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OVERWEIGHT AND OBESITY AS MODIFIABLE ENVIRONMENTAL RISK FACTORS AMONG HYPERTENSIVE PATIENTS AND THEIR EMERGING ROLE AS A CAUSE OF CLIMATE CHANGE

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ABSTRACT

Background: The environmental risk factors for hypertension (HTN) include obesity, lack of physical activity, excessive sodium and alcohol consumption, among others. Overweight is defined as body mass index (BMI) 25-29.9 kg/m^2, while obesity represents a BMI > 30 kg/m^2. **Aim:** To determine the prevalence of high BMIs among hypertensive patients, the risks of hypertension and climate change attributable to BMI **Materials and method**: Two hundred hypertensive patients aged 35-90 selected through purposive sampling were recruited for the study. Office blood pressures (BPs) of the patients were measured using standard mercury sphygmomanometer, and their heights with a stadiometer. The BMIs were calculated as the ratios of the weights in kilogramme to the squares of the heights in metre. HTN was defined as a BP ≥140/90. **Results:** Prevalence of overweight and obesity (high BMIs) was 65%. Risk of HTN and climate change was 0.65. Prevalence of overweight peaked at 55-64 years (43.6%), while obesity was at 35-44 years (57.1%). The females (36%) were more obese than the males (29%). Correlations between BMI and systolic BP was positive, strong and significant (r=0.88, p=0.05). For the diastolic BP it was also positive and strong, but not significant (r=0.76, p=0.14). **Conclusion:** To reduce the risk of high BP posed by high BMIs, and their emerging role in climate change, there is need to modify individual's eating habits and increase physical activity. Drugs and surgery could also be employed in some cases where conservative measures fail.

KEYWORDS: overweight, obesity, environmental, risk, hypertensive, climate.

INTRODUCTION

Hypertension (HTN) is defined as a blood pressure (BP) of ≥140/90 mm Hg according to JNC 7. However, recently this definition of HTN has undergone some modifications. So, according to the American College of cardiology/American Heart Association guidelines in 2017, stage I hypertension is now defined as a systolic BP of 130 to 139mm Hg, or a diastolic BP of 80 to 89mm Hg.[1] This is the prehypertension stage of JNC 7, with the associated risk for progression to hypertension which necessitates lifestyle modifications as important preventive strategies. Occasionally, there could be a discordant rise in both the systolic and diastolic BPs, giving rise to the so called isolated HTN. For this reason, isolated HTN can either be systolic with normal diastolic or diastolic with normal systolic. And as there appears to exist a positive correlation between the BP level and the severity of HTN, the interpretation is that its severity increases as the BP rises. The resultant severe cases of HTN, or hypertensive crises, are defined as a BP of >180/120mm Hg. This may further be categorized as hypertensive emergencies (with evidence of impending or progressive target organ dysfunction) or urgencies (without progressive target organ dysfunction).[1]

Globally, an estimated 26% of the world population (972 million people) has HTN, and the prevalence, driven largely by increases in economically developing nations, is expected to increase to 29% by 2025.[1] When HTN is uncontrolled or inadequately controlled, it can lead to some complications. These complications account for 9.4 million deaths worldwide every year.[2] Available statistics indicate that HTN is responsible for at least 45% of deaths due to heart disease, and 51% of deaths due to stroke.[3] Statistics further reveal that for every 20mm Hg systolic or 10mm Hg diastolic increase in BP above 115/75mm Hg, the mortality for both ischaemic heart disease and stroke doubles.[2]

Adequate prevention and control of HTN entail the knowledge of the so called risk factors. These factors could be broadly categorized into modifiable and non-modifiable ones. The non-modifiable factors include age, sex, heredity and race/ethnicity; while the modifiable

ones are mainly environmental in origin. Among the non-modifiable factors that affect the BP is age. From observation, it has been discovered that HTN prevalence increases along the same line as the patient's age. It has further been observed that the prevalence of HTN also differs on the basis of ethnicity and sex, being higher in black men and women (59%, 56% respectively) than in white, Asian and Hispanic men (47%, 45% and 44% respectively) and women (41%, 36% and 42%).[4]

The implicated environmental risk factors for HTN include obesity, lack of physical activity, excessive sodium and alcohol consumption, among others.[5] As defined by the WHO, obesity represents a body mass index (BMI) of 30kg/m^2 or more. In its own turn, obesity is influenced by some well-known environmental factors. The identified environmental factors include socioeconomic status, ethnicity, Region of residence, season, and urban living.[6]

The link between obesity and HTN has long been recognized, although the mechanism by which obesity directly causes hypertension still remains unclear up till now. However, activation of the sympathetic nervous system, the amount of intra-abdominal and intra-vascular fat, sodium retention leading to increase in renal reabsorption, and renin-angiotensin system are considered to have important roles in the pathogenesis of obesity-related HTN.[7,8]

Studies have shown that obesity can increase the risk of HTN to twofold as compared to normal weight, and up to two-thirds of HTN cases can be attributed to excess weight.[9] Findings from some past studies also indicate that more than 85% of cases of HTN occur in those with BMI greater than 25.[10] In 2008, it was found that more than 1.4 billion adults were overweight, and of these, over 200 million men and nearly 300 million women were obese.[11]

Apart from their effect on the BP, overweight (BMI of 25 to 29.9kg/m^2) and obesity (BMI $\geq$30kg/m^2) are also associated with a higher mortality risk. This has been validated by some past studies which observed that severely obese people die 8-10 years sooner than those with normal weight, the risk of early death increasing by 30% for every additional 15 kilogrammes of excess weight.[12] In 2004, the estimated disability due to obesity and its effect was estimated to be more than 36 million disability-adjusted life-years (DALYs).[13] A recent analysis of data from 195 countries revealed that the prevalence of obesity has doubled in more than 70 countries since 1980, and over 600 million adults were obese in 2015, with high BMI accounting for 4 million deaths globally.[14]

A growing body of evidence points to a positive correlation between weight reduction and decrease in the BP. Examples include findings from a health technology appraisal which have revealed that a fall in systolic BP of 6.1mm Hg was associated with weight loss of 10%, and a 10kg weight loss with an average fall in total blood cholesterol of 0.25 mmol/L and a fall in diastolic BP of 3.6mm Hg.[15]

Another problem associated with obesity is its impact on health expenditure. Statistics reveal that an obese person incurs 25% more health expenditure than a person of normal weight.[12] It is important to note that while in most OECD countries obesity alone is consuming 1 to 3% of total health expenditure, in the United States 5-10% of the total health expenditure is estimated to be spent on prevention and treatment of overweight and obesity and their related consequences.[12]

Some recent studies have revealed a link between obesity and climate change. As a matter of fact, obesity is said to contribute to climate change. And it is estimated that the current global burden of obesity adds about 700 megatonnes of extra carbon dioxide equivalent emissions per year, or about 1.6% of total global emissions.[16] Overall, being obese is associated with about 20% more greenhouse gas (GHG) emissions (carbon dioxide, methane and nitrous oxide) than being a normal weight.[17] This greenhouse gas (GHG) burden of obesity has three components: greater oxidative metabolic demands, associated with obesity (7% of total); increased food production needed to provide the higher energy intake (52%); and greater fossil fuel use to transport heavier bodies (47%).

Various studies from around the world reveal that obesity is gradually becoming a global problem, irrespective of the levels of development of the individual countries. In the past, it was considered a problem of only affluent nations. However, the trend is now changing as each country is presently having its own fair share of the emerging health problem. In Nigeria, for instance, the prevalence of overweight has been reported to range from 20.3% to 35.1%, while that of obesity was said to be from 8.1% to 22.2%.[18,19] Supplementary data from the 2010 WHO survey on Nigeria reveal that the prevalence of overweight was 26% and 37% in men and women respectively, while that of obesity was 3% in men and 8.1% among women.[20] Similar data from the WHO Global InfoBase, based on individuals aged 30 years and above, show that the prevalence of overweight and obesity together increased by 23% in men and 18% in women, while the prevalence of obesity alone increased by 47% in men and 39% in women between 2002 and 2010 in Nigeria.[20] This reported rise in the prevalence of overweight and obesity has been blamed on factors such as age, gender, marital and socio-economic statuses, occupation, urban residence, dietary intake and physical inactivity.[21-25]

Besides the well-known factors that affect the prevalence of obesity, regional variations have also been observed in Nigeria. A higher prevalence of obesity in the Southern

part of the country compared to the North was reported.[26] In Enugu State, for instance, prevalence of overweight and obesity of 29.9% and 13.1%, and 19% and 6.8% respectively had been reported.[27, 28] Other contrasting prevalence rates have been reported by different researchers at various times both for Enugu State, and Nigeria as a whole. However, the generally observed trend is that the prevalence of overweight and obesity has been on the rise since 2002 in Nigeria, and indeed other parts of the world.[20] The same trend also appears to exist in Enugu State.

Because overweight and obesity are risk factors for HTN with a reported apparent link with climate change, it is therefore logical that their prevention and control would ultimately lead to decrease in the prevalence of HTN and the morbidity and mortality associated with it, and the burden of climate change attributable to high BMIs. For this reason, this study aims to determine the prevalence of abnormally high BMIs among hypertensive patients, the risks of hypertension attributable to high BMIs and their contribution to climate change.

MATERIALS AND METHOD

The area of the study was Oji River Local Government Area (LGA) of Enugu State, Southeast Nigeria.

This was a survey study involving hypertensive patients who attended General Hospital Oji River within the period of the study (April-August 2020). Oji River LGA, situated in Enugu West Senatorial District, is bordered in the West and South by Anambra State, in the North by Udi and Ezeagu LGAs, and in the East by Awgu LGA. It is located within 6^o 16 N and7^o co-ordinates with a total area of 403km^2 and a population of 173, 800 (2016 population estimate). The LGA is made up of six towns, namely Oji urban centre, Inyi, Awlaw, Achi, Akpugoeze and Ugwuoba.

The study site- General Hospital Oji River-is situated in the urban area of the LGA serving the urban population and the surrounding major towns of Achi, Inyi, Awlaw, Akpugoeze and Ugwuoba. It is also a referral centre for the surrounding peripheral healthcare facilities. The choice of General Hospital Oji River guarantees a proper mix of urban and rural dwellers, and people of various socio-economic classes, bearing in mind that these are some of the factors that can affect overweight and obesity, and HTN.

The population of the study, selected through purposive sampling, was all the hypertensive patients who attended the hospital within the period of the study between April and August 2020 (200 in all).

The sample size was calculated using the following formula:

$n = Z^2 P (1-P)/d^2$,

Where,

n= sample size

Z= Z statistic for a level of confidence,

P=expected prevalence or proportion (In proportion of one, if 20%, p=0.2)

d=precision (In proportion of one, if 5%, d==0.05)

Z-statistic for level of confidence of 95% which is conventional, Z value=1.96.[29]

With a prevalence of 9.2% (437 hypertensive patients out of the 4758 seen in the hospital in 2019), the calculated sample size was 128.

Population study was adopted in this case since the number of patients (the population) seen within the period of the study (200) was not that large, and did not differ much from the calculated sample size (128). In addition, this would also help to increase the power of the study. Two hundred hypertensive patients between the ages of 35 and 90 were recruited. Inclusion criteria were known cases of primary hypertension, high blood pressure (BP) on the first or any other visit as defined by the JNC 7, i.e., a BP level ≥140/90 mm Hg. All known cases of secondary hypertension such as those with Diabetes mellitus, chronic kidney diseases, women on systemic contraceptives, and gestational hypertension were excluded. Cases of hypertension as defined by the American College of Cardiology/American Heart Association 2017 guidelines which split JNC 7 prehypertension category into elevated BP (120-129mm Hg systolic, diastolic of less than 80mm Hg) and stage 1 hypertension (130-139/80-89mm Hg) were also excluded from the study.

Office blood pressures of the patients were measured, taking all the necessary precautions using standard mercury sphygmomanometer. Their heights were measured using a stadiometer. The body mass indices (BMIs) were calculated as the ratios of the weights in kilogramme to the squares of the heights in metre. For the purposes of this study, BMI (in kg/m^2) was classified as follows:

Normal	18.5-24.9
Overweight	25-29.9
Obese class I	30-34.9
Obese class II	35-39.9
Obese class III	>40

Classification of low BMI was deliberately omitted as it did not serve the purpose of the study.

Data were collected for a period of four months (April-August 2020) and analysed as proportions, t-test, ANOVA, and Pearson product moment correlation using MaxStat (version 3.60) statistical software. Values of $p \leq 0.05$ were considered significant.

RESULTS

Table 1 presents the patients' demographics. As revealed by the table, 63 (31.5%) were males, while female were 137 (68.5%). The table also shows that majority of the

patients fell within the 55-64 (27.5%) and 65-74 (32%) age ranges. 45-54 and 75-84 age ranges constituted 15% and14% respectively. The extreme age ranges 35-44 (7%) and 84-94 (4.5%) had the least number of patients.

Table 1: Patients' demographics. (N=200)

Age (in years)	Sex		Total
	Male	Female	
35-44	2	12	14(7%)
45-54	7	23	30(15%)
55-64	15	40	55(27.5%)
65-74	21	43	64(32%)
75-84	12	16	28(14%)
85-94	6	3	9(4.5%)
Total	63 (31.5%)	137 (68.5%)	200 (100%)

Table 2 shows the prevalence of hypertension in General Hospital Oji-River in 2019. As seen in the table, 437 (9.2%) were hypertensive, while 4321 of the 4758 (90.8%) patients had normal BP. The prevalence of HTN was more in the females (6.1%) compared to the males (3.1%) giving a male to female ratio of approximately 1:2.

Table 2: Prevalence of HTN in General Hospital Oji-River in 2019.

BP (in mm Hg)	Number of patients	Sex	
		Male	Female
Normal	4321 (90.8%)	1440 (30.3%)	2881 (60.5%)
High	**437 (9.2%)**	**149 (3.1%)**	**288 (6.1%)**
Total	4758	1589	3169

Table 3 summarises the distribution of the patients' BMIs. As is evident in the table, normal weight (35%), overweight (31.5%) and obesity (33.5%) were almost uniformly distributed. There were more patients with obesity class I (21.5%) in the obese category, than those with obesity class II (8.5%) and class III (3.5%). This finding indicates that the majority of the hypertensive patients were overweight and obese (65%), compared to those with normal body weights (35%).

Table 3: Distribution of patients' BMI. (N=200)

BMI (in kg/m^2)	Number	Proportion (in %)
18-24.9 (Normal weight)	70	35
25-29.9 (Overweight)	63	31.5
30-34.9 (Obesity class I)	43	21.5
35-39.9 (Obesity class II)	17	8.5
>40 (Obesity class III)	7	3.5
Total	200	100

Table 4 shows the distribution of patients' BMIs according to age. The table reveals that the prevalence of overweight rose steadily (from 14.3% for 35-44 age range) as age increased and peaked at 43.6% (55-64 age range), before decreasing through 31.3% (65-74 age range) to 22.2% (the lowest prevalence for 85-94 age range). On the other hand, obesity was most prevalent in the 35-44 age range (57.1%), decreasing through 36.7% (45-54 age range) to 25.4% (55-64 age range), before spiking again to 42.1% (65-74 age range) and finally dropping to 11.1% in the 85-94 age range. This finding indicates that overweight was more prevalent in the 55-64 years category, obesity in the 35-44 years category and that majority of the patients (66.7%) in the 85-94 years category had normal weights. Statistically, there were no significant differences in BMI distribution among the different age ranges (p=0.951).

Table 4: Age distribution of BMI. (N=200)

Age	Normal	Overweight	Obese	Total
35-44	4 (28.6%)	2 (14.3%)	8 (57.1%)	14
45-54	13 (43.3%)	6 (20%)	11(36.7%)	30
55-64	17 (31%)	24 (43.6%)	14 (25.4%)	55
65-74	17 (25.6%)	20 (31.3%)	27 (42.1%)	64
75-84	14 (50%)	8 (28.6%)	6 (21.4%)	28
85-94	6 (66.7%)	2 (22.2%)	1 (11.1%)	9
Total	71	62	67	200
F	0.051			
p	0.951			

The distribution of BMIs according to sex is presented in Table 5. As revealed in the table, the prevalence of overweight was more in the males (34.9%) compared to the females (29.9%). On the other hand, obesity was more prevalent in the females (35.7%) than the males (28.6%).More males had normal weights (36.5%) compared to the females (34.4%). This finding implies that the males were more overweight while the females were more obese. Statistically, there was a significant difference between males and females in BMI distribution (p=0.001).

Table 5: Sex distribution of BMI. (N=200)

Sex	Normal	Overweight	Obese	Total
Male	23 (36.5%)	22 (34.9%)	18 (28.6%)	63
Female	47 (34.4%)	41 (29.9%)	49 (35.7%)	137
t	8.66			
p	0.001			

Table 6 summarises the relationship between BMI and mean systolic and diastolic BPs. As shown in the table, there is a steady rise of the systolic BP as the BMI increased from 25 to >40. The diastolic BP also increased steadily from BMI of 25 to 39.9, falling slightly when BMI > 40. This finding indicates that there is a strong positive correlation between the systolic and diastolic BPs and BMIs (r=0.88 for systolic, and 0.76 for diastolic BPs). However, for any given BMI, the correlation between the systolic and diastolic BPs was moderate, but not significant (r=0.47, p=0.42). Although the correlation was statistically significant for the systolic BP (p=0.05), it was not so for the diastolic (p=0.14).

Table 6: Relationship between BMI and BP.

BMI (in kg/m^2)	Mean BP (in mmHg)		
	Systolic		Diastolic
18.5-24.9	160		89
25.0-29.9	160		89
30.0-34.9	162		92
35.0-39.9	164		99
>40.0	173		94
r	0.88	0.47	0.76
p	0.05	0.42	0.14

DISCUSSION

In public health planning, risk is defined as the probability of the occurrence of a disease or other health outcome of interest during a specified period, usually one year. It is calculated by dividing the number who got the disease during the defined period by the total population of interest during that period. The risk of hypertension posed by overweight and obesity among hypertensive patients as found by the study was 0.65 or 65%. By extrapolation, this also represents the risk for climate change. This result represents a substantial risk when compared to the findings of a previous study which attributed 50% of hypertensive disease to high BMIs.[30] However, it is significantly lower than the risk ratio of 1.01 (mean) reported for both men and women from the general population in Canada, i.e. for both hypertensive and non-hypertensive patients.[31] This observed difference in risk could be attributed to a number of factors, which include differences in the environmental conditions (Oji-River versus Canada), patient/participant selection (35-94years versus 20-79years), socioeconomic statuses, dietary intake and physical activities, among others.

Majority of the hypertensive patients were overweight and obese (65%), compared to those with normal body weights (35%). This finding validates the study which reported an overall prevalence of 64% for overweight

and obesity among the general Nigerian population.[32] However, this contrasts with other Nigerian researchers who had previously reported various prevalence rates at various times in different parts of the country (57.3%, 31.8%, 43%).[19, 33, 27] In contrast with these studies, a significantly higher figure was reported among health services providers in a tertiary healthcare facility in Lagos, Nigeria (72%).[34]

Overweight was more prevalent in the 55-64 years category (43.6%), obesity in the 35-44 years category (57.1%), while majority of the patients (66.7%) in the 85-94 years category had normal weights. This is in tandem with the findings of the study which reported the highest prevalence of overweight and obesity among the middle-aged (40-64 years) in both rural and urban settings.[33] Similarly, three other studies also reported a peak in the prevalence of overweight and obesity at middle age in Nigeria.[26, 34, 28]

Contrary to the findings of others, this study found the prevalence of obesity to be highest in the 35-44 years age category. This finding could be interpreted in the light of the current global rise in the prevalence of obesity. It could be speculated that the younger age groups are now responsible for this observed increase, hence the present finding. It could also be that the apparently high prevalence observed in this age category might be the effect of a small sample size, considering the fact that only 14 patients (participants) were in this age category.

The study found the prevalence of overweight to be more in the males (35%) compared to the females (30%), while obesity was more prevalent in the females (36%) than the males (29%). These findings are in agreement with other similar studies that had reported obesity to be more prevalent among their female participants.[26-27, 32-35]

The study found a strong positive correlation between the BPs (systolic and diastolic) and BMIs (r=0.88 for systolic, and 0.76 for diastolic BPs). However, for any given BMI, the correlation between the systolic and diastolic BPs was moderate, but not significant (r=0.47, p=0.42).

These findings are supported by results from a technology appraisal which found that a fall in systolic BP of 6.1mm Hg was associated with weight loss of 10%, and a 10kg weight loss with a fall in diastolic BP of 3.6mm Hg.[15] The implication of the study findings is that the BP (both the systolic and diastolic) rises as the BMI increases, and vice versa. The significance consists in the fact that addressing the problem of high BMIs eventually would lead to reduction in high BP attributable to them.

Limitations of the study

Insufficient number of patients from the 35-44 years and 85-94 years age ranges because of their poor attendance to hospital, and low prevalence of hypertension in the 35-44 years age category. These might have affected the quality of the data collected for these two age categories.

CONCLUSION

The prevalence of overweight and obesity (high BMIs) among hypertensive patients was high (65%). This represents a 0.65 risk of hypertension for persons with high BMIs. Prevalence of overweight peaked at 55-64 years, while obesity was at 35-44 years. Obesity was more prevalent in the females (36%) than males (29%). Correlations between BMI and systolic BP was positive, strong and significant (r=0.88, p=0.05). Although, for diastolic BP the correlation was also positive and strong, it was not significant (r=0.76, p=0.14). With a risk of 0.65 for HTN from high BMI, hypertensive patients constitute significant contributors to climate change.

To reduce the risk of high blood pressure posed by overweight and obesity, and their emerging role in climate change, there is need for individuals/patients to modify their eating habits which will entail cutting down the consumption of energy-dense food, sugar and saturated fat. As a complimentary prevention/control measure, there is also need to increase the physical activity level of the individual. Furthermore, there is also a place for medical intervention in the form of blood lipid-reducing drugs (various classes) and surgery where the conservative measures fail to tackle the problem of high BMIs.

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