Measuring central percentiles of blood pressure levels among adults in Pakistan: A case study of Rawalpindi

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Abstract: The prevalence pattern of hypertension (HTN) in developing countries is different from that in the developed countries. In Pakistan, the percentage of hypertensive patients has been growing since last two decades. Various factors might have contributed to this rising trend like, age, body mass index (BMI), lack of physical activity, family history of HTN and smoking etc. In this study, we examine prevalence of HTN in Rawalpindi district of Pakistan using the Eighth Joint National Committee (JNC 8) criteria, with the aim to measure central percentiles of blood pressure (BP) depending on different stated factors. For this purpose, quantile regression is used. A cross-sectional study including 2000 volunteer adults was designed. The data were obtained about systolic BP (SBP), diastolic BP (DBP), gender, age, weight height, family history of HTN, physical activity, presence of any kidney disease and diabetic status etc. Quantile regression was used to estimate the central percentiles of SBP and DBP. The present study concludes that the central percentiles of BP reflect alarming situation as half of the adults fall into either pre-hypertensive or hypertensive category and thus, some special awareness program about HTN should frequently be organized.

Keywords: Hypertension, JNC 8 criteria, pre-hypertension, quantile regression.

INTRODUCTION

The term "hypertension" (HTN) is used to describe high blood pressure that is much greater than what is considered normal. It has become a common problem regarding public health and has been related to numerous health risks, both physical and psychological. It affects nearly 26% of the adult population worldwide. It has been reported that almost one billion of the World's adult population had hypertension in 2000, and in 2025 this proportion will increase by 29% or 1.56 billion (Kearney *et al*., 2005).

HTN is a result of an imbalanced diet, lack of physical activity, and various other social and demographic factors like age, weight, family history, drugs intake etc. It is well established that HTN is associated with adverse health effects, i.e. cardiovascular diseases such as cardiovascular death, renal failure, stroke, ischemic heart disease and myocardial infarction (Murray & Lopez, 1997; Fang *et al*., 2001; WHO, 2003; Li *et al*., 2004; Rosner *et al*., 2008).

HTN is an exacerbating public health problem not only in developed countries but also in developing countries like, Pakistan (Jafar *et al.*, 2003; Jafar *et al.*, 2005; Rahman *et al*., 2006; Abbas *et al*., 2009). Pakistan is, therefore, attributed to major health budget and disease prevention concern.

According to the medical definition BP is always specified as two numbers, systolic BP (SBP) and diastolic BP (DBP). Systolic number is always written before or over the diastolic number, for example 120/80 mmHg. The units used to measure BP are millimeters of mercury (mmHg). According to the Eighth Report of Joint National Committee (JNC 8) criteria, BP readings (below 120/80), (above 120/80 but below 140/90) and (at or above 140/90) are considered to be normal, pre-hypertensive and hypertensive, respectively for most of adults. However, different numbers apply to children (James *et al*., 2013).

SBP contributes more of the huge worldwide disease burden attributable to HTN then does diastolic pressure. Therefore, systolic HTN is much more common than diastolic HTN (Lewington *et al*., 2002; Chobanion *et al*., 2003; Lawes *et al*., 2008 and Williams *et al*., 2008). Systolic pressure is positively associated with age and it frequently increases with age. HTN is almost entirely related to systolic pressure and it is most important risk factor for early death and its worldwide burden is increasing (Williams *et al*., 2008; Sundstrom *et al*., 2011).

An extensive literature can be found exploring the BP status in Pakistan, as stated earlier but these studies are based on HTN prevalence and its harmful effects. Several studies (Rosner *et al*., 2008; Jafar *et al*., 2008 and Das *et al*., 2005) have been conducted to estimate BP response and to develop a model for BP and its predictors. These studies differ from each other in terms of both the method of estimation and the set of data used. Most of the studies (Rosner *et al*., 2008; Chadha *et al*., 1996; Lakshmanudu *et al*., 1992 and Muntner *et al*., 2004) have used ordinary regression to estimate the effects of various variables.

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Few studies, like Rosner *et al*. (2008) among many others, have even gone for non-linear models to estimate the relationship of variables. But no efforts, in the all mentioned studies, have been made to check the effect of covariates on different percentiles of BP levels in Pakistan. It is very realistic to measure the change on different levels of BP for the given predictor and this quantile or percentile of BP can be thought as an adaptable tool. For exploring of such changes, BP percentiles are required, namely the central percentile i.e. the median to assess the central levels of SBP and DBP.

Traditional regression methods are useful for estimating how independent variables are related to mean values of the dependent variable but will not accurately indicate changes at other points in the distribution without strong parametric assumptions. Such assumptions are unlikely to be justified since SBP and DBP increase more over time (in both percentage and absolute terms) at the high than the low end of the distribution as there is usually steeper increase in SBP and DBP toward the right tail of the distribution. As an alternative quantile regression is used. It provides most flexible and best fit of blood pressure data (Rosner *et al*., 2008).

Therefore, the main objective of the present study is to estimate the central level of BP, among adults, affected by different covariates like age, marital status, BMI and family history of HTN etc. (detail is being provided in the next section). These covariates were decided following different available studies (Verma *et al*., 1994; WHO, 2003; Chobanion *et al*., 2003; Hel & Macgregor, 2003; Chan, 2004; Williams *et al*., 2008).

MATERIALS AND METHODS

A cross sectional data of 2000 volunteer adults (aged 15 years or above), both males and females were taken from Rawalpindi district as a case study of Pakistan. The sample was taken during September and October 2012 from different institutions, public places and health centers, namely, PMAS Arid Agriculture University, Gordon College, Commercial Market and Holy Family Hospital etc. A simple self-administered questionnaire was designed to collect data with codes about BP (SBP and DBP, measured to nearest mmHg), gender, age, marital status (MSTAT = 1 if married and 0, otherwise), education (EDU = 1 if literate and 0, otherwise), weight (measured to nearest 0.5 Kg.), height (measured to nearest 10^{th} inch), physical activity (exercise; EXER = 1 if regular exercise is taken and 0, otherwise), family history of HTN (FHIST = 1 if positive history and 0, otherwise), personal history of kidney disease (KIDNEY = 1 if positive history and 0, otherwise), smoking status (SMOKING = 1 if regular smoker and 0, otherwise) and personal diabetic status (DIAB = 1 if diabetic and 0, otherwise). The BMI was computed as a ratio of weight in kilograms and height in meters squared. The measurements of BP were taken by a trained volunteer in a consistent, standardized manner using mercury manometer.

All the adult individuals, both males and females, of age 14 years or more who gave their positive consent, were included in the study. However, pregnant women and the individuals with heart disease were excluded from the study.

Unlike ordinary least square regression, quantile regression models permit for a full description of the conditional distribution of the response variable (Koenker & Basset, 1978; Koenker & Hallock, 2001).

The general BP function is explained as below:
$BP \sim f(X) + \varepsilon$,
Where BP is SBP or DBP, X represents all the explanatory variables and ε is the usual random error.

A linear quantile regression model can be written as

$$Q^{(\tau)}(y \mid X = x) = \beta_0^{(\tau)} + \sum_{j=1}^{k} \beta_j^{(\tau)} x_j = \beta^{(\tau)} X,$$

Where $\beta^{(\tau)}$ is a coefficient vector for specific τ th quantile (τ = 0.01,…, 0.99).
A special case of τ=0.5, which minimizes the sum of absolute residuals, is usually known as median regression. The median regression line passes through a pair of sample, by half of data falling the above median regression line, as well as the last half of data falling below median regression line. Thus, τ=0.5 provides central percentile which is being used in the present study. For the said measures, SBP and DBP are taken as dependent variables while X represents the covariates as stated above.

For descriptive measures and t-tests, SPSS 16 was used while the quantile regression is run using E-View 7.

RESULTS

In the present study of 2000 adult participants, 1160 (58.0%) are males and 840 (42.0%) are females. Among them, only 13% are doing any regular exercise. As for as the diabetes status is concerned, 21.4% are diabetic patients while 30% have positive family history of HTN. Mean age of the participants is 34.97±0.253 (mean ± standard error) years. These numbers are 37.43±0.339 and 31.57±0.344 for males and females, respectively. Table 1 portrays all the descriptive statistics of the subjects under study.

Table 2 displays the simple percentile summary of SBP, DBP and BMI. It is found that only 10% of the participants have normal SDP while half of them have normal DBP. The 75^{th} percentile of BMI i.e. 26 shows that

25% the participants are either overweight or obese. Similar results can also be depicted from table 3 showing distribution of BP levels following the JNC 8 criteria (James *et al*., 2013). According to the SBP levels, a clear majority (74.5%) acquire pre-hypertensive status. Only 7.6% and 31.2% respondents have normal BP according to the SBP and DBP levels, respectively. As much as 18% and 22.0% of the participants are found to be hypertensive following SBP and DBP, respectively. The mean SBP, DBP, weight and height comparisons of males and females using *t*-test are given in table 4. It is found that the means of all the stated measures of males are significantly greater than those of females.

Table 1: Frequency distribution of different characteristics of the respondents

Characteristics	Frequency	Percentage
Gender:		
Male	1160	58.0
Female	840	42.0
Marital Status:		
Married	1526	76.3
Unmarried	474	23.7
Literacy status:		
Literates	1406	70.3
Illiterates	594	29.7
Physical activity:		
Regular exercise	259	13.0
No exercise	1741	87.0
Family history:		
Positive	599	30.0
Negative	1401	70.0
Smoking Status:		
Smoker	642	32.1
Non-smoker	1358	67.9
Kidney problem:		
Yes	251	12.6
No	1749	87.4
Diabetes:		
Yes	428	21.4
No	1572	78.6

Table 5 presents analysis of quantile regression model estimating the central percentiles for SBP and DBP depending on different factors. When the SBP is focused, it is noted that all the mentioned factors contribute significantly to measure the central (50^{th}) percentile (i.e., median) of SBP. All the coefficients except exercise (i.e. physical activity) and marital status are reported to be positive showing the increase in central percentiles of the SBP in the presence (of positive family history, kidney disease, diabetes and smoking) or increase in age and BMI. The median SBP can be lowered about 2 points if a person is married and the central percentile decreases more than 4 points if some physical activities are regularly exercised. When the central percentile for DBP is focused, all the coefficients show the similar signs, however with different magnitude, except the positive family history whose statistical significance is at margin. Moreover, the marital status is not found to be statistically significant for measuring the 50^{th} percentile of DBP.

Table 2: Percentile summary of SBP, DBP and BMI

Measures		SBP	DBP	BMI
Percentiles	1	105.00	60.00	16.00
	5	117.00	65.00	18.00
	10	120.00	70.00	19.00
	25	123.00	75.00	21.00
	50	130.00	80.00	23.00
	75	137.00	86.00	26.00
	90	143.00	90.00	29.00
	95	149.00	95.00	31.00
	99	170.00	98.00	35.00

DISCUSSION

HTN is an exacerbating public health problem not only in developed countries but also in developing countries like, Pakistan. HTN is a result of an imbalanced diet, lack of physical activity, and various other social and demographic factors like age, weight and family history etc. (Murray & Lopez, 1997; Jafar *et al*., 2003; Jafar *et al*., 2005; Rahman *et al*., 2006; Abbas *et al*., 2009).

The present study of 2000 adults reveals that a clear majority (87%) of the respondents does take any regular exercise and thus becomes a convenient member of hypertensive club. These findings endorse what has been reported in earlier studies carried out by Jafar *et al*. (2003), Jafar *et al*. (2005), Rahman *et al*. (2006) and Abbas *et al*. (2009) etc. While considering the sample of adult population of Rawalpindi, an alarming situation is met as about only one third of them have normal BP while the rest of them are either pre-hypertensive or hypertensive. When the simple percentiles are focused, it is evident that with the increase in BMI percentiles there is increase in BP percentiles (both SBP and DBP). For example, the 75^{th} percentile of SBP and DBP (see table 2) is 137 and 86, respectively and the BMI is 26 at this position. So, overweight people tend to become hypertensive or at least pre-hypertensive. When males and females are compared, it is found that males have almost 7 Kg. more weight than females, on average. These findings are consistent with an already available study, reported in Aslam *et al*. (2010), of Pakistan. Similarly, males have 5 and 3 more points of SBP and DBP levels, respectively on average than their female counterpart.

The estimates of central percentiles reveal that age, BMI, positive family history, habit of smoking and diabetes tend to increase the BP while regular exercise is negatively related to the BP. Such findings have already

Table 3: Frequency distribution about blood pressure levels

SBP Levels	Frequency	Percentage
≤ 119 (Normal)	151	7.6
120 – 139 (Pre-hypertension)	1490	74.4
≥140 (Hypertension)	359	18.0
DBP Levels		
≤ 79 (Normal)	624	31.2
80-89 (Pre-hypertension)	937	46.8
≥ 90 (Hypertension)	439	22.0

Table 4: Mean comparison of different variables between males and females

Variable	Gender	n	Mean	Std. error	t-statistic	p-value
SBP	Male	1160	132.25	0.335	8.818	0.000
	Female	840	127.87	0.355		
DBP	Male	1160	82.05	0.258	7.256	0.000
	Female	840	79.10	0.318		
Weight (Kg.)	Male	1160	69.62	0.307	16.071	0.000
	Female	840	62.06	0.354		
Height (Inches)	Male	1160	67.90	0.100	27.751	0.000
	Female	840	63.38	0.133		

Table 5: Parameter estimates of the central percentile (median; $\tau = 0.5$) regression of blood pressure

Variable	Coefficient	Std. Error	t-statistic	p-value
SBP				
Constant	108.1389	1.2403	87.1860	0.0000
Age	0.5237	0.0351	14.9282	0.0000
BMI	0.2001	0.0476	4.2205	0.0000
Marital status	-1.8058	0.4188	-4.3119	0.0000
Exercise	-4.4512	0.4789	-9.2951	0.0000
Family history	1.4674	0.3884	3.7784	0.0002
Kidney disease	3.6120	0.6413	5.6319	0.0000
Diabetes	1.6670	0.4979	3.3478	0.0008
Smoking	1.5904	0.4211	3.7768	0.0002
DBP				
Constant	73.4537	1.4909	49.2667	0.0000
Age	0.0566	0.0234	2.4160	0.0158
BMI	0.1899	0.0522	3.6405	0.0003
Marital status	0.3630	0.4827	0.7520	0.4521
Exercise	-7.9483	0.8112	-9.7987	0.0000
Family history	0.8597	0.4901	1.7540	0.0796
Kidney disease	2.5497	1.0293	2.4773	0.0133
Diabetes	3.2505	0.6234	5.2141	0.0000
Smoking	3.7101	0.4594	8.0766	0.0000

been reported (see, e.g., Verma *et al*., 1994; Chobanion *et al*., 2003; Hel & Macgregor, 2003 and Chadha *et al*., 1999) but for traditional regression analysis of the BP. It is further found that married people have 1.8 mmHg less central SBP as compared to the unmarried ones. However, marital status is not statistical contributing factor while estimating median DBP.

When the magnitudes of estimates for measuring central (50^{th}) percentile SBP are focused, it noted that each additional year in age increases almost half point in the median value of SBP. Few other studies (like Lakshmanudu *et al*., 1992; Verma *et al*., 1994; Chobanion *et al*., 2003; Muntner *et al*., 2004 etc.) also reported such relationship between age and BP.

More than 3 mmHg increase in the median of SBP is reported if a person has any kidney disease. The second and third highest contributing factors are diabetes and smoking causing an increase of more than one and half

points in the median value of SBP. On the other side, the chief factor that plays its role for the SBP not to increase is physical activity (i.e. regular exercise). A person having regular exercise can have more than 4 points less in the median SBP as compared to another person who is not doing any regular exercise. It has already been established that reduction in BP over time may possible due to an increase in regular physical activities (Chobanion, 2003).

If a married person of age 28 years with normal body weight (supposed BMI = 22), doing any regular exercise, with no other diseases of family history of HTN is considered then the 50th percentile (using table 5) can be computed as 120.95. In other words, half of adults with the mentioned characteristics will have SBP less than 120 .95 (almost normal cut-off). Similarly, the 50th percentile increases to 135.54 if a person with same age (28) and BMI (22) is unmarried, smoker, diabetic, having no exercise and having positive family history of HTN. The 50th percentiles of DBP for two above stated cases can be computed as 71.63 and 89.59, respectively. Shortly, it can be noted that if all the stated factors those increase the BP (either SBP or DBP) are considered, half of the adult population would have potential to become hypertensive. Thus, using the estimates given in table 5, the central of 50th percentiles for SBP and DBP can readily be found.

CONCLUSION

The study revealed that the adults had great potential to become hypertensive. Simple 50th percentiles of SBP and DBP were found to be 130 and 80, respectively showing the border line of hypertension of half of the adult population. The major contributing factors to increase 50th percentile of BP are having kidney disease, diabetes and smoking habit while a regular exercise can be helpful to reduce BP levels. The observed prevalence of pre-hypertension and hypertension in this study suggests the need for a comprehensive national policy to control hypertension and pre-hypertension in Pakistan.

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