Path Analysis of Blood Pressure Correlates in a Village Sample of Sagar District, Madhya Pradesh

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ABSTRACT: Effects of different variables on the resting blood pressure were examined among adult males in a village of Sagar district, Madhya Pradesh. Path analysis was performed using multiple regression equations. Prevalence of hypertension was found to be considerably lower than that of the national prevalence. Path analysis reveals direct effect was much higher than indirect effect in case of all the variables in both the blood pressure excepting the variable namely diet in diastolic blood pressure. In which, indirect effect was recorded to be higher than direct effect. Variables like diet, alcohol consumption and central obesity emerged as important determinants of systolic blood pressure. While, variables like body built, diet, BMI, and central obesity emerged as important determinants of diastolic blood pressure.

INTRODUCTION

Measure of human resting blood pressure provides a ready index which immediately portrays some vital information on the state, status, and the functioning of the circulatory system. Thus, this index is considered as an important parameter for both the diagnostic and prognostic aspects of human beings (Pickering, ’61). Blood pressure variation and the rate of its change, inter and intra individual, are wide within and between populations, contributed by a multitude of personal and environmental factors. A wide range of variables have been investigated in different parts of the world for their possible associations and probable deterministic role (Bagchi and Indrayan, ’74). It is reported that blood pressure rises systematically with the advancement of age (Boyce *et al*., ’78, Hutchinson, ’76: *cf*. Chowdhury and Ghosh, ’95). It is also reported that social class (Keil *et al*., ’77) and occupational categories (Coble and Rose, ’73) influence blood pressure (*cf*. Chowdhury and Ghosh, ’95). Risk factors like age, BMI, high salt intake, family history of blood pressure were found to be associated with hypertension among the rural people of Western Maharashtra (Kharde *et al*., 2019). Multifactorial analysis revealed four important factors i.e. age, occupation, BMI and additional salt intake with diet had significant role in systolic and diastolic blood pressure among rural community of West Bengal (Sadhukhan and Dan, 2005). In an another study Sekhar *et al*. (2020) found the association of higher age group and managerial cadre of employment to be statistically significant with hypertension among bank employees working in an urban area of Marathwada region, Maharashtra. While, Skaric-Juric (2003) examined the familial resemblance in blood pressure using path analysis, among the populations in Middle Dalmatia, Croatia. Skaric-Juric (2003) explored to what degree the variation in blood pressure values attributed by path analysis. The present study

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examines the path analysis of blood pressure correlates in a village sample of Madhya Pradesh.

MATERIALS & METHODS

A cross-sectional study on resting blood pressure was carried out at Pathariya Hat village, District Sagar of Madhya Pradesh, during November-January 2015. 104 unrelated adult males of this village were examined. The males of age 18-65 years were included. Data on age, education, body built, caste hierarchy, diet, smoking habit, alcohol consumption, household income, height, weight, waist circumference, hip circumference, systolic and diastolic blood pressure were collected for each subject. Household income was calculated following the method described by Khongsdier ('99). Blood pressure level was recorded in the natural setting of living i.e., the home, using sphygmomanometer with 2 mm calibrated scales (Bagchi and Indrayan,'74). Subjects were measured in morning. The average of three readings of both systolic and diastolic pressures was considered to dilute the effect of fluctuations. For operational feasibility reasons, a few selected variables (six) were taken into consideration in the present study. The selection of these variables was not arbitrary. They were chosen (out of total 10 variables examined) on the basis of their strength in regression equation and certain theoretical relations associated with as well as their relevance on the study population. Six variables like age, body built, diet, alcohol consumption, BMI and central obesity were considered as independent variables and systolic and diastolic blood pressure were considered as dependent variable. For multi-factorial analysis, each variable was assigned independent score according to the nature of corresponding sub-variables. To identify factor-specific correlation multiple regression analysis was performed using SPSS. In order to find out the causal model to depict the relationships among different variables and systolic and diastolic blood pressure the path analysis was performed using multiple regression equations. For this purpose the method suggested by Wonnacott and Wonnacott ('90) was followed.

RESULTS

Systolic and diastolic blood pressures by different variables were furnished in Table 1. Mean and S.D. values of both the blood pressures showed a tendency of increase with the advancement of age, excepting S.D. values of diastolic pressure. Non educated males and subjects with endomorph body built showed higher mean values than high school level educated males and subjects with ectomorph and mesomorph body built respectively. But in case of S.D. values a reverse trend is evident. General castes subjects and individuals belong to higher income group were characterized with higher mean and S.D. values of both systolic and diastolic blood pressure than subjects belong to lower income group and ST, SC and OBC subjects. Higher mean and S.D. values of systolic and diastolic blood pressure were recorded among smoker and subjects consume alcohol and non-veg diet than their counterparts. A tendency of increase in mean and S.D. values of both the blood pressures is perceptible with the increase in BMI values though it is not uniform in case of S.D. values. However, centrally obese subjects were characterized with higher mean and S.D. values for both the blood pressures than the non-obese subjects.

TABLE 1

Systolic and diastolic blood pressure in mm of Hg) by different variables

	Variable	Number	Blood pressure			
			Systolic		Diastolic	
			Mean	S.D.	Mean	S.D.
Age(in years)	18-24	22	116.50	6.70	74.95	9.52
	25-34	19	118.37	13.13	78.74	8.62
	35-44	16	125.69	18.15	80.50	9.22
	45-54	21	128.19	13.07	81.81	6.92
	55 and above	26	134.81	22.10	83.61	5.25
Education	Non-literate	22	129.18	19.81	81.09	4.61
	Primary	36	126.94	19.44	80.22	10.21
	High school and above	46	121.91	12.76	79.41	8.20
Body built	Ectomorph	23	126.74	21.95	80.48	9.60

	Mesomorph	68	123.87	15.19	79.81	9.39
	Endomorph	13	135.38	19.41	85.54	8.41
Castehierarchy	ST,SC,OBC	73	124.03	15.75	79.07	8.57
	General	31	130.45	21.04	83.81	10.66
HouseholdIncome	Lower*	74	125.62	16.32	79.97	9.05
	Higher**	30	126.73	18.24	80.69	10.50
Diet	Veg	39	124.31	9.92	79.81	8.63
	Non-veg	65	126.92	10.32	81.59	9.90
SmokingHabit	Yes	20	129.70	24.25	79.50	12.44
	No	84	125.60	15.72	80.71	8.65
Alcoholconsumption	Yes	33	127.37	19.29	81.32	10.65
	No	71	122.88	16.77	78.67	8.79
BMI	<18.5	62	123.95	17.26	79.03	8.81
	18.5-22.9	38	128.81	18.77	82.63	10.40
	e”23.0	4	129.50	8.70	82.50	6.61
Central obesity	Yes+	47	128.81	21.54	80.28	10.53
	No++	57	124.21	12.87	80.86	8.31

* Lower income group: per capita income = <Rs. 479; **Higher income group: per capita income = ≥Rs. 479 +Centrally obese: waist hip ratio = >0.90; ++Non obese: waist-hip ratio = ≤0.90

A total of 12-variable correlation matrix was set out in Table 2. Highest correlation for systolic (r = -.566) and diastolic (r = +.296) blood pressure was noticed with household income. Central obesity showed an inverse relationship with systolic (r = -.287) and diastolic (r = -.270) blood pressure though of a lesser magnitude. Variables like smoking habit and BMI showed highest correlation (r = +.743) in the matrix. Side by side, age with education (r = +.583), diet with alcoholism (r = -.537), body built with caste hierarchy (r = -.444), alcoholism with central obesity (r = -.387) and education with body built (r = +.373) showed higher magnitude of correlation. Some of the correlations were found to be significant at 0.01 level and some of the correlation were significant at 0.05 level.

TABLE 2

12 variable correlation matrix

Variable	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1)		.583[2]	.270[2]	-.076	-.051	.007	.101	-.009	.003	.144	.054	.151
(2)			.373[2]	-.116	-.216[1]	.088	.000	-.143	-.054	.182	.205[1]	.098
(3)				-.444[2]	.045	.057	-.013	-.003	.197[1]	-.141	-.096	-.100
(4)					-.135	.159	.166	-.282[2]	.148	.091	.139	.118
(5)						.001	-.105	.197[1]	-.121	.182	-.566[2]	.296[2]
(6)							.142	-.537[2]	.073	.252[2]	.158	-.087
(7)								-.296[2]	.743[2]	.195[1]	-.047	.030
(8)									-.199[1]	-.387[2]	-.166	-.161
(9)										.100	-.018	-.012
(10)											-.287[2]	.201[1]
(11)												-.270[2]
(12)												

[1] Correlation is significant at 0.05 level

[2] Correlation is significant at 0.01 level

(1) age, (2) education, (3) body built, (4) caste hierarchy, (5) household income, (6) diet, (7) smoking habit, (8) alcoholism, (9) BMI, (10) central obesity, (11) systolic blood pressure, (12) diastolic blood pressure.

Score assigned: Age (in years): 15-24=1, 25-34=2, 35-44=3, 45-54=4, 55 and above=5; Education: non-literate=0, primary=1, high school and above=2; Body built: ectomorph=1, mesomorph=3, endomorph=3; Caste hierarchy: ST,SC,OBC=0, general caste=1; Household income: lower income group=0, higher income group=1; Diet: vegetarian=1, non-vegetarian=2; Smoking habit: yes=0, no=1; Alcohol consumption: yes=0, no=1; BMI: <18.5=1, 18.5-22.9=2, ≥23.0=3; Central obesity: centrally obese=0, non-obese=1; Systolic blood pressure: up to 99 mm Hg=1, 100-109 mm Hg=2, 110-119 mm Hg=3,120-129 mm Hg=4, ≥130mm Hg=5; Diastolic blood pressure: up to 59 mm Hg=1, 60-69 mm Hg=2,70-79 mm Hg=3, 80-89 mm Hg=4, ≥90mm Hg=5.

Regression coefficients for systolic and diastolic blood pressure were given in Tables 3 and 4 respectively. Using student's t-test it was seen that regression coefficients of the variables like age, alcoholism, BMI and central obesity are statistically significant for systolic blood pressure. While, variables like age, body built, alcoholism, BMI and central obesity were statistically significant for diastolic blood pressure.

TABLE 3

Regression coefficients: systolic blood pressure

Variable	Beta	Student-t	p-value
Age (X_1)	0.207	2.538	0.013*
Education (X_2)	0.003	0.018	0.986
Body built (X_3)	-0.179	-0.784	0.435
Caste hierarchy (X_4)	0.072	0.259	0.796
Household income (X_5)	0.321	0.907	0.367
Diet (X_6)	0.434	1.461	0.147
Smoking habit (X_7)	-0.074	-0.179	0.858
Alcohol consumption (X_8)	0.381	1.449	0.038*
BMI (X_9)	0.328	1.402	0.029*
Central obesity (X_{10})	0.564	2.340	0.021*

*Significant at 0.05 level

TABLE 4

Regression coefficients: diastolic blood pressure

Variable	Beta	Student-t	p-value
Age (X_1)	0.215	3.775	0.000**
Education (X_2)	-0.041	-0.374	0.709
Body built (X_3)	-0.318	-1.989	0.050*
Caste hierarchy (X_4)	0.077	0.393	0.695
Household income (X_5)	-0.142	-0.574	0.568
Diet (X_6)	0.120	0.577	0.565
Smoking habit (X_7)	0.120	0.419	0.676
Alcohol consumption (X_8)	0.390	2.121	0.037*
BMI (X_9)	0.364	2.224	0.029*
Central obesity (X_{10})	0.429	2.547	0.013*

*significant at 0.05 level

**significant at 0.01 level

In notation, obtained multiple regression equations are:

$$Y_{SBP} = a_1 + .207(X_1) + .003(X_2) - .179(X_3) + .072(X_4) + .321(X_5) + .434(X_6) - .074(X_7) + .381(X_8) + .328(X_9) + .564(X_{10})$$

$$Y_{DBP} = a_2 + .215(X_1) - .041(X_2) - .318(X_3) + .077(X_4) + .142(X_5) + .120(X_6) + .120(X_7) + .390(X_8) + .364(X_9) + .429(X_{10})$$

Where, Y_{SBP} and Y_{DBP} are systolic and diastolic blood pressure respectively.

Path Analysis

In order to find out the causal model to depict the relationships among different variables and systolic and diastolic blood pressure the path analysis was performed using multiple regression equations. The analysis was done following the method as described by Wonnacott and Wonnacott ('90). It has already been mentioned earlier that six variables (age, body built, diet, alcohol consumption, BMI, central obesity) were selected as independent variables and systolic and diastolic blood pressure were selected as dependent variables. The direction of causal relationship between six independent variables and two dependent variables were conceptualized and presented in path diagram separately for two blood pressures.

Systolic blood pressure:

For systolic blood pressure the following structural equations were evolved:

$$Y_0 = a_1 + .207(X_1) - .179(X_2) + .434(X_3) + .381(X_4) + .328(X_5) + .564(X_6)$$

$$X_6 = a_1 - .043(X_1) + .199(X_2) - .219(X_3) + .043(X_4) - .144(X_5)$$

$$X_5 = a_1 - .014(X_1) - .473(X_2) - .202(X_3) - .321(X_4)$$

$$X_4 = a_1 + .040(X_1) + .209(X_2) - .418(X_3)$$

$$X_3 = a_1 - .004(X_1) + .165(X_2)$$

$$X_2 = a_1 + .017(X_1)$$

X_1 = age, X_2 = body built, X_3 = diet, X_4 = alcohol consumption, X_5 = BMI, X_6 = central obesity

On the basis of structural equations the direction of causal relationship between six independent variables and one dependent variable (systolic blood pressure) was conceptualized and presented in path diagram (Fig.1). Further, on the basis of path coefficients the results on the direct, indirect and total effects of the six variables were find out and presented in Table 5.

Diastolic blood pressure:

For diastolic blood pressure the following structural equations were evolved:

$$Y_0 = a_1 + .215(X_1) - .318(X_2) - .142(X_3) + .390(X_4) +$$

$.364(X_5)+.429(X_6)$

$X_6 = a_1-.043(X_1)+.199(X_2)-.219(X_3)+.043(X_4)-.144(X_5)$

$X_5 = a_1-.014(X_1)-.473(X_2)-.202(X_3)-.321(X_4)$

$X_4 = a_1+.040(X_1)+.209(X_2)-.418(X_3)$

$X_3 = a_1-.004(X_1)+.165(X_2)$

$X_2 = a_1+.017(X_1)$

X_1= age, X_2 = body built, X_3 = diet, X_4 = alcohol consumption, X_5 = BMI, X_6= central obesity

Like systolic blood pressure in case of diastolic blood pressure also the results on direct, indirect and total effects of the six variables were find out and presented in Table 6 and path diagram (Fig. 2).

TABLE 5

Direct, indirect and total effects of the variables on systolic blood pressure

Variables	Direct effect	Indirect effect	Total effect
Age (X_1)	.207	-.018	.189
Body built (X_2)	-.179	.112	-.067
Diet (X_3)	.434	-.060	.374
Alcohol consumption (X_4)	.381	.071	.452
BMI (X_5)	.328	-.109	.219

TABLE 6

Direct, indirect and total effects of the variables on diastolic blood pressure

Variables	Direct effect	Indirect effect	Total effect
Age (X_1)	.215	-.012	.213
Body built (X_2)	-.318	-.025	-.343
Diet (X_3)	-.142	-.195	-.337
Alcohol consumption (X_4)	.390	-.097	.293
BMI (X_5)	.364	-.011	.353
Central obesity (X_6)	.429	-.076	.353

It reveals from Tables 5 and 6 that there was a positive effect of age on blood pressure (systolic blood pressure: +.189; diastolic blood pressure: +.213). Effect of this variable 3was however, mostly direct (systolic blood pressure: +.207; diastolic blood pressure: +.215) with negligible indirect effect (systolic blood pressure: -.018; diastolic blood pressure: -.012). Total effect of body built was negative on blood pressure, which was considerably higher in diastolic than systolic blood pressure (systolic blood pressure: -.067; diastolic blood pressure: -.343). Effect of diet on blood pressure was positive in systolic (+.374) but negative in diastolic blood pressure (-.337). In this category though direct effect was higher than indirect effect in systolic a reverse trend was perceptible in diastolic blood pressure. Effect of alcohol consumption on both the blood pressure was positive, which was true for direct (+.381) and indirect effect (+.071) for systolic but for diastolic it was positive for direct effect (+.390) and negative for indirect effect (-.097). Total effect of BMI on blood pressure (systolic blood pressure: +.219; diastolic blood pressure: +.293) was positive; whereas indirect effect was negative (systolic blood pressure: -.109; diastolic blood pressure: -.011) and direct effect was positive (systolic blood pressure: +.328; diastolic blood pressure: +.364). Like BMI a similar trend was evident in case of central obesity too.

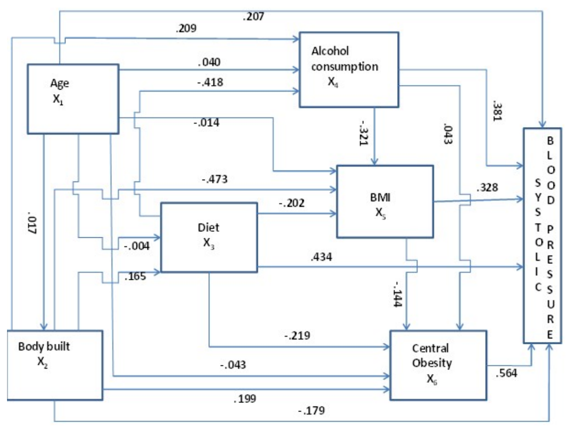

Fig. 1: Path diagram for systolic blood pressure in the village sample of Sagar district

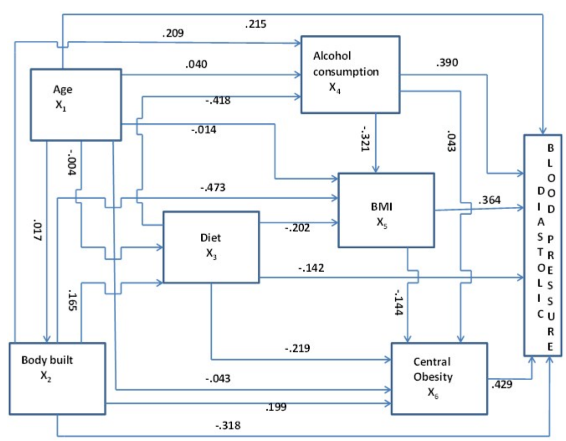

Fig. 2: Path diagram for diastolic blood pressure in the village sample of Sagar district

DISCUSSION

In this study, the prevalence of hypertension among the adult males in Pathariya Hat village in Sagar district, Madhya Pradesh was found to be 19.23%, which was much lower than the bank employees (32.4%) working in an urban area of Marathwada region, Maharashtra (Shekhar *et al*., 2020). According to WHO Health Statistics (2015), the prevalence of hypertension in India among e"18 years is 25.9% in males and 24.8% in females (WHO 2015). Thus, the subjects of the present study record a considerably lower value than that of the national prevalence in this context. Results of the present study showed a constant rise along with age in case of systolic and diastolic blood pressure both. This corroborate with the findings of Boyce *et al*. ('78), Hutchinson ('76), Chowdhury and Ghosh ('95), Kharde *et al*. (2019) and many others. Steep rise was evident in both the blood pressure levels among endomorph relative to mesomorph and ectomorph subjects. A similar trend was reported by Bagchi and Indrayan ('74) from a cross sectional study in Allahabad city. Gordon ('76) observed higher the income lower the blood pressure level. Findings of the present study was however, not similar with this finding. Both the blood pressure levels were considerably higher among the general castes subjects than the SC, ST and OBC subjects. A similar finding was reported by Sive *et al*. ('71) and Hamilton *et al*. ('54). Diet did not have much of a role with blood pressure in the present study. Findings of the present study also indicate a rising trend of blood pressure level with increase in BMI values. Kharde et al. (2019) and Sadhukhan and Das (2005) reported a similar finding in this context. Though systolic blood pressure was considerably higher among the centrally obese subjects than the non-obese subjects, no such trend was perceptible in case of diastolic blood pressure.

It appears from path analysis that direct effect was much higher than indirect effect in case of all the variables in both the blood pressure. Only exception in this respect was noticed in case of diet in diastolic blood pressure. In which, indirect effect was recorded to be higher than direct effect. It however, reveals that variables like diet, alcohol consumption and central obesity emerged as important determinants of systolic blood pressure. While, variables like body built, diet, BMI, and central obesity emerged as important determinants of diastolic blood pressure.

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