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Influence Of Some Correlates Of Blood Pressure On Its Distribution In An Adult Urban Population Of Allahabad

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Distribution of systolic and diastolic blood pressures of 2,023 individuals of age 15-74 years was found to be affected by age-sex structure as well as by built and social status of the individuals studied. Of these, age and sex were amenable to standardization. The distributions after such standardization of both systolic and diastolic pressures were found to be approximately lognormal. This has been used to find out cut-off points between normo-and hypertension at various probability levels.

Introduction

Blood pressure distribution in a population has been a subject of considerable discussion. Varying results have been obtained under different conditions (Lovell 1963, Dawber 1967). Various personal, social and environmental factors like age, sex, social status, diet, ethnicity have been cited as possible correlates. Some attempts have been made in India also to explain influence of some of these factors, particularly of age and sex (Wilson 1958, Padmavati and Gupta 1959, Singh **et al** 1968, Celine and Mathur 1970). Nevertheless, shape of the frequency distributions in relation to changing values of some of the correlates does not seem to have attracted sufficient attention as yet. Mean and standard deviation, usually used to represent characteristics of blood pressure distribution, may not quite often reveal the picture in its totality. Holland (1963) considered mean and standard deviation of mean as somewhat crude expressions for comparing levels of blood pressure of two or more groups and emphasized greater importance of precise form or shape of the frequency distribution. W.H.O. Expert Committees (1959, 1967) urged presentation of full distribution curves of blood pressure measurements wherever possible so that differences that are not obvious in summary statistics may be detected. The controversy between schools of Pickering (1967) and Platt (1967) centres on distribution aspect alone as the former insists on Gaussian characteristics of blood pressure distribution while the latter doubts existence of such a characteristic. Selection of suitable representative value for a particular population depends, to a large extent, on the shape of the frequency distribution. The determination of cut-off points between normo-and hypertension also

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requires knowledge of shape of the distribution. Influence of age, sex, built, social status, etc., on blood pressure levels can better be understood by studying changes in the shape of blood pressure distribution.

The present paper reports the blood pressure distribution in an adult urban population of Allahabad in relation to changes in some of the correlative factors, namely, age, sex, built and social status. A standardized form of distribution has also been discussed in an attempt to search a respresentative central value. Cut-off points between normo-and hypertension for the population studied have also been suggested on the basis of shape of the standardized distribution.

Material and Methods

The present study is a community based oross-sectional survey of casual blood pressure of persons of age 15-74 years belonging to 1,000 families resident of Allahabad city. The families comprised 5,384 individuals, of whom 2,458 were of age group 15-74 years. Of these, blood pressure mesaurements could be obtained for 2,023 (82%) individuals including those measured at second and subsequent visits. The remaining either were not available at the time of the survey or refused to co-operate notwithstanding efforts of persuasion at repeat visits. Measurements of only 1,576 (64%) individuals could be recorded at first visit. The remaining 447 (18%) measured at subsequent visits, can be viewed as a sample of the non-respondents at first visit. Mean blood pressure of this group did not significantly differ from those available at first visit ($Z=1{\cdot}02$, $P>0{\cdot}30$ for systolic and $Z=0{\cdot}96$, $P>0{\cdot}30$ for diastolic) and so both the data were pooled for all purposes.

The measurements were taken in the home i.e. the natural setting of living. This probably is the major difference from most other blood pressure studies which are either clinic based or record based. Since a change of natural environment is likely to be associated with altered emotional status which may predispose to blood pressure fluctuations, blood pressure taken in the home situation was likely to be more close to the actual.

Sphygmomanometer with 2 mm calibrated scale was used to measure blood pressure. With the subject in sitting posture, the auscultatory method detailed by American Heart Association (1951) was used to determine systolic and diastolic blood pressure levels. The measurements were taken between 7 a.m. and 10 a.m., during the period April to June, 1970. In spite of limitation of casual blood pressure, only this could be recorded in a field study like the present one because of obvious reasons (Davies and Lewist 1966). However, to eliminate effect of fluctuations to some extent, 3 consecutive readings of both systolic and diastolic pressures were taken for each individual and average of these three readings was utilized for all subsequent analyses. The survey was conducted with the help of 12 medical interns who were trained before hand in order to standardize the technique, as far as possible, and thus, minimise interobserver variation. The advantage of using such a large number of observers was that observers' contribution to total survey variance was not likely to be substantial (Gordon 1964). Four of the observers measured 1,698 individuals and a separate communication will report absence of any significant differences among these four observers.

In a field study like the present one, specially with very limited resources, it was feasible to collect only absolutely necessary information. Consequently, height and weight were not measured. Built of every individual was, however, classified as ecto-meso, or endo-morph on visual impression. This might have introduced some error in classification of borderline cases but, if errors were equally distributed on both the sides, the total error was not likely to be serious. No evidence contradicting this contention was available.

Social status was categorized into 5 classes based on per capita monthly income as suggested by Prasad (1968).

Age was divided into 10-year groups for comparability with other similar studies. Blood pressures, both systolic and diastolic, were classified into 10 mm Hg intervals to eliminate effect of digit preference, if any (Borhani et al 1968). Besides, use of average of 3 readings itself would dilute any such digit preference.

Results

Percentage distributions of both systolic and diastolic pressures for each age-group, sex, built and social class, are shown in Graphs 1 to 4 respectively. The distributions reveal some important trends not only in respect of means but in respect of other characteristics as well. For age, Graph 1 shows :

(*i*) That dispersion of systolic pressure was much greater than of diastolic in all the age-groups. This indicates much greater inter-individual variability in systolic than in diastolic pressure in each age-group.

(*ii*) Shifting of distribution to the right with advancing age which implies rise in blood pressure levels. This rise with age was more rapid in the case of systolic than in the case of diastolic pressure.

(*iii*) A tendency of increasing dispersion with advancing age, particularly in systolic blood pressure. That is, as age advanced, variability in blood pressure tended to become larger.

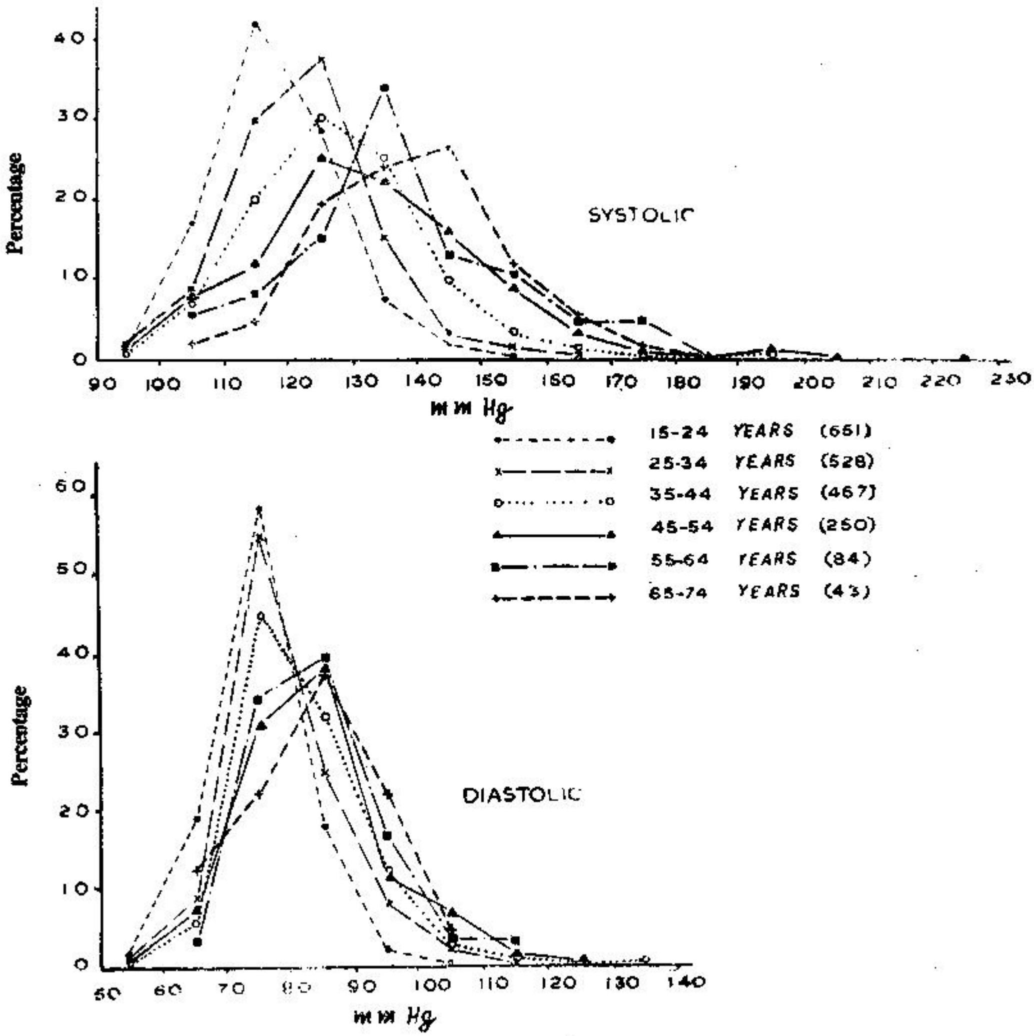
(*iv*) A tendency of right skewing with advancing age. This indicates that percentage of persons with raised level, particularly systolic, among higher age-groups was more than expected due only to constant age influence and suggest increasing impact of age in raising the level in these age-groups.

(*v*) Some tendency of decreasing peakedness of the distributions with advancing age. This relates to kurtosis of the distributions and, in general, means that percentage of individuals with blood pressure in the vicinity of central level (e.g.

mode) declined as age advanced and percentage at the two extremes (very low and very high) increased.

Graph 1

Percentage distribution of systolic and diastolic blood pressures in various age-groups

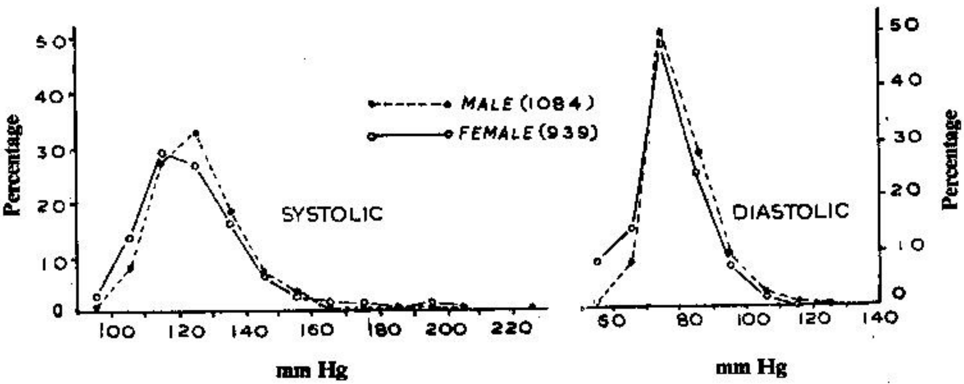


Some of these observations may look trivial but it is the totality of all these that reveals combined influence of age on various facets of the blood pressure distribution. In general, each one of the above observations is independent and none is consequence of the others. Condition may exist when only one or more of these observations hold true without holding the others.

For sex, it was observed that distributions of males and females approximate fairly close to each other, both in case of systolic as well as in case of diastolic pressures (Graph 2). However, distribution of females was on left to that of males, while differences in dispersion, skewness, and kurtosis were not apparent. This is indicative of lower level of blood pressure in females.

Graph 2

Percentage distribution of systolic and diastolic blood pressures in the two sexes

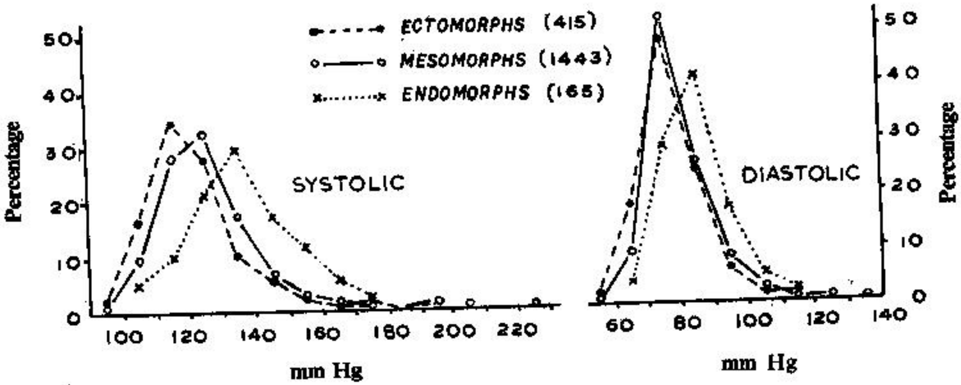


Graph 3 shows that as built changed from ecto- to meso- and then to endomorph, the blood pressure distribution shifted to right indicating rise in blood pressure level. The rise was quantitatively more from meso-, to endo-, than from ecto-, to mesomorph. Dispersion and skewness do not seem to vary with built but there was some tendency of decreasing peakedness. It shows that though built was contributory to rise in blood pressure level but this rise was not accompanied by increasing variability or right skewing as in the case of age. In fact, distribution of ecto- and meso-morphs were skewed to the right and distribution of endo- morphs was nearly symmetrical so that the changing pattern of skewness in the case of built was somewhat reverse to that of age.

Social class did not much influence the shape of the blood pressure distribution curve, specially of systolic (Graph 4). Distributions in various social classes were quite close to each other. However, there was slight tendency of shifting to right with increasing level of social class (i.e. from V to I) implying somewhat higher level of blood pressure in individuals of higher social class. No such regular trend was visible for dispersion and skewness. Peakedness, in diastolic pressure particularly, was reduced indicating lesser concentration of individuals towards the central blood pressure level as social class became higher.

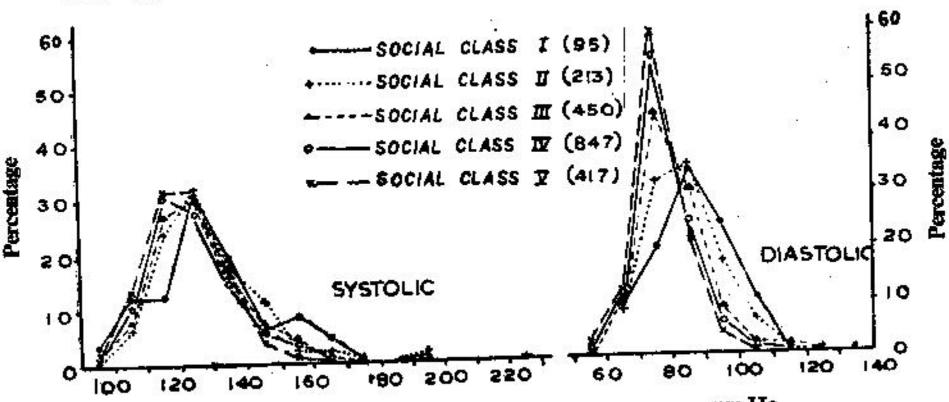
Graph 3

Percentage distribution of systolic and diastolic blood pressures in ecto-, meso- and endo-morphs



Graph 4

Percentage distribution of systolic and diastolic blood pressures in various social classes



Discussion

The results show that though each of the four factors—age, sex, built and social class—had at least some impact on the form of blood pressure distribution but the pattern of influence was not uniform. Mean was influenced by each but not dispersion, skewness and kurtosis. For instance, rise in blood pressure level was marked both with increase in age as well as with built but with age, dispersion, skewness increased and kurtosis decreased. Against this, with built, dispersion and skewness did not show much change though kurtosis decreased as in the case of age. Changes in form of blood pressure distribution with advancing age in the present study were same as those graphically represented by Lovell (1963) and Winkelstein and Kantor (1967). Winkelstein and Kantor (1967) showed slight differences in distributions of the two sexes also. Influence of built and social class on shape of blood pressure distribution does not seem to have been studied as much.

All this is indicative of need of prior consideration of the blood pressure correlates for comparing forms of distributions and, consequently, for comparing blood pressure levels also, of two or more groups. This would avoid possibility of attributing differences in distributions to say ethnicity which in fact are there due to differences in age, sex, built or social structure of the groups. It is only through some process of standardization of the characteristics of the populations that comparability among different groups can be attained. This is possible only if structure of the population in respect of the blood pressure correlates is available. Evidently, such data are not available for built and social class and so, for the present study, standardization was possible only in respect of age and sex. Of course, standardization based on any hypothetical data is not being considered.

The standardization in the present study was done according to age-sex structure of 1961 census population of Allahabad Town Group (Census 1966) though no generalization for that population is implied. The standardized distributions of systolic and diastolic blood pressure, arrived at after suitable adjustment of the data, are shown in Table I and plotted in Graph 5. The distributions evidently were unimodal.

Table I. Distribution of systolic and diastolic blood pressures standardized for age and sex : Allahabad Blood Pressure Survey 1970

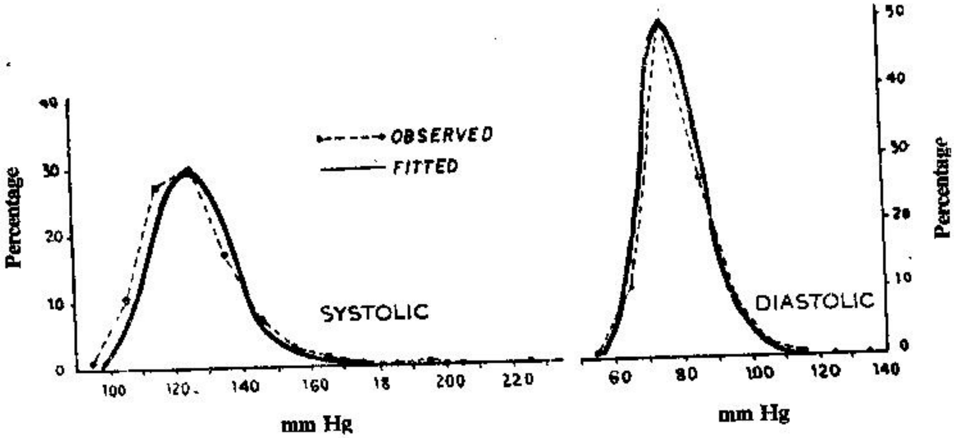
Systolic blood pressure			Diastolic blood pressure		
Interval (mm Hg)	Frequency	Percentage	Interval (mm Hg)	Frequency	Percentage
90— 99	28	1·39	50— 59	18	0·89
100—109	208	10·28	60— 69	218	10·78
110—119	555	27·43	70— 79	1010	49·92
120—129	608	30·06	80— 89	536	26·49
130—139	347	17·15	90— 99	117	8·75
140—149	156	7·71	100—109	50	2·47
150—159	69	3·41	110—119	11	0·55
160—169	31	1·53	120—129	2	0·10
170—179	10	0·49	130—139	1	0·05
180—189	3	0·15			
190—199	5	0·25			
200—209	2	0·10			
210—219	nil	0·00			
220—229	1	0·05			
Total	2023	100·00	Total	2023	100·00

Systolic BP : $\beta_1 = 1{\cdot}2581$, $\beta_2 = 6{\cdot}0283$ Diastolic BP : $\beta_1 = 0{\cdot}7534$, $\beta_2 = 4{\cdot}8491$

Graph 5

Observed and fitted percentage distribution of systolic and diastolic blood pressures standardized for age and sex

Standardized distributions (2023)



For removing chance fluctuations and to determine limits of normal blood pressure, it was necessary to find a theoretical statistical distribution adequate to describe the observed data. For this, it was desirable to keep option open so that the data may themselves show which distribution fits most close. The widest choice for this purpose was available from the 13 types of Pearsonian distributions (Kendall and Stuart 1969a). Of these, Type IV was found to be the best fit. This distribution has a function of the type :

$$f=k\left(1+\frac{x^2}{a^2}\right)^{-m}\exp.\left\{-\nu \text{ arc taa } (x/a)\right\}$$

The function is impossible to be expressed in terms of ordinary functions (Kendall and Stuart 1969a) and so is very difficult to handle in practice.

The values of β_1 and β_2 (Table I) show that the distributions of both systolic and diastolic pressure were positively skewed and lepto-kurtic. The frequencies rose from zero to maximum and then tailed off more slowly as blood pressure level increased. Lognormal distribution has exactly the same characteristics (Kendall and Stuart 1969b) and under the circumstances provides a close approximation to Pearsonian Type IV distribution. For fitting of lognormal distribution, the transformations obtained were :

$$\xi_s = -10{\cdot}556+2{\cdot}873 \log (y_s-83{\cdot}460)$$

for systolic, and

$$\xi_d = -12{\cdot}045+3{\cdot}616 \log (y_d-44{\cdot}874)$$

for diastolic pressure, where y_s and y_d are the systolic and diastolic pressures respectively and ξ_s and ξ_d are the corresponding standard normal variates. These transformations convert form of blood pressure distribution to that of normal. Pickering (1963) also demonstrated normality of blood pressure distribution by a log transformation.

For skewed distribution as Type IV or lognormal obtained for blood pressures, determination of representative central value and of cut-off points between normo- and hyper-tension is very difficult. The transformations, stated above, make the task very easy since, for standard normal distribution, central value and cut-off points at various probabilities are easily available in the Table (Fisher and Yates 1963). If the possibility of low blood pressure is kept out of purview, and consequently, one tail of normal distribution is considered, the cut-off points at various probabilities are shown in Table II.

Table II. Cut-off points between normo- and hyper-tension at various probabilities

Probability	Cut-off point (mm Hg)	
	Systolic	Diastolic
50%	123	73
80%	136	80
90%	145	85
95%	153	89
99%	172	98

The values at 50% probability i.e. 123 mmHg of systolic and 73 mmHg of diastolic pressure, are the central values representative of the entire group. For cut-off points between normo- and hyper-tension, one has to choose one particular probability. If 80% points are considered to delimit normal range and 95% as cut-off for hypertensives, then, for the sample under study, limits of normal blood pressure were 136/80 and hypertensive range was 153/89 and above. Use of these cut-off points would be epidemiologically justified in terms of WHO Expert Committee (1959, 1967) for the population under study. Against this, WHO Expert Committee (1959) recommended 140/90 as cut-off for normal range and 160/95 for hypertensive range. Cut-off points for systolic blood pressure determined by the present study are quite close to those recommended by WHO but diastolic cut-off points were relatively lower. This probably indicates low level of diastolic blood pressure in the sample studied.

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