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ORIGINAL ARTICLE

Prevalence, associated factors and relationship between prehypertension and hypertension: a study of two ethnic African populations in Northern Nigeria

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To determine the prevalence and relationship between prehypertension and hypertension, we studied 782 ethnic Hausa and Fulanis (men, 409; women, 373) aged 38.9 ± 13.9 years recruited by multistage cluster sampling. Demographic, anthropometry, metabolic and JNC VII-based blood pressure categories were obtained and analysed using univariate and multivariate models. The prevalence rates of prehypertension and hypertension were 58.7% (men 59.2%, women 58.2%) and 24.8% (men 25.9%, women 23.6%), respectively. Only 16.5% of the population had JNC VII defined optimum blood pressure. Compared to hypertension, prehypertension had earlier onset (second versus third decade) and peak (fourth versus fifth decade) of life. The peak and trough prevalence of hypertension and prehypertension, respectively were observed in the 5th decade of life. Obesity, abnormalities of glucose metabolism and insulin resistance were the major factors associated with prehypertension and hypertension. Multivariate analysis identified obesity and impaired glucose tolerance as independent predictors of hypertension. Of those with hypertension, 13.9% were aware of their high blood pressure status of which 85.7% were commenced on treatment and 12.5% achieved blood pressure control. Overall, 1.5% of the study population had blood pressure < 140/90 mm Hg. It is concluded that less than 20% of people of Hausa and Fulani ethnicities had optimum blood pressure. These are predominantly in their second decade of life suggesting that rise in blood pressure begins early in this population. The fifth decade of life may represent a period of transition from prehypertension to hypertension.
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Keywords: prehypertension; prevalence; associated factors; ethnicity

Introduction

Hypertension is a major global public health problem. It is estimated that about 26.4% of global adult population have hypertension with two third of them living in economically developing nations.[1] Furthermore, hypertension is one of the leading causes of morbidity and mortality worldwide, Nigeria inclusive.[2–5] The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood Pressure (JNC VII) recognised a new category of blood pressure status designated prehypertension.[6] This is increasingly being shown to be an independent risk factor of hypertension[7,8] and cardiovascular morbidity.[9–11] In addition, individuals with prehypertension are a potential target population for promotion of lifestyle modifications aimed at prevention of hypertension and cardiovascular diseases. Little is known about the magnitude of prehypertension and its associated factors in Africa. Comprehensive information on the burden of prehypertension and hypertension are vital in developing their effective national control strategies. This study determines the prevalence of prehypertension and hypertension and their associated factors among two major ethnicities in northern Nigeria.

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Methods

Study population
We studied 782 individuals (men, 409; women, 373) of Hausa and Fulani ethnicities aged 38.9 ± 13.9 years (range: 15–65 years) recruited from two urban and two rural settlements in Sokoto State of northwestern Nigeria using multistage cluster sampling.

Demographic and clinical data
Information on age, history of hypertension, parental hypertension or diabetes and tobacco and alcohol use was obtained using structured researcher-administered questionnaire. Anthropometric measurements included weight, height, waist and hip circumferences measured with the subjects lightly clothed and without shoes. Body mass index and waist–hip ratio were calculated. Three blood pressure values were obtained in sitting position after a minimum of 5 min rest using automated right upper arm validated manometer with cuff size of 14.5×42.0 cm (Omron SME-1 Omron Healthcare Ltd, Kyoto, Japan). The average of the last 2 of 3 readings was taken as the blood pressure. Automated blood pressure instrument has been found to be more objective, and eliminates digital preference in blood pressure measurement. It also correlates well with manual or mercury sphygmomanometer in population-based studies[12,13] and raises no environmental safety issues.

Metabolic profiles
About 10 ml of fasting blood was obtained for fasting blood sugar. Fasting serum lipid concentrations, oral glucose tolerance test and insulin resistance determined using fasting insulin and homeostasis model assessment–insulin resistance[14] were carried out in 100 randomly selected subsets of the population.

Definitions
Hypertension was diagnosed using JNC VII criteria[5] as systolic blood pressure $\geqslant 140$ mm Hg and/or diastolic blood pressure $\geqslant 90$ mm Hg or in individuals on antihypertensive medication. Systolic blood pressure of 120–139 mm Hg and/or diastolic blood pressure of 80–89 mm Hg constituted prehypertension, whereas isolated systolic hypertension was defined as systolic blood pressure > 140 mm Hg and diastolic blood pressure < 90 mm Hg. Obesity was defined as body mass index $\geqslant 30$ kg m^{-2}. Waist circumference $\geqslant 88$ cm (female) and $\geqslant 102$ cm (males) constituted abdominal adiposity.[15] Diabetes mellitus was diagnosed according to WHO criteria in subjects with fasting blood glucose greater than 7 mmol l^{-1} or 2 h glucose level (on oral glucose tolerance test) greater than 11.1 mmol l^{-1}.[16] Impaired glucose tolerance was diagnosed in subjects with fasting blood glucose of 6.1–6.9 mmol l^{-1} or 2 h blood glucose between 7 and 11.0 mmol l^{-1} on oral glucose tolerance test.[16] Based on normal reference values derived from the study population, HOMA value greater than 3.98 and/or fasting insulin greater than 19.7 microU ml^{-1} constituted insulin resistance.

Statistical analysis
Data entry and analysis was done using statistical software for social sciences (SPSS) software version 13.0. Numerical variables are expressed as means ± s.d. Categorical variables are expressed as percentages. Differences between means were tested using independent *t*-test (2-tailed) for two groups and analysis of variance where three or more groups were involved. Chi square or Fisher's Exact test as appropriate was used in comparing proportions. The relationship between mean arterial pressure and continuous variables was tested using linear regression. Multiple logistic regression models was used in determining the relationship between hypertension or prehypertension and variables of interest. A *P*-value < 0.05 was considered statistically significant.

Results

The general characteristics of the study population are shown in Table 1. Compared to men, women

Table 1 General characteristics of the study population

Characteristics	*Male* *409* N *(%)*	*Female* *373* N *(%)*	*Total* *782* N *(%)*	P-*value*
Urban dwelling	199 (48.7)	190 (50.9)	389 (49.7)	0.5
Literacy	187 (45.8)	96 (25.7)	283 (36.2)	<0.001
Low income occupation	207 (50.6)	318 (85.2)	525 (67.1)	<0.001
Cigarette smoking	82 (20)	0 (0)	82 (20)	—
General obesity	12 (2.0)	25 (5.9)	34 (4.3)	0.14
Abdominal obesity	10 (2.5)	92 (24.7)	102 (13.0)	<0.001
	Mean ± s.d.	*Mean ± s.d.*	*Mean ± s.d.*	
Age (years)	41.1 ± 13.9	36.1 ± 13.5	38.9 ± 13.9	<0.001
WC (cm)	82.3 ± 10.0	80.5 ± 10.0	81.4 ± 10.0	0.01
BMI (kg m^{-2})	22.8 ± 3.6	23.2 ± 4.0	23.0 ± 3.8	0.09
SBP (mm Hg)	128.1 ± 13.5	126.9 ± 11.0	127.6 ± 13.8	0.2
DBP (mm Hg)	78.1 ± 10.0	77.7 ± 10.3	7.3 ± 10.2	0.2
MAP (mm Hg)	95.3 ± 10.2	94.2 ± 10.4	94.7 ± 10.3	0.14

Abbreviations: BMI, body mass index; DBP, diastolic blood pressure; MAP, mean arterial pressure; SBP, systolic blood pressure; WC, waist circumference.

Table 2 Comparison of demographic, anthropometric and clinical profiles of normotensive, pre-hypertensive and hypertensive individuals

Parameter	*Normotensives* N = *129*	*Pre-hypertensives* N = *459*	*Hypertensives* N = *194*	P-*value*
Males *N* (%)	61 (47.3)	242 (52.7)	106 (54.6)	0.4
Urban dwelling *N* (%)	60 (46.5)	232 (50.5)	97 (50.5)	0.7
Illiteracy *N* (%)	67 (51.9)	287 (62.5)	145 (74.7)	<0.001
Sedentary occupation *N* (%)	79 (61.2)	304 (66.2)	142 (73.2)	0.05
Cigarette smoking *N* (%)	11 (8.5)	46 (10.0)	25 (12.9)	0.4
Family history of HBP *N* (%)	9 (7.0)	28 (6.1)	10 (5.2)	0.7
Family history of DM *N* (%)	7 (5.4)	19 (4.1)	(2.6)	0.6
Abdominal obesity *N* (%)	7 (5.4)	45 (9.8)	50 (25.8)	<0.001
General obesity *N* (%)	1 (0.8)	7 (1.5)	26 (13.4)	<0.001
Type II diabetes *N* (%)	1 (0.8)	3 (0.7)	17 (8.5)	<0.001
	Mean ± *s.d.*	*Mean* ± *s.d.*	*Mean* ± *s.d.*	
Age (years)	31.2 ± 11.0	37.8 ± 13.6	46.5 ± 12.5	<0.001
Body mass index (kg m^{-2})	21.6 ± 3.2	22.5 ± 3.2	24.9 ± 4.6	<0.001
Waist circumference (cm)	76.3 ± 7.8	80.5 ± 8.5	86.9 ± 11.9	<0.001
Hip circumference (cm)	91.3 ± 7.8	94.0 ± 7.9	97.2 ± 9.3	<0.001
Waist–hip ratio	0.84 ± 0.06	0.85 ± 0.06	0.89 ± 0.07	<0.001
SBP (mm Hg)	110.7 ± 5.3	126.1 ± 6.5	142.3 ± 15.4	<0.001
DBP (mm Hg)	67.1 ± 5.6	77.0 ± 7.1	89.0 ± 8.6	<0.001

Abbreviations: DBP, diastolic blood pressure; DM, diabetes mellitus; HBP, hypertension; SBP, systolic blood pressure.

tended to be younger, less educated and belonged to the low income group. Optimum blood pressure (systolic < 120 mm Hg and diastolic pressure < 80 mm Hg) was observed in only 16.5% of the population who were predominantly in their second decade of life. The prevalence rates of prehypertension and hypertension were 58.7% (men 59.2%, women 58.2%) and 24.5% (men 25.9% women 23.6%), respectively. Isolated systolic hypertension (systolic pressure > 140 mm Hg and diastolic pressure < 90 mm Hg) was observed in 63 individuals (32 men, 31 women) and constituted 8.1% of the total population and 13.9% of hypertensive population. They were older compared to the rest of the study population (45.3 ± 14.1) versus (38.4 ± 13.8 years; $P < 0.001$). Twenty two subjects (2.8%) consisting 11 men and 11 women had stage 2 hypertension (systolic pressure > 160 mm Hg and/or diastolic pressure > 100 mm Hg). Twenty one individuals (2.7%) had diabetes of which 3 (14.3%) and 17 (80.9%) had prehypertension and hypertension, respectively.

Of those with hypertension, only 13.9% were aware of their high blood pressure status. Though 85.7% of those who were aware of their high blood pressure status were commenced on treatment, only 12.5% achieved blood pressure control. Overall, 3.5% of the study population were aware of their high blood pressure status, 11.9% were on antihypertensive medication and 1.5% achieved blood pressure control. Eleven (1.4%) were on herbal medications believed to cure hypertension. None of the prehypertensives were aware of their blood pressure status.

The prevalence of various blood pressure categories in different age groups are shown in Figure 1. Compared to hypertension, prehypertension had earlier onset (15–20 versus 26–30 years of age) and peak (36–40 versus 41–45 years of age). The minimum prevalence rate of prehypertension and the peak prevalence of hypertension were observed in the 46–50 years and 41–45 years age groups, respectively. Hence, the 5th decade of life (41–50 years) corresponded to the minimum prevalence of prehypertension and maximum prevalence of hypertension. After the fifth decade of life the prevalence of hypertension and prehypertension tended to increase perhaps because of aging and increase in the prevalence of obesity (Figure 1).

The clinical and metabolic profiles of individuals with normotension, prehypertension and hypertension are compared in Tables 2 and 3, respectively. Compared to normotensives, the pre-hypertensives and hypertensives were significantly older, and had higher frequency of illiteracy, cigarette smoking and sedentary occupation. Age, body mass index, waist circumference, serum triglyceride, fasting insulin and homeostasis model assessment–insulin resistance levels increased across the gradient of blood pressure status from normotension through prehypertension to hypertension.

Mean arterial pressure correlated positively with anthropometric parameters, duration of cigarette smoking and plasma lipid concentrations (Table 4). Prehypertension was more likely in individuals with abdominal adiposity (OR = 1.9, 95% CI = 0.8–4.7), parental history of hypertension (OR = 1.0, 95% CI = 0.6–1.8), parental history of diabetes

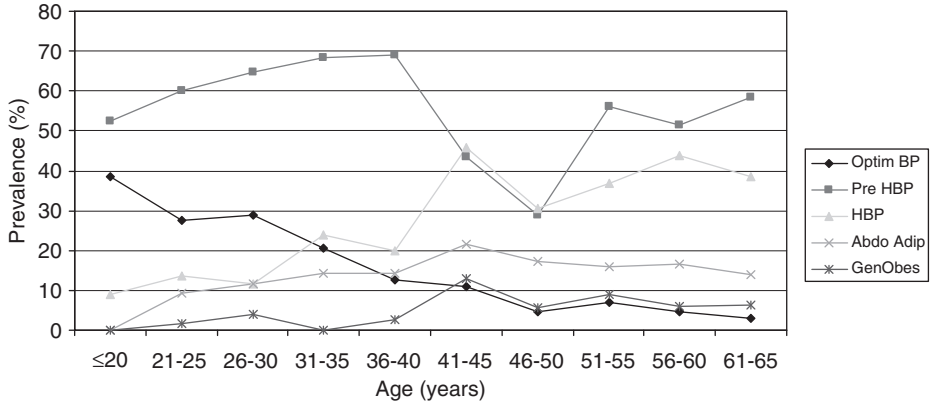

Figure 1 Blood pressure categories and obesity in different age groups. Abdo Adip, Abdominal obesity; Gen obes, General obesity; HBP, Hypertension; OptimBP, Optimum blood pressure. PreHBP, Prehypertension.

Table 3 Comparison of the metabolic profiles of normotensive, pre-hypertensive and hypertensive individuals

Parameter	*Normotensives* N = *19*	*Pre-hypertensives* N = *59*	*Hypertensives* N = *22*	P-*value*
IGT *N* (%)	0 (0)	5 (8.5)	6 (2.7)	0.02
IFG *N* (%)	0 (0)	17 (28.8)	22 (100)	<0.001
Insulin resistance *N* (%)	2 (18.2)	11 (17.2)	13 (52.0)	0.003
	Mean ± *s.d.*	*Mean* ± *s.d.*	*Mean* ± *s.d.*	
FBG (mmol l^{-1})	4.9 ± 0.6	5.0 ± 0.9	5.9 ± 2.3	<0.001
2 h PPG (mmol l^{-1})	6.3 ± 0.5	6.2 ± 0.9	7.2 ± 2.1	0.02
Fasting insulin (microU ml^{-1})	11.7 ± 2.0	14.3 ± 18.1	29.1 ± 37.2	0.02
HOMA	2.4 ± 2.0	3.2 ± 4.5	11.8 ± 24.0	0.002
Total cholesterol (mg per 100 ml)	169.0 ± 21.3	152.1 ± 23.9	184.6 ± 67.3	0.002
HDL-cholesterol (mg per 100 ml)	50.6 ± 8.5	51.6 ± 9.2	48.3 ± 12.1	0.4
LDL-cholesterol (mg per 100 ml)	105.7 ± 18.8	90.2 ± 29.5	110.2 ± 64.0	0.09
Triglyceride (mg per 100 ml)	86.5 ± 32.3	105.6 ± 34.9	118.7 ± 48.1	0.07

Abbreviations: HDL, high density lipoprotein; HOMA, homeostasis model assessment; IFG, impaired fasting glucose; IGT, impaired glucose tolerance; LDL, low-density lipoprotein; PPG, post prandial blood glucose.

Table 4 Correlates of mean arterial pressure

Parameter	r-*value*	P-*value*
Waist–hip ratio	0.860	<0.01
Duration of cigarette smoking	0.458	<0.01
Waist circumference (cm)	0.384	<0.01
Age (years)	0.362	<0.01
Total cholesterol	0.351	<0.01
Low-density lipoprotein cholesterol	0.308	<0.01
Triglyceride	0.219	<0.01

Table 5 Factors associated with hypertension

Parameter	*OR*	*95% CI*	P-*value*
Diabetes	14.0	4.3–5.7	<0.001
Impaired glucose tolerance	4.4	2–9.8	0.02
Impaired fasting glucose	4.4	2.1–9.2	<0.001
Insulin resistance	2.3	1.8–6.3	0.04
General obesity	11.2	4.7–27.5	<0.001
Abdominal obesity	3.6	2.2–5.6	<0.001
Cigarette smoking	1.4	1.6–2.8	0.04

(OR = 1.5, 95% CI = 0.6–2.9) and cigarette smoking (OR = 1.1, 95% CI = 0.7–1.8). The likelihood of hypertension (Table 5) was more in those with diabetes (OR = 14.0, 95% CI = 4.3–5.7, $P<0.001$), impaired glucose tolerance (OR = 4.4, 95% CI = 2.0–9.8, $P<0.001$), impaired fasting glucose (OR = 4.4, 95% CI = 0.1–9.2), insulin resistance (OR = 2.3, 95% CI = 1.9–6.3, $P=0.04$), general obesity (OR = 11.2, 95% CI = 4.7–24.0, $P<0.001$), abdominal obesity (OR = 3.6, 95% CI = 2.2–5.6, $P<0.001$) and cigarette smoking (OR = 1., CI = 1.6–2.8, $P=0.04$). Multiple regression analysis showed significant relationship between hypertension and all the variables combined ($r=0.536$, $P<0.001$). However, only age greater than 35 years ($\beta=0.258$, $P=0.01$), obesity ($\beta=0.246$, $P=0.02$) and impaired glucose tolerance ($\beta=0.299$, $P=0.01$) were independently associated with hypertension.

Discussion

This study is to our knowledge the first population-based report on prehypertension in Nigeria. It shows

that less than 20% of people of Hausa and Fulani ethnicities had JNC VII defined optimum blood pressure and these were predominantly in those in their second decade of life. This suggests that blood pressure begins to rise early in life in this population. The prevalence rate of prehypertension is high and compares favourably with values obtained in recent reports from Ghana, West Africa,[17] Middle East,[18] Asia [C[19]], Europe,[20] America[21] and China.[22] We observed, as expected, higher prevalence of hypertension than values of 10–15% obtained in the nation-wide and other epidemiological surveys that used cut-off values of 160/95 mm Hg in diagnosing hypertension in Nigeria.[23–25] Our result is, however, in agreement with estimated global adult burden of hypertension (26.4%).[1] It is also similar to prevalence rates ranging from 20.3–27.1% in other population-based JNC VII-defined hypertension studies (cut-off values of 140/90 mm Hg) in mid-western,[26] central[27] and eastern[28] parts of Nigeria but lower than a value of 36.6% obtained from the western part of the country.[29] In Accra and Ashanti regions of Ghana, 28.3 and 29% of the population, respectively have hypertension.[17,30] Data from the National Health and Nutritional Examination Surveys showed that 28 and 29% of United States adults aged 18 or more years have prehypertension and hypertension, respectively.[31]

Differences in genetic and environmental determinants of blood pressure may partly underlie intra and inter-population variation in hypertension prevalence. As an illustration of such environmental influence, African Americans have been shown to have higher prevalence of hypertension than their genetically related native Africans living in Africa.[32] A clear demonstration of the influence of genetic factors on blood pressure level is the high prevalence of hypertension among Whites than Black native South Africans, the prevalence rate among the latter, being similar to the value obtained in this report.[1]

In this report, prehypertension and hypertension were associated with factors that have been previously documented.[8,17,18,24,25,27,32,33] However, our results interestingly demonstrated early onset of prehypertension in life as well as its link with abdominal adiposity and markers of genetic predisposition to high blood pressure including parental hypertension or diabetes. Hypertension, on the other hand tends to begin later in life and more strongly linked with glucose tolerance abnormalities and established environmental determinants of high blood pressure, particularly obesity. The peak age of prehypertension and hypertension were lower but similar in pattern to north Indian population in whom the highest prevalence of these conditions were in 30–39 years and 60–69 years age groups, respectively.[34]

On the whole, our results appear to suggest that prehypertension may be largely genetically determined, and support the concept that it could increase the risk of hypertension given suitable environmental conditions,[7,8] particularly obesity which is believed to contribute to high blood pressure through neurohormonal (renin–angiotensin and sympathetic nervous systems) activation.[35] In the ATTICA study, 50% of individuals aged less than 65 years developed hypertension over a 5-year period.[8] The Framingham Heart Study also showed that prehypertensives have 10% annual risk of progression to hypertension.[33]

The fifth decade of life corresponded to the maximum prevalence of hypertension and minimum prevalence of prehypertension. We propose that this decade represents a period of transition from prehypertension to hypertension status in the study population. This, however, needs to be substantiated in a longitudinal study. The lower prevalence of hypertension after the fifth decade of life may be due to antihypertensive medications. The subsequent higher prevalence of hypertension may not be unrelated to non adherence to drugs, poor blood pressure control and age-related arteriolosclerosis, which was however not investigated in this study.

We observed, like in the many previous reports from Nigeria,[24,25,27] slight male dominance in the prevalence of hypertension. This is in spite of higher frequency of obesity among female than male individuals. Gender differences in hypertension are not consistent across ethnic groups and appear related to interplay of different life styles.[36] Contrary to most previous works in Africa including Nigeria,[23,37,38] we observed no rural–urban difference in the prevalence of hypertension. Rural–urban differences in the epidemiology of hypertension are attributable to variation in geographical distributions of environmental determinants of hypertension, particularly life styles, which are in turn related to socioeconomic status. These gaps might have been closed in our study population majority of whom belong to the middle or low socioeconomic class irrespective of their place of domicile (rural or urban). Furthermore, people of Hausa and Fulani ethnicities are culturally homogenous and tend to reside in their geographical places of birth irrespective of their socioeconomic status.

Awareness, treatment and control rates of hypertension have generally remained low worldwide in spite of the ease in the diagnosis of hypertension and availability of efficacious antihypertensive agents. The rates obtained in the current report are nonetheless higher than values reported in mid-western Nigeria,[26] but lower than that from an urban community in Ghana, West Africa.[30] High blood pressure status awareness, treatment and control rates are comparatively higher and range between 26–43%, 34–42% and 12–16%, respectively among Caucasians.[39,40] Recent data from the National Health and Nutritional Examination Surveys in the Unites States, however, showed higher rates of hypertension awareness (78%), treatment (68%)

and control (64%).[31] Blood pressure control rates are also obviously higher in a population than in hospital-based studies[41,42] as the latter tend to select more drug adherent hypertensives.

In conclusion, less than 20% of people of Hauas and Fulani ethnicities had JNC VII-defined optimum blood pressure and these were predominantly in their second decade of life suggesting a rise in blood pressure beginning early in life in this population. The prevalence of prehypertension and hypertension are high and appear associated with genetic factors, obesity and glucose intolerance. Awareness and control rates of hypertension are unacceptably low. This underscores the need for community-based strategies aimed at prevention, detection, and treatment of hypertension and prevention of prehypertensives from developing hypertension.

What is known about topic
- Hypertension is prevalent in Africans.
- Individuals with prehypertension are at risk of hypertension.

What this study adds
- Less than 20% of ethnic Hausa and Fulani has JNC VII-defined optimum blood pressure, with rise in blood pressure beginning early in life.
- The fifth decade of life may represent the period of transition from prehypertension to hypertension.

Conflict of interest

The authors declare no conflict of interest.

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