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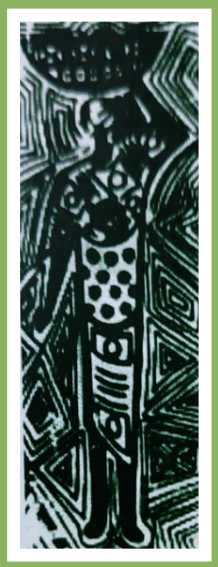

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Prevalence and Risk Factors for Elevated Blood Pressure Patterns and Hypertension Among Children Attending a Tertiary Outpatient Clinic in Port Harcourt, Nigeria

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Abstract

Background: The prevalence of hypertension among children is on the increase, and it is of global concern.

Objectives: To determine the prevalence and associated risk factors of elevated and hypertensive-range blood pressure among children and adolescents.

Methods: This was a cross-sectional, prospective study of patients who attended the Paediatric Outpatient Clinic of the River State University Teaching Hospital, Nigeria. Their biodata, family and social history, dietary history and blood pressure (BP) were recorded, assessed and analysed.

Results: The mean systolic and diastolic BP of 500 children aged 3 to 18 years were 102.6 (±10.1) mmHg and 60.0 (±9.0) mmHg. BP levels in higher-than-normal cut-off ranges were recorded in 76 (15.2%) children. A hypertensive BP range was found in 44 (8.8%), while 32 (6.4%) had elevated blood pressure. Elevated BP was significantly higher among subjects with a family history of hypertension (OR = 2.07, 95%CI = 1.01, 4.26; p = 0.04), children who skipped breakfast regularly (OR = 5.9, 95%CI = 1.74, 20.1; p = 0.01), and obese or overweight children (OR = 2.79, 95%CI = 1.43, 5.42; p = 0.002).

Conclusions: Obesity, skipping breakfast, and a family history of hypertension were the identified risk factors for elevated blood pressure. Early screening and lifestyle modifications are essential in controlling hypertension in children.

Keywords: Children, Elevated blood pressure, Hypertension, Obesity, Risk factors.

Introduction

Hypertension in children, although seen less commonly when compared to the adult population, has become a growing concern globally, as its prevalence is on the rise. The prevalence of hypertension varies globally and with age. This prevalence ranges from 1% to 5% worldwide in children, although a significant proportion is usually undiagnosed.[1,2] It is uncommon in infants and young children with a prevalence of < 1%.[3] Reports have shown the prevalence of hypertension in the USA[4] as 4.6%, China[5] 5.8 – 13.75% and Europe[6] 2.2 – 22%. In Africa, the pooled prevalence rate from a meta-analysis was 7.45%,[7] while in Nigeria,[8–12] some documented prevalence of hypertension in children range from 3.0 to 13%.

The risk factors for elevated BP during childhood and adolescence include obesity, a positive family history of hypertension, changes in dietary habits (high sodium intake), sedentary lifestyle, prolonged screen time, air pollution with particulate matter, inhalation of cigarette smoke, either by active or passive smoking, and an increase in stress.[13,14] Primary hypertension is influenced by the age of the child, foetal maturity at birth (low birth weight), heredity and diet. In contrast, secondary hypertension is influenced by diseases such as renal abnormalities, cardiac diseases like coarctation of the aorta, intake of medications that may increase BP and neoplasms.[15] Obesity is the major determinant of hypertension in children.[16] Interestingly, an overweight child has been observed to be three times more likely to develop hypertension when compared to a child with a normal Body Mass Index (BMI).[9,17,18]

A high index of suspicion is, therefore, key to early diagnosis and prompt commencement of appropriate treatment and the reduction of hypertension complications in children, thereby reducing morbidity and mortality. Although studies on hypertension in children have been carried out in Rivers State, Nigeria,[19–21] they were community-based studies. The present study was carried out to ascertain the prevalence of elevated and hypertensive-range BP among children seen at the paediatric outpatient clinic; it also aims to identify the risk factors in these children. The data obtained from this study will add to the body of knowledge on hypertension in children in Nigeria and strengthen the habit of routine BP checks in children and adolescents in the children's clinic, which is presently not the case. It may assist with formulation of policies to prevent hypertension in children and for its early diagnosis and treatment.

Methods

This cross-sectional, prospective study was carried out over four months (01 April 2022 to 30 July 2022) at the Paediatric Outpatient Clinic of the Rivers State University Teaching Hospital, Port Harcourt, Nigeria. The hospital is one of the two referral hospitals in Rivers State, located in south-south Nigeria. Most patients seen in the hospital are urban dwellers who live in Port Harcourt. Ethical approval was obtained from the Rivers State University Teaching Hospital Health Research Ethics Committee (RSUTH/REC/2023349). The minimum sample size was calculated to be 327, but 500 children were enrolled to accommodate a 20% attrition rate.

All children aged between 3 years and 18 years were eligible for enrollment into the study. Those whose parents/guardians gave consent were consecutively recruited till the sample size was reached. An interviewer-administered questionnaire was used to collect data on their age, sex, weight, height, social and family history, dietary history and determine socioeconomic status.[22] Their diet was classified by assessing their adherence to the Mediterranean diet using the KIDMED test tool [23] which was validated by Serra-Majem *et al*. [24] for a Spanish population and had been previously used for nutrition assessment in a Nigerian population. [10] However, the KIMDED test tool was modified to adjust for a Nigerian diet, as shown in Supplementary Table. The KIDMED questionnaire has 16 items, four of which denote a negative connotation and are scored -1, and 8 of which are positive connotation questions with a score of +1. A score of 0-3 reflects poor adherence, 4-7 shows average adherence, and 8-12 reflects good adherence. Information concerning the frequency of physical exercise, exposure to screen time (both television and other screens), and parents' assessment of screen time exposure were also noted. The children's body mass index (BMI) was calculated and expressed in percentiles.

The BP was measured using a Reister aneroid auscultatory sphygmomanometer with appropriately sized cuffs (a cuff that is 80% in

length and at least 40% in width of the patient's arm circumference). The cuff was applied to the right arm, [25] when the study participant sat calm and rested for at least five minutes. The BP reading was repeated thrice at least three minutes apart, and the average of the last two readings was recorded. The mean BP value was documented, and then their blood pressure percentile was calculated and classified as per the AAP Paediatric Hypertension guidelines.[26] The subjects were classified as normal if their SBP or diastolic blood pressure (DBP) were less than the 90th percentile, elevated blood pressure if their SBP or DBP were ≥ 90th to < 95th percentile or 120–129/< 80 mmHg and hypertensive range if their SBP or DSP were ≥ 95th percentile. All those that had hypertensive range BP were further divided into stage 1 if SBP or DSB were ≥ 95th percentile but less than 12 mmHg above 95th percentile, or 130-139/80-89 mmHg or whichever is lower, and stage 2 if SBP or DSB were ≥ 12mmHg above 95th percentile or ≥ 140/90 mmHg or whichever is lower. According to the AAP guidelines, children whose BP were elevated or within the hypertensive range were referred to the paediatric cardiology clinic for further evaluation.

The primary outcome of interest was the presence of hypertensive range BP, while the secondary outcome was the presence of elevated blood pressure and associated risk factors of hypertension. The data were analysed with IBM SPSS, version 23. The distribution of categorical variables was expressed in frequencies and percentages, while the numerical variables were expressed in means and standard deviations (SD). Test for associations was done using analysis of variance (ANOVA) for numerical variance, Chi-squared test, and univariate logistic regression. The results were expressed with a 95% confidence interval, and the level of significance was set at a p-value < 0.05.

Results

Characteristics of the study population

The mean age of the study population was 8.1±3.5 years, and their age ranged from 3 to 18 years. There were more males than females, with a male-to-female ratio of 1.06:1. The majority were from the middle socioeconomic class (379; 75.8%) and had normal body weight (313; 62.6%). Ninety-six (19.2%) of the children were overweight or obese. The prevalence of overweight/obesity was significantly higher in younger children and decreased with increasing age (25.5% in the 3 to < 6 years old compared to 8.9% in the 14 to 18 years old; p = 0.001) as shown in Table I.

Prevalence of hypertensive range BP and elevated blood pressure in the study population

The mean systolic and diastolic blood pressures were 102.6±10.1 mmHg and 60.0±9.0 mmHg, respectively. Blood pressure levels higher than normal cut-off for age, sex and height were observed in 76 (15.2%) children. Of these, 44 (8.8%) were classified as hypertensive range BP, while 32 (6.4%) were classified as elevated BP as shown in Table I.

Relationship between blood pressure categories and sociodemographic characteristics of the study population

When the study population was sub-categorised into children with normal and 'higher-than-normal BP levels, it was found that those with higher-than-normal BP were significantly younger (7.0±3.4 vs 8.3±3.5years, p = 0.003), males (18.2%, p = 0.03) and, belonged to the upper socioeconomic class when compared to low socioeconomic class (17.8% vs 2.1%, p = 0.028). Higher-than-normal BP was also significantly more frequent among children with a BMI percentile > 95th percentile when compared to children with lower BMI percentiles (29.7% vs 18.8%, p = 0.002) as shown in Table I.

Family, social history and lifestyle patterns of the study population

Two hundred and ninety-three (58.9%) children were not exclusively breastfed at birth. None of the children had exposure to maternal smoking.

A family history of hypertension was present in 171 (34.2%) cases.

Table I: Association between sociodemographic and anthropometric parameters and blood pressure subcategories

Variable	Normal BP n = 424 (%)	Higher than normal BP n = 76 (%)	Total (n = 500) (%)	p
Age				
Age years (Mean±SD)	8.3±3.5	7.0±3.4	8.1 ± 3.5	0.003
3 to < 6 years	110 (25.9)	31 (40.8)	141 (28.2)	0.03
6 to < 10 years	163 (38.4)	26 (34.2)	189 (37.8)	
10 to < 14 years	109 (25.7)	16 (21.1)	125 (25.0)	
14 to 18 years	42 (9.9)	3 (3.9)	45 (9.0)	
Gender				
Female	213 (88.0)	29 (12.0)	242 (48.4)	0.034
Male	211 (81.8)	47 (18.2)	258 (51.6)	
Socioeconomic group				
Low socioeconomic class	47 (97.9)	1 (2.1)	48 (9.6)	0.028
Middle socioeconomic class	317 (83.6)	62 (16.4)	379 (75.8)	
Upper socioeconomic class	60 (82.2)	13 (17.8)	73 (14.6)	
Mean blood pressure recordings				
Systolic BP (Mean±SD) mmHg	100±9	115±8	103 (± 10)	0.0001
Diastolic BP (Mean±SD) mmHg	58±8	70±8	60(±9.0)	0.0001
Nutritional status (BMI percentile)				
Underweight (< 5th)	74 (81.3)	17 (18.7)	91 (18.2)	0.002
Healthy weight (5th -85th)	278 (88.8)	35 (11.2)	313 (62.6)	
Overweight (85th - < 95th)	27 (84.4)	5 (15.6)	32 (6.4)	
Obese (≥ 95th)	45 (70.3)	19 (29.7)	64 (12.8)	
BMI percentile (Mean±SD)	44±33	53±39	45±34	0.037
Birthweight	3.5±0.7	3.5±0.65	3.5±0.69	0.463
Low birth weight (<2.5kg)	15 (3.5)	2 (2.6)	17 (3.4)	
Normal (2.5 to 4kg)	215 (50.7)	43 (56.6)	258 (51.6)	
Macrocosmic (> 4kg)	47 (11.1)	11 (14.5)	58 (11.6)	
Cannot recall	147 (34.7)	20 (26.3)	167 (33.4)	

The lifestyle analysis of the study cohort showed that 176 (35.2%) did weekly physical exercise while most (359; 71.8%) watched television daily on weekdays with a daily mean television screen time of 2.59±1.1 hours. Exposure to other screens was reported by 262 (52.4%) of the children; the most popular second screen they were exposed to was a mobile phone in 176 (35.2%), giving them a mean total screen time of 3.38±1.8hours. Most of the parents, (225; 45%), thought the time the children spent in front of the screens was minimal. Only 59 (11.8%) of the children had a good KIDMED diet score. Among the study population, 169 (33.8%) came for a scheduled specialist paediatric clinic consultation, with the majority of the specialist consultations being for infectious diseases (69; 40.8%), neurology (50; 29.2%) and respiratology (31; 18.3%) specialist clinics (Table II).

Table IIa: Comparison of Family and social history, lifestyle patterns of the blood pressure categories

Variable	Normal BP n = 424 (%)	Higher than normal BP n = 76 (%)	Total n = 500 (%)	P
Maternal smoking assessment				
Exposed to Maternal smoking	0(0)	0(0)	0(0)	-
No exposure to maternal smoking	424(84.8)	76(15.2)	500(100)	
Hypertension in family history				
Has a Family history of hypertension	138(80.7)	33(19.3)	171(34.2)	0.045
No Family history of hypertension	286(86.9)	43(13.1)	329(65.8)	
Physical exercise history (per week)				
> 3 days per week *	153(86.9)	23(13.1)	176(35.2)	
1 – 3 days per week	131(86.2)	21(13.8)	152(30.4)	0.84
None	140(140)	32(18.6)	172(34.4)	0.15
Screen-time assessment history				
Watch television daily on weekdays	302(84.1)	57(15.9)	359(71.8)	0.5
Does not Watch television daily on weekdays	122(86.5)	19(13.5)	141(28.2)	
Mean Television screen time (±SD) Hours	2.6±1.1	2.2±1.2	2.59(±1.1)	0.19
TV time >2Hrs in children <10years	138(84.7)	25(15.3)	163	0.35
TV time >2Hrs in children ≥ 10years	94(88.7)	32(19.2)	106	0.93
The mean number of other screen exposures outside of TV	1.16±0.4	1.07±0.25	1.15(0.38)	0.275
Sources of other screen time				
Mobile phone	147(83.5)	29(16.5)	176(35.2)	0.32
Video games	68(89.2)	8(10.5)	74(14.8)	0.25
Computers	37(88.1)	5(11.9)	42(8.4)	0.53
Other screen times, mean (± SD) hours/day	2.07±1.1	1.8±1.3	2.04±1.1	0.36
Total number of screen exposure				
* No other screen	65(87.8)	9(12.2)	74(14.8)	
1 Screen	189(83.4)	37(16.4)	226(45.2)	0.38
2 Screens	149(84.2)	28(15.8))	177(35.4)	0.45
≥ 3 Screens	21(91.3)	2(8.7)	23(4.6)	0.64
Mean total screen time (± SD) hours/day	3.4±1.7	3.1±1.7	3.38± 1.8	0.604
Parents' assessment of screen time				
*Excessive	44(88.0)	6(12.0)	50(10)	
Moderate	190(87.6)	27(12.4)	217(43.7)	0.93
Minimal	182(80.9)	43(19.1)	225(45)	0.23
Unclassified	8(100)	0	8(1.6)	

*** The reference to which others were compared.**

Relationship between higher-than-normal blood pressures and family, social history and lifestyle pattern.

Significantly higher-than-normal BP values were seen in children with a positive family history of hypertension compared to those without (19.3% vs 13.1%, p = 0.045). A higher prevalence of blood pressures that were above the normal cut-off values was seen in those who did not exercise regularly when compared to those who exercised regularly (18.6% vs 13.1%), those who watched TV daily on weekdays when compared to those who did not (15.9% vs 13.5%), children whose parents assessed their screen time as minimal compared to those whose parents felt that their screen time

was excessive (19.1% vs 12.0%) and, children with poor KIDMED diet scores compared to those with good KIDMED diet scores (15.7% vs 11.9%). However, the differences were not statistically significant *P*> 0.05 as shown in Table II.

Table IIb: Comparison of Family and social history, lifestyle patterns of the blood pressure categories

Variable	Normal BP n = 424 (%)	Higher than normal BP n = 76 (%)	Total n = 500 (%)	p
Past Nutritional History				
Exclusively breastfed in infancy	172(83.1)	35(16.9)	207(41.4)	0.21
Not Exclusively breastfed in infancy	252(86.0)	41(14.0)	293(58.9)	
Recent Nutritional History (KIDMED diet Score)				
***Good (8-12)**	52(88.1)	7(11.9)	59(11.8)	0.44
Average/Poor (4 -7)	372(84.1)	69(15.7)	443(88.2)	
Present clinic follow-up History				
Not on specialist clinic follow-up	275(83.1)	56(16.9)	331(66.2)	0.08
On specialist clinic follow-up	149(88.2)	20(11.8)	169(33.8)	
Type of specialist clinic follow-up (n=149)				
Infectious diseases	69(40.8)			
Neurology	50(29.2)			
Respiratory	31(18.3)			
Dermatology	6(3.6)			
Endocrinology	5(3.0)			
Haematology	3(1.8)			
Cardiology	3(1.8)			
Nephrology	2(1.2)			

*** The reference to which others were compared.**

Types of hypertensive range BP.

The mean systolic BP was 102.6±10.1) mmHg. High systolic blood pressure was recorded in 59 (11.8%), with 32 (6.4%) in the systolic hypertensive range, most of whom had stage 1 systolic hypertension (23; 4.6%). The mean diastolic blood pressure was 60.0±9.0 mmHg, and diastolic hypertensive range BP was recorded in 25 (5%) of the cases, with stage 1 diastolic hypertension being more prevalent 16 (3.2%) as shown in Table III.

Factors associated with hypertensive range BP in children

Table IV shows the relationship between BP and risk factors associated with hypertensive range BP. The prevalence of elevated blood pressure was significantly higher in those with a family history of hypertension (OR = 2.07, 95%CI = 1.01, 4.26; p = 0.04) and among children who skipped breakfast regularly (OR = 5.9, 95%CI = 1.74, 20.1; p = 0.01) while a low socioeconomic status significantly decreased the likelihood of having elevated BP (p = 0.04). The prevalence of hypertensive range BP was significantly higher among younger children aged 3-6yrs when compared to older children (OR = 3.12, 95%C = 1.66, 5.87; p = 0.001) and also more among obese or overweight children (OR = 2.79, 95%CI = 1.43, 5.42; p = 0.002). Although more children with daily screen time of greater than two hours had a higher prevalence of elevated blood pressure compared to those with fewer daily screen time hours (8.3% Vs 5.4%), though the difference was not statistically significant. In contrast, children with a screen time of greater than two hours daily significantly had a lower prevalence

of hypertensive range BP (OR = 0.47, 95% CI = 0.24, 0.89; p = 0.02), while children whose parents subjectively assessed their children's screen time to be minimal had a higher prevalence of hypertensive range BP (13.3% vs 2.4%, p = 0.06).

Table III: Types of hypertensive range BP in the study population

Variable	All patients (n= 500) (%)
Systolic blood pressure (Mean ± SD) mmHg	102.6 (± 10.1)
Classification of systolic blood pressure	
Normal systolic BP	441 (88.2)
Elevated systolic blood pressure	27 (5.4)
Hypertensive range	32 (6.4)
Stage 1 hypertensive BP range	23 (4.6)
Stage 2 hypertensive BP range	9 (1.8)
Diastolic blood pressure (Mean ± SD) mmHg	60.0(±9.0)
Normal diastolic BP	460 (92)
Elevated diastolic BP	15 (3.0)
Diastolic hypertension	25 (5.0)
Stage 1 diastolic hypertensive BP range	16 (3.2)
Stage 2 diastolic hypertensive BP range	9 (1.8)

Table IVa: Factors associated with hypertensive range BP in children

	Ref	**Elevated blood pressure**			**Hypertensive range BP**		
Variable	Normal BP	Elevated BP((%)	Odds ratio (95% CI)	*P*	HTN BP 44(%)	Odds ratio (95% CI)	*P*
3-6 years	110	8(6.8)	0.95 (0.41, 2.18)	0.9	23(17.3)	3.12 (1.66, 5.87)	0.001*
> 6 years	314	24(7.1)			21(6.3)		
<10 years	273	22(7.5)	1.21 (0.56, 2.63)	0.62	35(11.3)	2.15 1.06, 4.56	0.04*
≥ 10 years	151	10(6.2)			9(5.6)		
Female	213	11(4.9)	0.51 (0.24, 1.01)	0.08	18(7.8)	0.68 (0.36, 1.28)	0.23
Male	211	21(9.1)			26(10.9)		
BMI > 85 percentile	72	8(10.0)	5.6 (0.7, 3.7)	0.25	16(18.2)	2.79 (1.43, 5.42)	0.002*
BMI < 85 percentile	352	24(6.4)			28(7.4)		
Exclusive Breastfed (in 3-6yrs old)	48	2(4.0)	0.3 (0.08, 2.22)	0.34	13(21.3)	1.67 (0.67, 4.15	0.25
No EBM (in 3-6yr old)	62	6(8.8)			10(13.9)		

Table IVb: Factors associated with hypertensive range BP in children

	Ref	Elevated blood pressure			Hypertensive range BP		
Birth weight < 2.5kg	15	0(0)	-	0.26	2(11.8)	1.14 (0.24, 5.3)	0.86
Birth weight ≥ 2.5kg	215	18(7.7)			25(10.4)		
Birth weight > 4kg	47	4(7.8)	1.01 (0.32, 3.14)	0.97	7(13.0)	1.28 0.52, 3.13	0.58
Birth weight < 4kg	215	18(7.7)			25(10.4)		
Family Hx of Hypertension	138	16(10.4)	2.07 (1.01, 4.26)	0.04*	17(11.0)	1.3 (0.68, 2.47)	0.41
Nil Family Hx of HTN	286	16(5.3)			27(8.6)		
Low SEC	47	0(0)	-	0.04*	1(2.8)	0.18	0.06
Middle/Upper SEC	377	32(7.8)	-		43(10.2)	(0.02, 1.38)	
Exercise >3days/wk	153	8(5)	0.59	0.20	15(8.9)	0.98	0.96
Exercise <3days/wk	271	24(8.4)	(0.25, 1.34)		29(9.1)	(0.50, 1.96)	
Watch TV daily	302	22(6.8)	0.88	0.76	35(10.4)	1.57	0.24
No daily TV	271	24(8.1)	(0.41, 1.92)		9(6.8)	(0.73, 3.3)	
≥ 1 Screen	170	13(7.1)	1.02	0.95	17(9.1)	0.94	0.85
< 1 Screen	254	19(6.9)	(0.49, 2.12)		27(9.6)	(0.49, 1.77)	
Screen time >2hours daily	232	21(8.3)	1.57 (0.74, 3.35)	0.23	16(6.4)	0.47 (0.24, 0.89)	0.02*
Screen time < 2hours daily	192	11(5.4)			28(12.7)		
Parents' screen time assessment: Minimal	182	15(7.6)	0.9 (0.28, 2.8)	0.413	28(13.3)	3.3 (0.77, 14.7)	0.06
Parents' screen time assessment: excessive	44	4(8.3)			2(2.4)		
Skip breakfast	10	4(28.6)	5.9	0.01*	0(0)	-	0.303
Do not Skip breakfast	414	28(6.3)	1.74, 20.1)		44(9.6)		
KIDMED ≤ 3	119	10(7.7)	1.16	0.69	7(5.6)	0.48	0.08
KIDMED > 3	305	22(6.7)	(0.53, 2.5)		37(10.8)	(0.21, 1.12)	
Specialist follow up	149	8(5.1)	0.61	0.24	12(7.4)	0.69	0.29
General Clinic visit	275	24(8.0)	(0.26, 1.4)		32(10.4)	(0.34, 1.38)	

Discussion

This study aimed to determine the prevalence of elevated blood pressure and hypertensive range BP, including its risk factors, among children and adolescents attending a tertiary hospital's general and specialist outpatient clinic. This study found that 15.2% of the children had higher-than-normal blood pressure; of these, 8.8% had hypertensive range BP. This finding is within the pooled 95% confidence interval prevalence rate of hypertension in children in Africa between 5.5% and 9.92%.[7] It is also similar to earlier studies in Nigeria, which reported prevalence rates between 9.5% and 9.8% [27, 28] among primary school pupils. However, some studies from different parts of Nigeria also reported lower prevalence rates of 0.5% - 3.5% among school children.[8,9,29] A higher rate of hypertension was reported among Nigerian adolescents, 13% and 12.9%, in southwest and northcentral Nigeria, respectively.[11,12]

The variations in the prevalence could be attributed to the different criteria used to define hypertension, the methods used to measure blood pressure, the frequency of BP measurements and the differences in the age range of children studied. When compared to the findings from previous studies conducted in the same city, the reported prevalence was between 3.2% and 4.6% [20,30] over a decade ago

but appeared to have remained relatively constant at 4.1% in 2014 [21] and 4.4% in 2021.[19] This present study, however, found a higher prevalence. A possible reason for the higher prevalence reported in this work compared to previous studies conducted in Port Harcourt is the hospital-based design, whereas all the earlier studies were community-based. This is because children who come to the hospital are likely to have an underlying pathology that could affect their blood pressure. Also, the timing of blood pressure measurement could be contributory. The present study was conducted among children who presented to the hospital for the first time or for a follow-up visit with the effects of 'stressful' waiting hours or anxiety associated with taking the blood pressure measurement as two-thirds (66%) of the study population were below 10 years of age.

Nonetheless, this study highlights the need for early screening and detection of elevated BP among children attending routine outpatient paediatric clinics in Nigeria. This is further buttressed by the fact that although our reported point estimate was within the crude prevalence of hypertension which ranged from 0.1% [95% CI: 0.1% - 0.3%] to 17.5% [95% CI: 13.6% - 21.4%] in Nigerian children in an earlier systematic review,[31] it was higher than the pooled prevalence of 5.1% [95% CI: 2.9% - 8.6%] for hypertension reported among children and adolescents in Nigeria in a more recent systematic review.[32] This study demonstrated a 6.4% prevalence of elevated blood pressure. Our finding was higher than previous studies conducted in Port Harcourt, which reported the prevalence of elevated blood pressure to range from 4.4 to 4.6%.[19,20,30] The differences observed in the prevalence of elevated blood pressure could partly be explained by the fact that studies varied in the proportions of children and adolescents who were either overweight or obese. Our findings are, however, lower than the pooled prevalence rate of elevated blood pressure (11·38%) in children and adolescents in Africa.[7] The prevalence of elevated blood pressure reported here is concerning. This is because childhood and adolescent elevated blood pressure is a powerful predictor of hypertension in adulthood with adverse cardiovascular outcomes, and development from elevated blood pressure to hypertension has been found to progress faster and at a younger age in people of African descent compared to Caucasians.[33] It is, therefore, critical to measure the blood pressure of Nigerian children and adolescents to identify cases early, especially when in the elevated BP phase. This is to enable prompt initiation of timely interventions to avert the progression to established hypertension.

Another significant finding in this study is the higher prevalence of both hypertensive range BP and elevated blood pressure of 40.8% and 32.8%, among children within the 3 to < 6 years and 6 to < 10 years categories, respectively. This is an unusual finding but is plausibly explained by the fact that in this study, a greater proportion (25.5%) of the children within the 3 to < 6-year age group also had higher BMI percentiles (were overweight/obese) compared to those in the older age groups. This finding is similar to the report in a study conducted among 1000 children attending paediatric outpatient clinics in a tertiary facility in Karachi, Pakistan, [34] where children aged between 4 to 7 years were found to have a higher prevalence of hypertension and prehypertension (35.0%) compared to their older counterparts. The authors attributed it to increased BMI after the initial decline in weight that occurs in the first year of life, which could lead to higher blood pressure in a child with a genetic predisposition. Comparably, an earlier study conducted in Port Harcourt, Rivers State, among 710 nursery school children found that overweight and obesity were prevalent primarily among the two-year-olds, and a significant positive linear relationship existed between systolic and diastolic blood pressures and BMI.[36] In that study, it was reported that the obese toddlers, which comprised a quarter (25%) of the study cohort, had significantly higher blood pressure. Other studies have also demonstrated that

atherosclerosis is seen even in children as early as two years of age and is strongly linked to elevated systolic and diastolic blood pressures, elevated BMI and dyslipidaemia, which are known CVS risk factors.[37]

Furthermore, there is increasing evidence that, in addition to genetic predisposition, certain environmental factors, like nutrition and the level of physical activity in early life, predict later health.[14,38] The early adiposity rebound recorded in most obese children, especially between ages 5 and 7, suggests that factors promoting body fat development have already been in operation in the first years of life.[39] Thus, beyond birth weight and growth velocity, children's body mass index (BMI) trajectories, especially within their first 1000 days, have been demonstrated to be very sensitive to environmental conditions present in early childhood, which are drivers for hypertension and cardiovascular diseases.[16,40] The present study brought to the fore the fact that apart from having a family history of hypertension as a possible genetic predictor of elevated blood pressure in the children in our series, improper nutrition or dietary intake, including improper time scheduling of meals and being overweight/ obese and maintaining a sedentary lifestyle as evidenced by reduced physical activity and increased screen time were risk factors for high BP.

Concerning nutrition, this study uncovered that only 1 in 10 children had a good KIDMED diet score, which is reflective of the poor meal quality received at home. This is also predictable given that the typical Nigerian diet includes an increased amount of highly processed, high-energy, high-sugar, and high-fat foods, as well as a notable surge in the prevalence of overweight, obesity, and non-communicable diseases caused by improper nutrition in Nigeria.[41,42] Likewise, children in this part of the world are faced with the double burden of malnutrition: overnutrition and undernutrition, which are well documented in the existing literature to be independent drivers of hypertension, cardiovascular disease and mortality.[43] Our study findings showed that children with a good KIDMED diet score had a lower prevalence of BP elevated above the cut-off value (11.9%) when compared to those with either an average or poor KIDMED diet score (15.7%), although the association lacked statistical significance. These data suggest a protective effect of balanced nutrition.

Additionally, it was found that skipping breakfast was a recurring issue among the children sampled and was worrisome. This could be because most children are sent off to begin formal education at younger ages nowadays, and the need for working-class parents to arrive at work on time has caused a hike in the use of processed foods, snacks or drinks and skipping of meals. Though unintentional, this has become a trend. Skipping breakfast has also been proposed to cause lower satiety during the day, resulting in subsequent overeating and obesity.[44] We found that children who skipped breakfast regularly had 5.9 times increased odds of having BP levels higher than the normal cut-off values. A possible mechanism through which skipping breakfast causes elevated BP includes its effect in causing higher insulin stimulus of hydroxyl methyl glutaryl Co-A (HMG-CoA) reductase, which induces higher low-density lipoprotein cholesterol levels and, thereafter, atherosclerosis.[45] Our findings are consistent with a systematic review[46,47] which found an association between breakfast skipping and cardiometabolic risk factors, including hypertension, among children aged 10 – 19 years. Our study also highlights the importance of providing good nutrient-rich diets without skipping breakfast but adapted to every stage of childhood. It also indicates, however, that good nutrition alone is less likely to be the only rate-limiting factor implicated in reducing the likelihood of having elevated blood pressures in children and adolescents since blood pressure levels above the normal cut-off values were still observed among children with a good KIDMED diet score, albeit, to a lesser extent,

and is consistent with reports from other studies in Europe.[38]

The lifestyle analysis of the study cohort revealed a tendency towards adopting sedentary lifestyles. While only about a third (35.2%) reportedly engaged in weekly physical exercise, almost three-quarters (71.8%) watched television (TV) every day on weekdays. Even so, about a third were also exposed to mobile phones, making, on average, about three hours of screen time. Unsurprisingly, we found that children who did not exercise regularly had a higher prevalence of BP above the normal cut-off values than those who did. Similar observations were noted among children who watched TV daily on weekdays compared to those who did not. Our finding is similar to what Stabouli and colleagues[48] reported in a cohort of hospitalised children in Greece, where the hypertensive children reported significantly higher daily and weekly screen time levels compared to normotensive children. Further, obese children with hypertension were observed to have the highest mean weekly screen time levels. Moreover, the present study shows that children whose parents assessed their screen time as minimal had a higher prevalence of elevated BP above the normal cutoff values when compared to children whose parents felt that their screen time was excessive. Ironically, increased screen time exposure appeared to be a protective factor, probably because parents (unaware of their children's blood pressure status or cumulative sedentary lifestyle) reported screen times more than two hours per day every week as appropriate behaviour. This is why most of their parents thought that the time the children spent in front of the screens was minimal – meaning they were unlikely to reduce this inappropriate sedentary behaviour. Nevertheless, the association between screen time and elevated BP in children remains debated in existing literature. Whereas some cross-sectional studies [49] have found a relationship between screen time and elevated blood pressure, temporal associations are yet to be convincingly demonstrated.

Contrary to what has been previously documented in the literature regarding socioeconomic status (SEC) and the prevalence of elevated BP in children, we found that being in the low SEC significantly decreased the likelihood of elevated BP. This is possible because the majority of the cohort of children in this study were from more affluent homes, and that could also be the underlying reason for the interplay between increased BMI percentiles and hypertension in this study – arising from a background of genetic predisposition, malnutrition and sedentary lifestyles. Hence, in our setting, when children from high SEC or affluent homes engage in physical inactivity, increased daily screen time and improper nutrition (more calories and fewer vegetables or fibre diets), these result in an interaction that may have a synergistic effect that subtly drives cardiometabolic risks in children in our setting.

In addition, among the study population with blood pressure above the normal cut-off values, this study found that about 5.1 - 7.4% came for a scheduled specialist paediatric clinic consultation, and 8.0 - 10.4% were seen in the Paediatric Outpatient Clinic, meaning that on the average, as high as 1 in 10 children visiting either the consultant specialist or paediatric outpatient clinics had elevated BP for their age, sex and height. This goes on to buttress the implications of this study, which is to emphasise routine BP measurement to identify children and adolescents attending paediatric clinics who have elevated BP at each visit and to promptly assess them for the risk factors of hypertension. It is essential to note the skewed distribution of patients in all specialist clinics, with only the infectious disease, neurology and respiratology clinics having >30 sample population, while the rest had <10 patients. These findings are limited in estimating the prevalence of hypertension in the less represented specialist clinics.

Limitations of the study

Although this study achieved the intended aim to determine the point prevalence and associated risk factors of elevated BP levels and hypertensive range BP among children and adolescents, it should be noted that the BP values in this study were a single-point cross-sectional measurement. Therefore, these children would require further evaluation and follow up to confirm the persistence of recorded BP values and diagnosis of hypertension according to the AAP guidelines. Furthermore, some recall bias could not have been avoided as parents had to recall their children's past lifestyle events and dietary history. Larger multicentre studies are recommended to explore the generalisability of the observed risk factors in our study.

Conclusion

This study observed a higher prevalence of elevated BP and hypertensive range BP among children attending the general and specialist clinics. Significant risk factors for hypertensive range BP and elevated BP include age less than 10 years, a high BMI percentile (> 85%), a family history of hypertension, and skipping breakfast. Routine assessment of BP is important, from as early as three years of age, in preventing and improving the management of hypertension.

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Supplementary Table: Modified KIDMED Nigeria diet

	KIDMED Mediterranean	Score	Modified KIDMED Nigeria
1	Takes a fruit every day	+1	Takes a fruit every day
2	Has a second fruit every day	+1	Has a second fruit every day
3	Has fresh or cooked vegetables regularly once per day	+1	Has fresh or cooked vegetables /Nigerian soups regularly
4	Has fresh or cooked vegetables more than once per day	+1	Has home-cooked meals more than once per day
5	‘Consumes fish regularly (at least 2-3 times per week)	+1	‘Consumes fish regularly (at least 2-3 times per week)

6	Goes to a fast-food (hamburger) restaurant more than once per week	-1	Goes to a fast-food (doughnuts, meat pie, puff, hamburger, commercial sausage roll) restaurant more than once per week
7	Likes pulses and eats them more than once per week	+1	Eats pulses like beans, and lentils at least once per week
8	'Consumes whole-grain pasta or whole-grain rice almost every day (5 or more times per week)	+1	Consumes Rice, Yam, or Plantain at least 4 or more times per week)
9	Has whole cereals or whole grains (whole-meal bread, etc.) for breakfast	+1	Has whole cereals or whole grains (whole-meal bread, etc.) for breakfast
10	Consumes nuts regularly (at least 2-3 times per week)	+1	Consumes nuts regularly (at least 2 times per week)
11	Uses olive oil at home	+1	Uses healthy cholesterol-free oil at home
12	Skips breakfast	-1	Skips breakfast
13	Has a dairy product for breakfast (yogurt, milk, etc.)	+1	Has a dairy product for breakfast (yogurt, milk)
14	Has commercially baked goods or pastries for breakfast	-1	Unfortified noodles or plain Pap in the diet
15	'Takes two yogurts and/or some cheese (40 g) daily	+1	Has eggs at least twice weekly
16	Takes sweets and candy several times every day	-1	Takes sweets and candy at least daily
	KIDMED Mediterranean	Score	Modified KIDMED Nigeria
1	Takes a fruit every day	+1	Takes a fruit every day
2	Has a second fruit every day	+1	Has a second fruit every day
3	Has fresh or cooked vegetables regularly once per day	+1	Has fresh or cooked vegetables /Nigerian soups regularly
4	Has fresh or cooked vegetables more than once per day	+1	Has home-cooked meals more than once per day
5	'Consumes fish regularly (at least 2-3 times per week)	+1	'Consumes fish regularly (at least 2-3 times per week)
6	Goes to a fast-food (hamburger) restaurant more than once per week	-1	Goes to a fast-food (doughnuts, meat pie, puff, hamburger, commercial sausage roll) restaurant more than once per week
7	Likes pulses and eats them more than once per week	+1	Eats pulses like beans, and lentils at least once per week
8	'Consumes whole-grain pasta or whole-grain rice almost every day (5 or more times per week)	+1	Consumes Rice, Yam, or Plantain at least 4 or more times per week)
9	Has whole cereals or whole grains (whole-meal bread, etc.) for breakfast	+1	Has whole cereals or whole grains (whole-meal bread, etc.) for breakfast
10	Consumes nuts regularly (at least 2-3 times per week)	+1	Consumes nuts regularly (at least 2 times per week)
11	Uses olive oil at home	+1	Uses healthy cholesterol-free oil at home
12	Skips breakfast	-1	Skips breakfast
13	Has a dairy product for breakfast (yogurt, milk, etc.)	+1	Has a dairy product for breakfast (yogurt, milk)
14	Has commercially baked goods or pastries for breakfast	-1	Unfortified noodles or plain Pap in the diet
15	'Takes two yogurts and/or some cheese (40 g) daily	+1	Has eggs at least twice weekly
16	Takes sweets and candy several times every day	-1	Takes sweets and candy at least daily

0-3: Poor score; 4-7: Average score, 8-12: Good score.