+1.6	-0.9	+0.4
45-	+0.7	+1.4	+3.4	+2.3	-0.1	-1.1	-1.3	-0.5
50-	-1.2	-6.0	+0.6	+0.2	-3.6	-7.5	-3.0	-1.3
55-	+28.2	+16.8	+14.9	+10.1	-6.9	-7.1	-4.1	-5.1
60-	+4.6	+14.9	+2.9	+8.8	-7.7	-1.1	-3.6	+4.2
65-	+7.8	+15.8	+3.0	+0.3	+14.0	+8.0	-16.8	+10.2
70-	+24.4	+31.9	+6.5	+12.4	-19.6	-22.0	+1.5	+3.7
75+	-1.9	+7.5	+7.1	-5.6	-10.3	+12.0	-6.3	+5.2

FIG. 4.—Frequency distributions of arterial pressure in Jamaican males.

TABLE IV.—Percentages of Rural and Urban Populations with Systolic and Diastolic Pressures above Certain Thresholds

Age	Systolic Pressure						Diastolic Pressure						Total No. of Subjects	
	Exceeding 160 mm. Hg		Exceeding 190 mm. Hg		Exceeding 220 mm. Hg		Exceeding 100 mm. Hg		Exceeding 115 mm. Hg		Exceeding 130 mm. Hg			
	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural	Urban
Females														
15-	0.4	—	—	—	—	—	3.7	0.4	—	—	—	—	245	226
25-	3.5	1.6	0.5	—	—	—	4.0	3.6	1.0	1.0	—	—	199	192
35-	8.3	7.0	3.6	—	1.8	—	17.7	7.9	3.6	0.9	1.8	—	169	114
45-	33.8	36.6	11.7	16.9	4.1	1.4	26.2	21.1	9.0	5.5	3.4	1.4	145	71
55-	64.6	38.9	27.8	8.3	15.2	—	44.3	30.6	24.1	—	11.4	—	79	36
65-	63.0	46.7	29.5	6.7	11.1	—	42.6	20.0	7.4	6.7	3.7	—	54	15
75+	62.5	80.0	31.3	20.0	12.5	—	18.8	40.0	6.3	—	—	—	16	5
Males														
15-	1.0	—	—	—	—	—	1.0	1.7	—	—	—	—	238	117
25-	4.8	2.0	—	1.0	—	—	5.5	5.1	1.4	—	—	—	146	98
35-	4.3	1.5	0.7	—	—	—	8.0	11.9	1.4	1.5	0.7	—	138	67
45-	16.8	20.6	2.7	4.8	—	1.6	14.1	22.2	4.0	4.3	2.0	3.2	149	63
55-	32.9	50.0	5.5	12.5	3.2	—	21.9	42.8	8.2	—	2.7	—	73	16
65-	47.7	50.0	15.9	33.3	—	—	34.1	—	9.1	—	2.3	—	44	6
75+	20.0	50.0	—	—	—	—	40.0	50.0	—	—	—	—	5	4

though the numbers are small they reflect the same trend. Nine of the 12 rural females affected had diastolic pressures exceeding 110 mm. Hg. Only one of the five urban subjects, a woman, had a pressure exceeding 110 mm. Hg. Vascular lesions of the central nervous system on a background of hypertension seem to be more common in the rural area.

TABLE V.—Proportion of Subjects in Rural and Urban Populations in Jamaica who Have Suffered a Cerebrovascular Accident

Age	Females				Males			
	Rural		Urban		Rural		Urban	
	Affected No.	%	Affected No.	%	Affected No.	%	Affected No.	%
15-	—	—	278	—	333	—	231	—
25-	1	0.4	237	—	295	—	167	—
35-	1	0.5	214	1	175	1	171	—
45-	2	1.1	185	—	108	1	178	—
55-	5	3.6	137	1	61	2	124	1
65+	3	2.2	135	1	51	3	94	1

(2) Relationship between Hypertension and Renal Disease in These Populations

Urine analyses for protein, using "albustix" reagent strips, were carried out in 97.2% of females examined and in 94.4% of males. There is no marked difference between the rural and urban populations in this respect in either sex (Table VI) though the overall rates are slightly higher in the rural subjects.

Specimens of clean-voided urine were collected from 89.3% of the rural women under the age of 65, and from 96.2% of the urban women of all ages. The technique of quantitative bacteriological investigations of the urine developed by Kass and his colleagues was used (Kass, 1955, 1956, 1957). Urine specimens were collected into sterile containers after cleansing the vulvae with soap and water, were refrigerated immediately, and were cultured that evening or the following day. Subjects with colony counts of more than 100,000 bacteria per ml. were reinvestigated. Any person showing Gram-negative rods (82% had *Escherichia coli*) in concentrations of 10^5 bacteria per ml. or greater in repeated specimens is considered to have true bacteriuria—that is, bacteria multiplying within the urinary tract. The validation of this technique was reviewed recently by Quinn and Kass (1960).

Table VII shows, for all females under 65 examined, the prevalence of bacteriuria in these two populations. With the exception of the youngest age-group, bacteriuria

TABLE VI.—Prevalence of Proteinuria. Rural and Urban Populations, Jamaica

Age	Rural Population						Urban Population					
	Proteinuria		Normal	Total Tested	Lapses	Total	Proteinuria		Normal	Total Tested	Lapses	Total
	No.	%					No.	%				
Females												
15-	17	6.2	259	276	2	278	16	5.0	305	321	12	333
20-	10	4.2	226	236	1	237	12	4.2	276	288	7	295
25-	12	5.8	195	207	7	214	8	4.7	161	169	6	175
35-	10	5.5	173	183	2	185	6	5.8	97	103	5	108
45-	14	10.5	119	133	4	137	5	8.9	51	56	5	61
55-	9	10.2	79	88	4	92	8	22.9	27	35	—	35
65+	6	16.2	31	37	6	43	2	13.3	13	15	1	16
Total	78		1,082	1,160	26	1,186	57		930	987	36	1,023
Males												
15-	16	7.1	210	226	5	231	7	5.1	129	136	21	157
20-	5	3.1	156	161	6	167	5	3.5	138	143	13	156
25-	6	3.7	157	163	8	171	1	1.1	89	90	9	99
35-	11	6.3	164	175	3	178	5	6.4	78	83	10	93
45-	10	8.3	110	120	4	124	4	13.8	25	29	3	32
55-	9	13.8	56	65	2	67	2	16.7	10	12	—	12
65+	3	12.0	22	25	2	27	1	9.1	10	11	—	11
Total	60		875	935	30	965	25		479	504	56	560

was found more frequently in the rural females. This difference is significant at the 2% level. Only three cases of bacteriuria were found among 700 men examined. Two of them had recently undergone prostatectomy.

TABLE VII.—Prevalence of Bacteriuria in Rural and Urban Jamaican Females

Age	Total No. of Subjects		Subjects Investigated Bacteriologically				Subjects with Bacteriuria			
	Rural	Urban	Rural		Urban		Rural		Urban	
			No.	%	No.	%	No.	%	No.	%
15-24	278	333	247	88.5	320	96.1	2	0.8	6	1.9
25-34	237	295	205	86.5	287	97.3	9	4.4	3	1.0
35-44	214	175	200	93.5	165	93.7	10	5.0	3	1.8
45-54	185	108	165	89.7	104	98.2	10	6.1	5	4.8
55-64	137	61	119	86.1	55	91.5	14	11.8	1	1.8

Bacteriuria is defined as urine containing 10^5 Gram-negative bacteria per ml. on repeated culture.

Table VIII shows the mean arterial pressures of those with and those without bacteriuria, using all females from both populations who were under the age of 65. From age 30 to age 60 the pressures of those with bacteriuria are higher than in those without. Above the age of 60 this trend disappears. To test the significance of these differences, the deviation in standard

TABLE VIII.—Mean Systolic and Diastolic Pressures of Women Aged 15-64 With and Without Bacteriuria

Age	No. of Subjects		Mean Systolic Pressure		Mean Diastolic Pressure	
	Bacteriuria		Bacteriuria		Bacteriuria	
	With	Without	With	Without	With	Without
15-	—	286	—	120.9	—	74.4
20-	8	273	120.0	119.7	78.8	74.6
25-	6	268	107.5	120.3	65.8	77.0
30-	6	212	131.7	123.3	85.8	78.4
35-	11	186	149.3	127.6	93.9	81.0
40-	2	166	137.5	136.7	85.0	85.5
45-	6	138	155.8	146.5	96.7	90.2
50-	9	116	176.9	158.7	104.7	93.1
55-	11	94	175.7	160.1	98.0	93.8
60-	4	65	137.5	170.6	86.3	94.8

deviation units of the average systolic pressure of the bacteriuric women from the average systolic pressure of the normals in each age-group has been used. At ages 25-30 the pressures of bacteriuric women are significantly below average; at ages 35-40 they are significantly above average. In no other age-groups do the differences reach a significant level. The overall difference in systolic pressure between bacteriuric and

non-bacteriuric women of all ages, using this index weighted inversely by its variance, is $+0.247 \pm 0.133$, but it is possible that there is a trend of pressure in bacteriuric women below 65 from below average to above average. This would accord with the belief that the onset of bacteriuria may be associated with hormonal changes in pregnancy (Quinn and Kass, 1960); for, as shown below, the pressures of pregnant women are below average in Jamaicans.

Though nearly 15% of subjects with diastolic pressures above 110 mm. Hg had bacteriuria, removing such subjects from both populations left the difference in the distributions of pressure in these two female populations almost unchanged. Similarly the difference in the prevalence of bacteriuria between the two sexes does not seem to account for the differences in the distributions of arterial pressure between the sexes. Omitting bacteriuric subjects leaves the sex difference in pressure little affected. It is worth noting that the vast majority of these women were free from urinary symptoms and had no protein in the urine; if, as seems likely, bacteria multiplying in the urinary tract are a cause of ascending infection, pyelonephritis, and resultant hypertension, as is discussed more fully elsewhere (Kass *et al.*, 1962), this would explain our findings. However, the difference in the prevalence of bacteriuria in the urban and rural populations is not sufficiently marked to provide an explanation for the disparity in blood-pressure levels in these two groups of women; if differences in the prevalence of pyelonephritis do in fact account for the different distributions of blood-pressure in these rural and urban groups, we must conclude either that our techniques for detecting it are inadequate or that many of these infections burn out, leaving scarred and damaged kidneys and a sterile urinary tract.

Comparisons with Other Surveys of Negro Populations in the West Indies

Few surveys have been carried out in representative population samples in the West Indies. Schneckloth *et al.* (1962) carried out a survey in the Island of St. Kitts, in the Eastern Caribbean, in which they examined men and women in three villages and achieved 83% coverage of the males and 89% coverage of the females in the age-groups selected, the three decades

from 20 to 50. Examinations were made at central clinics: that is, under circumstances in which systolic pressures have been shown in Wales (but not in the West Indies) to be about 12.5 mm. Hg higher than when measured at home and diastolic pressures about 2.5 mm. Hg higher (Miall and Oldham, 1958). Age statements showed some digit preference and were not checked; pressure measurements also showed marked digit preference in favour of readings ending in 0.

Fig. 5 shows a comparison of mean pressures for females and males in various surveys of negro populations in the West Indies and the United States*; in St. Kitts mean systolic pressures for subjects aged 30–50 are about 10 mm. Hg higher in both sexes than in our rural population in Jamaica. Schneckloth and his colleagues used the disappearance of sounds (phase V) as their diastolic measurement whereas we used the muffling of sounds (phase IV). Nevertheless mean diastolic pressures were also somewhat higher in St. Kitts. A comparison of the frequency distributions for diastolic pressure indicated that the whole range of pressures was higher in St. Kitts than in rural Jamaica; the difference in means was not explained by the

FIG. 5.—Mean systolic and diastolic pressures in representative Western negro populations. —, Jamaica, rural. Present series. ■, St. Kitts, rural (Schneckloth *et al.*, 1962). ×, Bahamas, urban (Johnson and Remington, 1961). △, U.S., rural (Gover, 1948). ○, Georgia, U.S., rural (Comstock, 1957).

distributions being more skewed towards the higher pressures in St. Kitts. Though these differences may be real ones it is equally likely that they reflect the circumstances under which the measurements were made.

Johnson and Remington (1961) report the results of a survey in the Bahamas carried out with similar techniques to ours in Jamaica. Stratified samples of the urban population of Nassau were examined at home, and again mean pressures were much higher than those obtained in our rural population (Fig. 5) and thus much higher than in our urban population. Comstock's (1957) survey of the inhabitants of Muscogee County, Georgia, is also comparable with our own, as this was based on a census and measurements were made in the home environment in over 90% of cases. The mean values for negroes in Georgia are consistently higher for males and females up to age 55 than in Jamaica; at greater ages Comstock's numbers are small.

*For clarity, the data from the urban survey in Jamaica have been omitted in Fig. 5.

Gover (1948) analysed the results of physical examinations of members of borrower families from the U.S. Farm Security Administration; these examinations covered 91% of the members of such families and were carried out at central clinics. The mean values for systolic pressure for these rural negro populations in different parts of the U.S. average about 15 mm. Hg higher, for diastolic pressures 5–10 mm. Hg higher, than our rural Jamaicans.

In none of these surveys were age statements checked, but the possible bias introduced by inaccurate age data is unlikely to account for such great differences. The different circumstances under which measurements were made and the differences in the selection of populations cast serious doubt on the validity of any such comparisons of data collected by different observers when no attempt has been made to make them really comparable. Where such an attempt has been made smaller differences of the magnitude shown in Fig. 2 can be expected within different samples of the same population. Nevertheless these surveys do suggest that there may be very different distributions of arterial pressure within different negro populations in the West Indies and United States, and suggest that the role of environmental factors may be great.

This is also the conclusion we draw from the comparison between our rural and urban populations in Jamaica. The higher pressures in women in the rural area were not attributable to excess weight, for the mean weights of the women from Kingston were consistently higher at all the ages between 35 and 80 years. Nor were they due to differences in reaction to the examination: mean pulse rates were about 2 beats per minute faster in the rural area. The measurements were all made under similar circumstances by the same two observers, who independently obtained similar findings. Of the other factors which could contribute to this regional difference, internal migration and inter-marriage need consideration. There is much migration into and out of the urban population, and this may be related to health; but, as can be seen in Fig. 3, the differences in the distributions of pressure are found even in the youngest age-groups; in females there is a consistent difference in all age-groups under 50, where migration would be little influenced by arterial pressure.

It is possible, too, that there is more intermarriage in the rural than in the urban population, but in the absence of any suggestion of genetic differences in any other characteristics it would be unwise to attribute the different prevalence of hypertension to genetics without first investigating further the role of other environmental factors.

Influence of Pregnancy on Arterial Pressure in Negro Females

All women were asked whether they were pregnant; though there is probably a deficiency in the data for the first trimester of pregnancy, it is unlikely that there is any serious error thereafter.

Mean systolic as well as diastolic pressures of pregnant women were lower in every age-group below 40 than in those not pregnant† (Table IX); the differences between the mean pressures of the pregnant and the non-pregnant women increase with the age of the subjects up to 40, suggesting either that pregnancy has a greater effect on arterial pressure in older women or that those with low pressure tend to be more fertile. Similar findings were reported in the St. Kitts survey.

TABLE IX.—Effect of Pregnancy on Systolic and Diastolic Pressures in Jamaican Women Aged 15–44 Years

Age	No. of Subjects		Mean Systolic Pressure		Mean Diastolic Pressure	
	Pregnant	Not Pregnant	Pregnant	Not Pregnant	Pregnant	Not Pregnant
15–	23	287	116.6	122.0	69.2	75.4
20–	46	255	117.6	120.8	68.4	76.3
25–	37	257	114.8	120.7	69.4	78.8
30–	19	219	110.9	125.3	67.0	79.9
35–	23	184	122.9	129.7	72.7	83.5
40–	2	180	137.5	137.1	82.5	86.1

This factor, however, will not explain the differences in pressure between these two groups of women; at every age-group there was a higher percentage of pregnant women in the rural area.

Influence of Parity on Arterial Pressure

In Jamaica, as in Britain (Miall and Oldham, 1958; Miall, 1959) and Norway (Humerfelt and Wedervang, 1957), there is a relationship between parity and arterial pressure. Nulliparous women have higher mean pressures than parous women (Table X), but within the parous group the relationship between a subject's pressure and her family size is less marked than in South Wales. Below age 55 mean pressures are lowest in those with two to five children and rise again in the grand multiparous women, a finding which probably bears some relationship to the increase in the prevalence of bacteriuria found in the grand multipara. The prevalence of diastolic hypertension (100 mm. Hg or more) is greater in nulliparous than in parous women and varies with family size (Table XI), as do the mean pressures. In Wales there is apparently a linear trend of lower pressures with increasing family size, but the number of women with large families of 10 and more children was small. Somewhat similar findings were obtained in the survey of St. Kitts: the prevalence of diastolic hypertension was highest in the nulliparous

†As the comparison shown in Table IX is limited to the younger age-groups, where age is generally known reasonably accurately, all subjects have been included, whether their ages were verified or not. One woman, aged 35, with severe pre-eclampsia, unfortunately confirmed at necropsy within two weeks of her examination in the survey, is omitted. Her arterial pressure was 195/125.

TABLE X.—Mean Systolic and Diastolic Pressures by Family Size. Jamaican Females

Age	No. of Children											
	0			1			2–5			6–9		
	No. of Subjects	Mean Pressures		No. of Subjects	Mean Pressures		No. of Subjects	Mean Pressures		No. of Subjects	Mean Pressures	
		S.	D.		S.	D.		S.	D.		S.	D.
15–	266	122.0	75.4	103	120.8	74.5	102	119.0	78.2	—	—	—
25–	78	121.7	76.3	74	121.8	77.9	194	120.5	76.5	42	126.2	80.0
35–	54	139.8	89.5	39	129.0	82.0	112	125.7	81.9	57	133.3	84.4
45–	31	156.7	93.6	33	156.6	91.4	78	150.9	89.1	45	152.4	92.9
55–59	16	162.2	100.9	9	158.6	95.3	22	164.3	95.7	14	158.6	95.4

TABLE XI.—Prevalence of Diastolic Hypertension (100 mm. Hg and more) in Jamaican Females, by Family Size

Age	No. of Children											
	0			1			2–5			6–9		
	No. of Subjects	Exceeding 100 mm.		No. of Subjects	Exceeding 100 mm.		No. of Subjects	Exceeding 100 mm.		No. of Subjects	Exceeding 100 mm.	
		No.	%		No.	%		No.	%		No.	%
15–	266	7	2.6	103	1	1.0	102	2	2.0	—	—	—
25–	78	2	2.6	74	4	5.4	194	4	2.1	32	3	7.1
35–	54	10	18.5	39	3	7.7	112	7	6.3	57	6	10.5
45–	32	10	31.3	33	8	24.2	78	15	19.2	45	9	20.0
55–59	16	7	43.7	9	4	44.0	22	7	31.8	14	5	35.7

from age 30 to 49 but not at younger ages. No clear trend with family size was found either in St. Kitts (Schneekloth *et al.*, 1962) or in the Bahamas (Johnson and Remington, 1961). In Britain a relationship between arterial pressure and family size has been demonstrated in males also (Miall and Oldham, 1958; Lowe, 1961, personal communication); no such trend was found in Jamaica.

Body Build and Arterial Pressure

The significance of any relationship between body build and arterial pressure as measured indirectly with a sphygmomanometer is open to some doubt because of the artifact introduced by differences in arm girth. Table XII shows the relationship between diastolic pressure and ponderal index ($\text{ht.}^3/\text{wt.}$) for females

TABLE XII.—Relationship Between Ponderal Index ($\text{Ht.}^3/\text{Wt.}$) and Diastolic Pressure. Jamaica

Age	Ponderal Index									
	< 12 (Heavy Build)		12–		12.5–		13–		> 13.5 (Light Build)	
	No.	Mean	No.	Mean	No.	Mean	No.	Mean	No.	Mean
<i>Females</i>										
15–	25	78.1	72	79.2	157	76.2	107	74.1	65	73.3
25–	74	80.6	72	79.9	106	76.1	76	75.8	24	76.7
35–	83	87.6	56	83.8	65	83.3	47	81.1	13	83.7
45–	55	93.8	59	91.9	59	93.0	33	86.7	9	86.4
55–	32	94.1	30	93.5	30	101.0	15	98.5	7	106.1
65+	21	92.5	17	90.4	22	98.0	16	95.9	11	97.0
<i>Males</i>										
15–	(2)	(92.5)	26	78.5	89	78.2	125	75.8	81	73.8
25–	8	86.3	40	79.8	112	80.7	68	80.1	12	75.8
35–	14	91.8	42	83.9	85	82.7	50	82.9	13	79.8
45–	11	97.0	50	88.9	82	87.9	58	87.5	10	82.5
55–	(2)	(85.0)	10	98.5	40	92.0	31	83.0	(4)	(92.5)
65+	(1)	(112.5)	(4)	(80.0)	21	91.1	23	92.1	8	93.1

(excluding those who were pregnant and those whose hypertension was secondary to known renal disease) and for males.

Below age 55 the relationship between overweight (low ponderal index) and higher pressure is fairly consistent though not very large. Above age 55 this trend disappears and in women those who are underweight tend to have higher mean pressure. Similar results were obtained in Wales, and presumably are explained either by an increased mortality in those who

are both hypertensive and overweight—the overweight surviving population being those that are not hypertensive—or by a tendency for elderly hypertensive subjects to lose weight. Follow-up studies will be needed to determine which of these factors is the more important.

Influence of Occupation

The two populations selected for this study were chosen to be as similar as possible socio-economically. As a result few males in either population were engaged in sedentary or light occupations, and with the exception of cultivators no other homogeneous occupational group was represented adequately for an analysis by occupation. The rural population was very largely composed of cultivators, the urban population of men engaged in a wide variety of semi-skilled occupations, and the similar distributions of pressure in the two male populations suggest that no major occupational influences are present.

We have been able to compare those from the agricultural area whose predominant past occupation was agricultural work with those engaged in other occupations, mostly shopkeepers, masons, drivers, and general labourers. This was done to determine whether there was any evidence of a factor associated with the lives of cultivators (and their wives) which would explain the regional differences in the prevalence of hypertension; it has been found (Burnell, 1961, personal communication) that some of the herbal beverages consumed in rural areas in Jamaica, and known locally as “bush teas,” contain unidentified pressor agents. The analysis showed that the agricultural workers had greater pulse pressures—systolic means were slightly higher, diastolic means slightly lower. The differences, however, were immaterial and may reflect only the usual short-term effects of exercise on arterial pressure.

Role of Inheritance

As in previous investigations of the inheritance of arterial pressure we have derived scores which allow direct comparison of the pressure of members of the same family who differ in age and sex. These scores have been described in detail elsewhere (Hamilton *et al.*, 1954a); briefly they are derived as follows. For either sex the deviation of an individual's pressure from the smooth curve relating pressure with age in that population is noted. The deviation is then adjusted to allow for the increase in the variance of pressure which occurs in older people.

These scores have been criticized (Platt, 1959; Morrison and Morris, 1959) on the ground that they may artificially obscure bimodality in blood-pressure distribution. They have the property of giving equal weight to the pressures of subjects who deviate proportionately from the norm of their age and sex; they therefore allow for any increase in mean pressure which occurs with age whether this is due to changes in pressure occurring in a minority or in the majority of the population. Figs. 3 and 4 indicate that the pressure distributions for the whole population shift to the right in succeeding age-groups; a small minority in these populations could conceivably show no increase in pressure with age, but these would be those forming the upper end of the frequency distributions at younger ages and the lowest at older ages, an inherently unlikely situation.

The scores also give less weight to a deviation from the norm in old people, where the scatter of pressures is greatest, and most weight to deviations in young people, where the scatter is least. Biologically the validation of these scores has yet to be demonstrated, but Hamilton *et al.* (1954b) found that even the disproportionately high scores of young hypertensives drawn from a hospital population were reflected faithfully by correspondingly higher average scores of their relatives.

The unstable nature of the urban population was manifested in very incomplete families, and we have therefore limited the genetic analysis to the more complete families in the rural population. In this population the smoothed curves relating standard deviations of systolic pressure to age for each sex cross at the ages of 20 and 35 years; for diastolic pressures they cross at ages $22\frac{1}{2}$ and 37 years. We chose to adjust scores to age 35, thus making the necessary allowance for sex. A factor is derived for each age- and sex-group by dividing the variance at age 35 by the appropriate variance at other ages, and the deviation of an individual's pressure from the norm for his or her age is then multiplied by this factor.

The scores were derived from the curves relating pressure with age in those with verified ages only; the genetic analysis included all members of the family whether their ages were checked or not. Nevertheless the scores as applied to everyone showed no significant residual relationship with age in either sex, and, with one exception (diastolic scores of men aged 65–69, which had a mean value of +6 mm. Hg), the mean scores for each five-year age-group never deviated by more than 4 mm. Hg from zero in those under age 70. Subjects over 70 were few in number and have been omitted from these analyses.

The analyses are confined to first-degree relatives; groups of siblings were taken first, and in each group one subject was chosen by random methods as *propositus*. The age-adjusted systolic and diastolic scores of the relatives were then plotted against those of the *propositi*. Similar tabulations were made for the scores of siblings against their mothers, fathers, sons, and daughters, in each case using the subject in the elder generation as *propositus*. This method of analysis is somewhat different from that employed by Miall and Oldham in their analysis of data collected in Wales, where *propositi* were randomly selected from a larger population and where only they and their relatives were seen in the survey. We have used the technique described above to make maximal use of the data for the whole of a geographically defined population. There is no reason to suspect that these different techniques would influence the findings.

The overall regression for all relatives on all *propositi* had the value 0.187 (S.E. ± 0.025) for systolic pressure and 0.178 (S.E. ± 0.025) for diastolic pressure (Figs. 6 and 7). The separate regressions for different relationships (Table XIII) showed significant variability, at the 5% level only, from the average regressions for all relatives on male and female *propositi*.

These statistically significant differences may arise from applying significance tests that are inappropriate to distributions of scores which are markedly skewed, as are these; they may result from environmental influences, but it seems unlikely that they represent true genetic differences, and a comparison with the similar regressions derived from Welsh populations shows no

consistent pattern in this variability between the different relationships.

The separate average regressions for systolic and diastolic scores for all relatives on male and female *propositi* do not differ significantly, and if we assume that the heterogeneity found is due to personal and environmental factors, or to chance, the overall regressions adequately represent the genetic dependence of blood-pressure of relatives of any kind on *propositi* of either sex. They compare closely with those derived from populations in Wales (Miall and Oldham, 1958), where the regression for systolic scores had a value of 0.224 and that for diastolic scores 0.178, and those derived from the analysis of hypertensive families (Hamilton *et al.*, 1954b) in which the regressions had values of 0.240 and 0.238 respectively. The deviations of the mean scores of relatives from these regression lines (Figs. 6 and 7) are small except at the extremes, where small numbers probably account for them. We conclude, therefore, that the resemblance in blood-pressure levels between close relatives in Jamaica, as

FIG. 6.—Relationship between systolic blood-pressure scores of *propositi* and mean systolic scores of relatives. Jamaica.

FIG. 7.—Relationship between diastolic blood-pressure scores of *propositi* and mean diastolic scores of relatives. Jamaica.

TABLE XIII.—Regression Coefficients of Relatives on *Propositi* (Age-adjusted Scores)

Relatives	Male <i>Propositi</i>		Female <i>Propositi</i>	
	Systolic	Diastolic	Systolic	Diastolic
Brothers ..	0.125	0.081	0.203	0.265
Sisters ..	0.376	0.254	0.335	0.292
Sons ..	0.078	0.016	0.221	0.189
Daughters ..	0.285	0.256	0.075	0.168
All relatives ..	0.214	0.143	0.171	0.209

in Wales, is independent of the range of pressure considered, and this adds further weight to the evidence that arterial pressure, if inherited at all and not merely similarly influenced within families by common environmental factors, is polygenically determined.

Such an analysis, however, does not exclude the possibility that single gene inheritance could be the mechanism for transmission of a small fraction of hypertension in those populations, in the same way that a small fraction of cases of hypercholesterolaemia seems to be transmitted by a dominant gene (Aldersburg *et al.*, 1957; Epstein *et al.*, 1959).

We have examined the distributions of systolic and diastolic pressures in the middle-aged relatives (in our case those aged 35–59 years) of middle-aged hypertensives in the Jamaican population, as did Platt (1959) and Oldham *et al.* (1960). The hypertensive *propositi* for this analysis comprised all subjects with diastolic pressures exceeding 100 mm. Hg provided that pressure was at least 15 mm. Hg above the mean for his or her age-group. At age 35, 100 mm. Hg was the criterion for both sexes; at age 59 the values were 120 mm. Hg for women and 105 mm. Hg for men.

The distributions of systolic and diastolic pressure for the 81 middle-aged siblings of these hypertensive subjects showed small dips at 125 and 150 mm. Hg systolic, and at 90 and 120 mm. Hg diastolic. These dips were entirely due to small numbers and represented no more than three subjects. When plotted in groups of 10 mm. (Fig. 8) there was no suggestion that these siblings are divided into two groups, those who have and those who have not inherited a specific gene for hypertension. Nor when we plot the age-adjusted scores for all the first-degree relatives of these middle-aged hypertensives—a more sensitive test as it avoids the errors introduced

FIG. 8.—Frequency distributions of systolic and diastolic pressures in siblings aged 35–59 years of hypertensive *propositi* aged 35–59 years. Jamaica.

FIG. 9.—Frequency distributions of age-adjusted systolic and diastolic scores of all first-degree relatives of middle-aged (35–59 years) hypertensive subjects. Jamaica.

by combining data from both sexes and covering a wide age range—do we have any suggestion of a bimodal distribution (Fig. 9).

These data suggest, therefore, that if single gene inheritance occurs it forms a small fraction of hypertension seen in the general population.

Genetic Hypertension in Bacteriuric Women

The aetiological role of pyelonephritis in causing hypertension is accepted by many but denied by those who suggest that kidneys damaged by the vascular changes secondary to hypertension are more susceptible to infection. If the first of these hypotheses is correct we would expect the relationship between the arterial pressure of bacteriuric subjects and their first-degree relatives would differ from that for all families in which the propositus was not bacteriuric. If the second hypothesis is correct, and bacteriuria is secondary to the hypertension, the genetic factor in arterial pressure of families containing bacteriurics would be similar to that found in the general population.

The regression coefficients for systolic scores of all relatives of bacteriuric women is +0.13, compared with +0.17 for that of all women; for diastolic scores the respective regressions are +0.07 and +0.21. These differences suggest that the pressures of bacteriuric women are being influenced by some non-genetic factor, presumably the bacteriuria, but the differences are not significant statistically.

Summary

Representative rural and urban populations in Jamaica were defined geographically, enumerated by private census, and visited at home by two physicians who carried out indirect arterial blood-pressure measurements. These readings have been related to a number of personal and environmental factors, and this analysis shows the following facts.

1. There was a considerable difference in the prevalence of hypertension, particularly among women, between neighbouring rural and urban negro populations, with a higher prevalence in the women from the rural area. This was not attributable to differences in survey technique, weight, or pulse rate, nor to differences in the prevalence of hypertension secondary to renal disease as detected by proteinuria.

2. Bacteriuria (the presence of Gram-negative rods in a concentration of 10^5 or more bacteria per ml. in repeated specimens of clean-voided urine), which was usually asymptomatic, was a common finding among women (4.4% of women investigated), was significantly more common in the rural area, was related to hypertension, and was found in 15% of females with diastolic pressures exceeding 110 mm. Hg in these surveys. Bacteriuria was found in only 0.5% of males.

3. The relationship between bacteriuria, as detected in one prevalence study, and hypertension was not sufficient to account for the differences in the prevalence of hypertension between these two female populations.

4. Mean arterial pressures as found in these Jamaican populations were lower than those reported in other surveys of Western negro populations.

5. Pregnant women in Jamaica had significantly lower systolic and diastolic pressures than those who were not pregnant. The prevalence of diastolic hypertension (100 mm. Hg or more) was higher in nulliparous than in

parous women, and was least in those with moderate-sized families of two to five children. The prevalence of hypertension increased again in those with very large families, as did the prevalence of bacteriuria.

6. Body build, as measured by the ponderal index, had a small but consistent influence on arterial pressure, as measured indirectly, in Jamaican subjects under age 55. The absence of this relationship in the elderly may be due to increased mortality among obese hypertensives.

7. The use of a quantitative method for determining the genetic factor in arterial pressure suggests that its inheritance is graded, the resemblance in pressure between close relatives being independent of the range of pressure considered, and closely similar to the genetic factor in blood-pressure found in the Welsh.

8. The pressures of the middle-aged siblings of middle-aged hypertensives showed no bimodality in their distribution.

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REFERENCES

- Adams, J. M. (1932). *Amer. J. med. Sci.*, **184**, 342.
 Aldersburg, D., Schaefer, L. E., and Steinberg, A. G. (1957). *Circulation*, **16**, 487.
 Comstock, G. W. (1957). *Amer. J. Hyg.*, **65**, 272.
 Dahl, L. K., and Love, R. A. (1954). *Arch. intern. Med.*, **94**, 525.
 Epstein, F. H., Block, W. D., Hand, E. A., and Francis, T., jun. (1959). *Amer. J. Med.*, **26**, 39.
 Gover, M. (1948). *Publ. Hlth Rep. (Wash.)*, **63**, 1083.
 Hamilton, M., Pickering, G. W., Roberts, J. A. F., and Sowry, G. S. C. (1954a). *Clin. Sci.*, **13**, 37.
 ——— (1954b). *Ibid.*, **13**, 273.
 Humerfelt, S., and Wedervang, F. (1957). *Acta med. scand.*, **159**, 489.
 Johnson, B. C., and Remington, R. D. (1961). *J. chron. Dis.*, **13**, 39.
 Kass, E. H. (1955). *Amer. J. Med.*, **18**, 764.
 ——— (1956). *Trans. Ass. Amer. Physns.*, **69**, 56.
 ——— (1957). *Arch. intern. Med.*, **100**, 709.
 ———, Miall, W. E., and Stuart, K. L. (1962). *J. clin. Invest.* In press.
 Lennard, H. L., and Glock, C. Y. (1957). *J. chron. Dis.*, **5**, 186.
 Miall, W. E. (1959). *Brit. med. J.*, **2**, 1204.
 ——— and Oldham, P. D. (1955). *Clin. Sci.*, **14**, 459.
 ——— (1958). *Ibid.*, **17**, 409.
 Morrison, S. L., and Morris, J. N. (1959). *Lancet*, **2**, 864.
 Moser, M., Morgan, R., Hare, M., Hoobler, S. W., Remington, R. D., Dodge, H. J., and Macaulay, A. I. (1959). *Amer. J. Cardiol.*, **4**, 727.
 Oldham, P. D., Pickering, G. W., Roberts, J. A. F., and Sowry, G. S. C. (1960). *Lancet*, **1**, 1085.
 Platt, R. (1959). *Lancet*, **2**, 55.
 Quinn, E. L., and Kass, E. H. (1960). *Biology of Pyelonephritis*. Little, Brown, Boston.
 Saunders, G. M., and Bancroft, H. (1942). *Amer. Heart J.*, **23**, 410.
 Schneekloth, R. E., Stuart, K. L., Corcoran, A. C., and Moore, F. E. (1962). In press.
 Stamler, J., Kjelsberg, M., and Hall, Y. (1960). *J. chron. Dis.*, **12**, 440.