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Assessment Of The Nutritional Status Of School-Aged Children (6–59 Months Old) In Abia State, Nigeria

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Abstract
The nutritional status of school-aged children in Abia State was investigated. A sample of 450 school children was included in the study. The analysis of the anthropometric data was carried out via the WHO Anthro-software. The anthropometric results revealed that 7.6%, 20.8%, 4.4% and 1.10 % were underweight, stunted, wasting and overweight respectively. The proximate composition results of the children's ready-to-eat food showed that fried plantain had the lowest moisture content of 40.1%, and pap/maize gruel (Akamu) had the highest value of 84.6%. Similarly, the carbohydrate content was lowest in steamed bambara paste (Okpa) (11.7%) and highest in fried plantain (50.3%), whereas the protein content was highest in steamed bambara paste (14.8%) and lowest in fried potatoes (0.91%). Bean cake (Akara) contained fat (14.5%), and pap/maize gruel contained the least fat (0.27%). The ash content of the ready-to-eat foods for children was highest for rice with tomatoes (5.6%) and lowest for maize gruel (Agidi 0.6%). The energy content of the different foods ranged from 242.96 KJ in pap/maize gruel to 1084.9 KJ in bean cake. The serum micronutrient levels were magnesium (1.6mg/dl), zinc (10.39 µg/l), calcium (4.77 mg/dl) and phosphorus (4.25 mg/dl), while the serum albumin level was 3.8 mg/L, and the C-reactive protein level was 5.40 mg/L. The prevalence rates of albumin, zinc, magnesium and phosphorus deficiency were 8.4%, 11.8%, 7.8% and 9.1%, respectively. There was a positive correlation between albuminemia and underweight status and between albuminemia and wasting status (P<0.05). However, the major nutritional problem in this study was stunting.

Keywords: *Malnutrition, underweight, wasting, stunting, obesity, school children, micronutrients*

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I. Introduction

The demand for sustainable food production is increasing in response to rising global needs, particularly in countries facing problems of hunger, poverty, inadequate food intake and malnutrition, especially in Africa [1,2,3]. In Nigeria, despite various food sources, there is often a lack of quantity and quality, resulting in poor nutrition, as manifested in various anthropometric nutritional indicators of the population. Today, malnutrition is one of the greatest challenges facing developing countries, including Nigeria with children being the most affected[5]. This is because the nutrition of preschool children requires much attention, as they are in a formative stage of life where they are growing rapidly and have relatively high nutritional requirements [6,7]. Adequate nutrition plays a critical role in ensuring children's survival, promoting their healthy growth and development, and enabling better cognitive and economic progress.

It also effectively reduces child morbidity and mortality rates and the likelihood of chronic diseases. Child growth assessment serves as a universal measure to evaluate the adequacy of nutrition, health and development of individual children while providing an assessment of the overall nutritional status and health of populations [8]. The World Food Programme estimates that 135 million people worldwide suffer from acute hunger, mainly due to climatic changes, war, conflict and economic meltdown [9].

This number of people at risk of hunger may have doubled due to the effects of COVID-19 and the Russian–Ukrainian war. According to the World Health Organization, approximately 54% of global child mortality is due to malnutrition. Malnutrition includes both undernutrition and overnutrition. Undernutrition occurs when food intake is inadequate or insufficient, leading to adverse effects on growth and development [10, 11]. On the other hand, overnutrition is defined as a body mass index (BMI) for individuals who exceeds +1 Z score for age [12].

Adequate assessment of growth and nutritional status by measuring weight, height, head circumference, body mass index, skinfold thickness and mid-upper arm circumference is critical for detecting growth deficiencies (undernutrition) or excessive growth due to overnutrition [13]. A nutrition survey conducted by the National Bureau of Statistics in Nigeria in 2018 revealed a significant prevalence of underweight (39.8%), stunted (64%), wasting (18.77%) and overweight (1.2%) in children aged 0–59 months at the national level. These indicators were found in all states, with the burden being highest in the Northern states. The aim of this study was to determine the prevalence of malnutrition and its causes among preschool children in Abia State, Nigeria, to develop a targeted nutrition intervention programme.

II. Materials And Methods

Study area

The study was conducted in Abia State, which is one of the Southeast states of Nigeria. The state was created in 1991 with Umuahia as the capital. It has a total population of approximately 2,833,999 according to the 2006 census figure. The climate in this state is characterized by a prolonged rainy season with a limited dry season. Several foods are produced in the state, as the inhabitants are mostly farmer Agriculturists.

Study population

The research sample consisted of school-aged children (aged 6-59 months) from Abia State, Nigeria. Four hundred and fifty (450) school-aged children were chosen for the study from the three zones of the state. Only healthy children were included in the study, while those who were ill or displayed symptoms of illness were excluded.

Sample size

The size of the sample was determined via the formula described by Ake-Tano et al. (2011):

$N= e^2pq/i^2$

P = percentage of national preschool children with malnutrition

Q= 1 – p

e = Probability that a sample will fill within a certain distribution (1,96)

i = 5% confidence interval

The minimum sample size obtained by this formula, which allows a reliable result, was 450 children.

Ethical approval

Prior to data collection, the university (ABSU) Ethics Committee granted approval for this study, ensuring adherence to ethical guidelines. Additionally, we engaged with the relevant authorities in various village/hospital/school settings, informing them about the objectives of our study and seeking their consent, support, and assistance. Importantly, only children whose parents provided consent were included in this study.

Data collection

The study is descriptive, analytical and cross-sectional. Three categories of data were needed: anthropometric measurements, which were collected through a pretested structured questionnaire; and food samples (ready to eat food) for proximate analyses, which were collected from the school children. The food samples were collected in triplicate via a multistage random sampling method, placed in plastic boxes and transported in insulated containers with ice parks to the laboratory for proximate analyses. Venous blood samples were collected from the children (whose parents signed consent forms) by the nurses recruited for this study. After blood collection, the blood was introduced into dry labelled tubes and transported in an insulated container with ice to the laboratory for biochemical analyses.

Anthropometric data

Weight was assessed via an electronic scale (Hanson model), with each child's weight recorded to the nearest 0.1 kg. The children were weighed while standing upright in minimal clothing and without shoes. Prior to each use, the scale underwent daily calibration using a known weight to guarantee accuracy. Height measurements were taken via a 120 cm meter ruler, with each child measured while standing barefoot. Information regarding the child's birth weight and age was gathered from school records.

Proximate analysis

The proximate compositions of the collected ready-to-eat food (moisture, ash, crude lipid, nitrogen, crude fibre and carbohydrate contents) were determined according to the recommended methods of the Association of Official Analytical Chemists (AOAC) (1990).

Biochemical analysis

The following biochemical parameters were measured: the levels of albumin, C-reactive protein, zinc, phosphorus, magnesium and calcium were spectrophotometrically determined via standard ready-to-use kits from Randox Laboratory Ltd., Co. Antrim, United Kingdom.

Blood analysis

School children whose parents consented to be part of the research were recruited, and 2–4 ml nonfasting venous blood samples were taken by the certified nurses recruited for this study. Venous blood was drawn into sterile noncontaminated tubes. All the tubes were kept in dark cool boxes (00–40°C) and transported to the laboratory for analysis. The collected blood samples were centrifuged (Sigma, Laborzentrifuger, Germany) at a speed of 3600 rev/min for 10 minutes. The obtained serum was used for determining the serum Zn, Ca, Mg, P, albumin and C-reactive protein contents.

Exclusivity criteria

Children with edema, children 0–5 months of age, and those above 59 months of age, including those whose parents did not give signed consent letters, were excluded from the study.

Statistical analysis

The anthropometric indices and cut-offs based on the WHO normalized reference table of weight-for-age, weight-for-height and height-for-age and the mean Z score were used to assess the degree of malnourishment. The WHO Anthro-Software Package (version 3.2.2) released in January 2011 was used to analyse the anthropometric data collected. Data collected from proximate compositions were subjected to statistical analysis via Fischer's exact test, and differences in means were separated via least significant difference (LSD), while Pearson correlation was used to determine the relationship between body mass index (BMI) and nutrient intake and to compare the values of different parameters. The energy values of the food were calculated via Atwater factors of 4, 4 and 9 kcal for protein, carbohydrate and fat, respectively. The results are presented as the means ± standard deviations, and differences were considered significant at $p<0.05$.

III. Results

Table 1 shows the results of the overall mean level of anthropometrics of the study participants as well as those at different zones under consideration. The results revealed that the overall mean age, height, weight and BMI were 28.53 months, 75.13 cm, 12.19 kg and 23.63 kg/m^{2,} respectively. The analyses further revealed that there was no significant ($p>0.05$) difference in the anthropometrics of the study participants among the three zones under consideration.

Table 1: Measurements of age, height, weight and BMI of the study participants

Variables	Overall Mean(SD)	Zone Mean(SD)			F value	p value
		Abia North	Abia South	Abia Central		
Age (months)	28.53(16.21)	30.03(16.28)[a]	28.42(15.79)[a]	27.14(16.52)[a]	1.204	0.301
Height (cm)	75.13(17.35)	76.56(17.36)[a]	72.91(17.28)[a]	75.92(17.30)[a]	1.902	0.150
Weight (kg)	12.19(3.79)	12.62(3.81)[a]	12.12(3.47)[a]	11.82(4.05)[a]	1.710	0.182
BMI (kg/m^2)	23.63(12.58)	23.63(13.06)[a]	25.22(12.30)[a]	22.04(12.25)[a]	2.406	0.091

Means along rows with different alphabetical superscripts indicate significant (p<0.05) differences.

Table 2 shows the frequency and percentage distributions of the nutritional status (using weight-for-age, height-for-age and BMI-for-age) of the study participants across the zones under consideration. Analysis of the dependence of the zones on the status was also conducted via chi-square or Fisher's exact tests where the chi-square assumption was not met. The prevalence of weight-for-age underweight was 12% (4.4% for severely underweight individuals and 7.6% for underweight individuals), and the prevalence of obesity was 2.7%. With respect to height-for-age, the prevalence of stunting was 20.8% (2.5% for severe stunting and 18.3% for moderate stunting).

Table 2: Nutritional status of the study participants in the study area

Nutritional Status	Overall n(%)	Zone n(%)			Chi-square	p value
		Abia North	Abia South	Abia Central		
Weight-for-Age						
Severely Underweight	20(4.4)	5(3.3)	6(4.0)	9(6.0)	*2.079	0.927
Moderately Underweight	34(7.6)	11(7.3)	11(7.3)	12(8.0)		
Normal	384(85.3)	130(86.7)	130(86.7)	124(82.7)		

Obese	12(2.7)	4(2.7)	3(2.0)	5(3.3)		
Height-for-Age						
Severely Stunting	11(2.5)	4(2.7)	3(2.0)	4(2.7)	*4.433	0.623
Moderately Stunting	81(18.3)	28(19.0)	22(14.9)	31(20.9)		
Normal	129(29.1)	45(30.6)	39(26.4)	45(30.4)		
Tall	222(50.1)	70(47.6)	84(56.8)	68(45.9)		
Weight for height						
Wasting	18 (4.1)	3 (2.0)	6 (4.1)	9 (6.1)	11.379	0.099
Normal	408 (90.7)	138(92.0)	131(87.3)	130(86.7)		
Risk of overweight	15 (3.8)	5 (3.3)	7 (4.7)	4 (2.7)		
Overweight	5 (1.1)	3 2.0)	4 (2.7)	6 (4.0)		
Obese	4 (0.9)	1 (0.7)	2 (1.3)	1 (0.7)		

*=Fisher's exact test.

The prevalence of wasting was 4.1% for the BMI-for-age group and 0.9% for the obese group.

The results revealed that there was no significant (p>0.05) association between nutritional status and zone; i.e., nutritional status did not differ among the zones. The same prevalence of malnutrition is observed in all three zones. The results revealed that the 37–42 month age group had the highest prevalence of underweight (22%), followed by the 50–59 month age group (18.5%). The 43–49-month-old group had the highest prevalence of stunting (37.0%), followed by the 24–36-month-old group (25.5%). The 50–59 month age group had the highest prevalence of wasting (11.5%), followed by the 43–49 year age group (11.1%), whereas the lowest prevalence of wasting was observed among the 6–12, 13–23 and 24–36 month age groups (0%).

Table 3: Analysis of differences in nutritional status among age groups

Nutritional status	Age Group (months) n(%)							
	6-12 (n=118)	13-23 (n=46)	24-36 (n=161)	37-42 (n=17)	43-49 (n=54)	50-59 (n=54)	Fisher's exact	p value
Weight-for-age								
Severely Underweight	0(0.0)	0(0.0)	0(0.0)	20(16.9)	0(0.0)	0(0.0)	183.442	<0.001
Moderately Underweight	0(0.0)	0(0.0)	10(6.2)	6(5.1)	8(14.8)	10(18.5)		
Normal	17(100)	34(73.9)	151(93.8)	92(78.0)	46(85.2)	44(81.5)		
Obese	0(0.0)	12(26.1)	0(0.0)	0(0.0)	0(0.0)	0(0.0)		
Height-for-Age								
Severely Stunting	0(0.0)	6(13.0)	0(0.0)	5(4.4)	0(0.0)	0(0.0)	132.814	<0.001
Moderately Stunting	0(0.0)	6(13.0)	41(25.5)	0(0.0)	20(37.0)	5(9.6)		
Normal	9(52.9)	18(39.1)	30(18.6)	31(27.4)	17(31.5)	33(63.5)		
Tall	8(47.1)	16(34.8)	90(55.9)	77(68.1)	17(31.5)	14(25.9)		
BMI-for-Age								
Wasting	0(0.0)	0(0.0)	0(0.0)	6(5.3)	6(11.1)	6(11.5)	83.365	<0.001
Normal	13(76.5)	33(71.7)	127(78.9)	78(66.1)	32(59.3)	30(55.6)		
Risk of overweight	4(23.5)	4(23.5)	29(18.0)	22(19.5)	11(20.3)	8(14.8)		
Overweight	0(0.0)	0(0.0)	4(2.5)	10(8.5)	4(7.4)	10(18.5)		
Obese	0(0.0)	0.(0.0)	1(0.6)	2(1.7)	1(1.9)	0(0.0)		

n=frequency, %=percent, p<0.05 indicates significance.

Table 4 below shows the list of some commonly consumed foods in Abia State with their local and scientific names.

Table 4: List of some foods commonly consumed by preschool children in Abia State

S/N	Local name	Common name	Scientific name
1.	Osikapa na ofe	Rice and tomato stew	*Oryzasativa and Persicuum esculenta*
2	Osikapa agworoagwo	Jollof rice	*Oryza sativa*
3	Osikapa na agwa agworoagwo	Jollof rice and beans	*Oryyza sativa and Vigna spp*

4	Okpa	Steamed bambara paste	*Vigna subterranean*
5	Agidi	Maize meal	*Zea mays*
6	Une eghereghe	Fried plantain	*Musa pradisaca*
7	Ji agworoagwo	Yam mixed with vegetables	*Dioscorea esculenta and Telfairia occidentalis*
8	Ji na ofe	Boiled yam and tomato stew	*Dioscorea esculenta and Persicuum esculenta*
9	Ji eghereghe	Fried yam	*Dioscorea esculenta*
10	Jinwanunu eghereghe	Fried potatoes	*Ipomea batatas*
11	Akamu	Pap/maize gruel	*Zea mays*
12	Akidi agworoagwo	Bean pottage (local beans)	*Vigna spp*
13	Akara	Bean cake	*Vigna spp*
14	Moi-Moi	Steamed bean paste	*Vigna spp*

Table 5 shows the proximate composition of some selected ready-to-eat foods commonly consumed by preschool children in Abia State. The moisture content ranged from 40.1±0.04 in fried plants to 78.3±0.04 in Agidi. The carbohydrate content ranged between 12.31±0.01 in Akamu and 50.25±0.05 in fried plantain. The ash content ranged between 0.6±0.1 in Agidi and 5.6±0.03 in Rice and Tomato stew. The protein content ranged between 14.8±0.01 in Okpa potatoes and 0.91±0.01 in fried potatoes. The fat content ranged from 0.27±0.01 in Akamu to 7.3±0.02 in okpa. The fibres ranged between 0.02±0.01 in Akamu and 0.4±0.01 in Plantain. The energy ranged between 242.96 kJ/10 g in Akamu and 1084.91±0.03 kJ/100 g in Akara.

Table 5: Proximate composition of some selected ready-to-eat foods commonly consumed by preschool children in Abia State.
(g/100 g portion)

Food sample	Moisture %	Carbohydrate	Ash%	Protein%	Fat%	Fibre%	Energy (KJ/100 g)
Rice and Tomato stew sauce	68.6±0.4	20.6±0.06	5.6±0.03	2.1±0.03	2.8±0.6	0.3±0.5	485.34±0.02
Jollof Rice	71.2±0.03	19.8±0.02	5.3±0.06	1.9±0.07	1.6±0.4	0.2±0.03	423.42±0.03
Jollof Rice & beans	70.4±0.06	14.7±0.03	4.6±0.02	6.8±0.03	3.2±0.05	0.3±0.04	480.32±0.03
Okpa (steamed bambara paste)	62.0±0.01	11.72±0.02	4.02±0.02	14.8±0.05	7.3±0.02	0.16±0.03	718.73±0.02
Agidi (maize gruel)	78.3±0.04	14.02±0.06	0.6±0.01	1.85±0.01	5.1±0.06	0.13±0.01	457.65±0.04
Fried Plantain	40.1±0.04	50.25±0.05	4.3±0.02	1.1±0.03	3.85±0.01	0.4±0.01	1004.37±0.03
Yam mixed with Vegetables sauce	49.1±0.03	40.42±0.03	3.0±0.04	4.5±0.01	2.7±0.02	0.28±0.01	853.45±0.01
Boiled Yam and stew	57.2±0.03	32.45±0.01	3.7±0.01	3.4±0.05	2.9±0.01	0.35±0.02	709.19±0.01
Fried Yam	46.0±0.01	44.6±0.02	3.8±0.02	2.3±0.01	3.0±0.02	0.3±0.03	897.89±0.02
Fried Potatoes	42.5±0.03	49.61±0.01	2.0±0.02	0.91±0.01	4.8±0.02	0.18±0.01	1026.25±0.02
Akamu (pap/maize gruel)	84.6±0.01	12.31±0.01	1.2±0.01	1.6±0.02	0.27±0.01	0.02±0.01	242.96±0.01
Akidi (Bean Pottage)	56.8±0.01	24.8±0.05	4.6±0.06	8.5±0.02	4.8±0.02	0.5±0.03	738.06±0.04
Akara (bean cake)	50.0±0.02	17.5±0.03	2.9±0.06	14.7±0.01	14.5±0.02	0.4±0.05	1084.91±0.03
Moi-moi (steamed bean paste)	73.0±0.01	9.45±0.02	4.8±0.03	7.4±0.02	5.0±0.01	0.35±0.02	470.28±0.01

Mean ±SD of 3 Determinations
The local names of these foodstuffs are bracketed.

Table 6 shows the sex distribution of the serum ALB concentration and the number of children examined. The results revealed that there was a significant difference in the mean standard deviation (SD) of the serum ALB concentration between males and females (P<0.005). Compared with males, females presented a greater mean SD value. Hypoalbuminemia is more common in female children (9.47%) than in male children (7.31%). The same trend was observed for hyperalbuminemia.

Table 6: Distribution of the serum ALB concentration by sex and number of children

Parameter	Male n(%)	Female n(%)	Total n(%)	P
Albuminemia	5.00 ± 2.69^{a}	7.77 ± 3.29^{b}	5.89 ± 2.26^{a}	
Reference value (Normal)	170(82.13)	184(75.72)	354(78.67)	0.002

Hypoalbuminemia	15 (7.31)	23(9.47)	38(8.44)	
Hyperalbuminemia	22(10.63)	36(14.81)	58(12.89)	

N-number, %=percentage, mean± standard deviation.

Table 7 shows the distribution of children according to nutritional parameters and age groups. The results revealed deficiencies in the parameters albumin, magnesium, zinc, phosphorus and calcium in children aged 6 to 12 months.

Table 7: Distribution of children according to nutritional parameters and age groups

	(Age groups months) proportion deficient N(%)					
Parameters	6 – 12	13 – 23	24 – 36	37 – 42	43 – 49	50 – 59
Albumin	0(0.0)	4(8.70)	8(4.97)	7(5.93)	12(22.22)	7(12.96)
Magnesium	0(0)	0(0)	14(8.70)	6(5.08)	10(18.52)	5(9.25)
Zinc	0(0)	4(8.70)	22(13.66)	11(9.32)	7(13.21)	9(16.67)
Phosphorus	0(0)	2(4.35)	18(11.18)	12(10.17)	4(7.41)	5(9.26)
Calcium	2(11.76)	5(10.87)	17(10.56)	18(15.25)	5(9.26)	2(3.70)

Table 8 shows the distribution of children based on serum micronutrients. The results revealed that 7.78% of the study population had hypomagnesemia, whereas 6% had hypermagnesemia. A total of 9.11% of the children had hypomagnesemia, with 3.11% having hyperphophoremia. The percentage of children with hypocalcemia was 10.89%, while 2.22% had hypercalcemia, and 11.78% had hypozinicemia, with 2.44% having hyperzincemia. In all, a greater percentage of the study population (85% and above) are within the normal or reference values for the mineral elements examined.

Table 8: Distribution of children based on serum micronutrients (mineral elements)

Parameter	Magnesium Range (mg/dl) N(%)	Iron Range (µmol/L) N(%)	Phosphorus Range (mg/dl) N(%)	Zinc Range (µg/dL) N(%)
Hypo	<1.9 35(7.78)	<11 41(9.11)	<10 49 (10.89)	53 (11.78)
Reference value (Normal)	388 (86.22)	395 (87.78)	391 (86.89)	386 (85.78)
Hyper	27 (6.00)	14 (3.11)	10 (2.22)	11 (2.44)

Table 9 shows the distribution of children according to serum micronutrient deficiency by sex. The results revealed that a greater percentage of male children than female children had a magnesium deficiency of 10.14%, phosphorus deficiency of 11.59% and calcium deficiency of 11.11%. However, a greater percentage of zinc (13.58%) was observed in female children than in their male counterparts (9.66%).

Table 9: Distribution of children according to serum micronutrient deficiency by sex

	Male		Female	
Micronutrient	Mean ±SD	Deficiency N(%)	Mean ±SD	Deficiency N (%)
Magnesium	1.62±0.20	25(10.14)	1.62±0.23	10(4.12)
Zinc	10.25±0.90	20(9.66)	10.50±1.04	33(13.58)
Phosphorus	4.20±0.5	24(11.59)	4.29±0.88	17(7.00)
Calcium	4.78±3.37	23(11.11)	4.76±3.38	26(10.70)

Table 10 shows the correlations between biochemical parameters and anthropometric indices. The results revealed a correlation (P<0.05) between the serum ALB concentration and underweight status, between the serum ALB concentration and wasting status, between magnesemia and wasting status, and between provincemia, stunting and calcemia.

Table 10: Correlations between biochemical parameters and anthropometric indices

	Underweight		Stunting		Wasting	
Parameters	R	P	R	P	R	P
Albuminemia	0.26*	0.04	-0.06	0.73	0.35*	0.04
Serum CRP	-0.33	0.15	-0.25	0.45	0.28	0.03
Magnesemia	0.06	0.44	-0.07	0.34	0.36*	0.03
Phosphoremia	-0.01	0.87	0.006	0.85	-0.07	0.53
Zincemia	-0.02	0.75	-0.38*	0.03	0.002	0.49
Calcemia	-0.03	0.58	0.28*	0.02	-0.27	0.32

r= correlation coefficient, P= significance, *correlation is significant at the 0.05 threshold

IV. Discussion

This research offers insights into the nutritional status of preschool-aged children in Abia State, Nigeria. Findings from the study validate the presence of malnutrition among children aged 6–59 months in Abia State. The data analysis revealed four indicators of child malnutrition: underweight, stunted, wasting, and overweight/obese. Underweight is one of the key indicators identified in the study.

Underweight

Underweight is a condition characterized by a below-average weight for a specific age group, indicating that a child is excessively thin in relation to their age. This condition is determined by measuring the standard deviation from the median weight-for-age of the reference as outlined by WHO and UNICEF population[7]. In 2015 and 2018, the National Bureau of Statistics (NBS) conducted the Nigerian National Nutrition Health Survey (NNHS), which revealed that 19.9% of children under the age of five were classified as underweight. However, this figure was lower than that reported in 2008, which was 23% (NBS, 2018). The WHO, 2006, has placed the global prevalence at 15% for children under five years of age [14].

The present study revealed a 7.6% prevalence of moderate underweight among the 450 preschool children studied. The study revealed that 4.4% of the participants were severely underweight, whereas 85.3% of the study population was normal, resulting in a total underweight of 12%. This finding is greater than the findings of a previous study in Abia State (Abia North District) by Akubugwo et al., which revealed an underweight prevalence of 2.86% [15]. However, the results of the present study differ from those of Umeokonkwo et al. who reported an 8% prevalence in Abakiliki in the metropolis of Ebonyi State, Nigeria [16].

Similarly, our findings are lower than the global prevalence of 15% and those of NBS 2015 (23%) and 2018 (19.9%). The 2018 NHNS report reported that the prevalence of underweight in Abia State was 17.4%, with 12.2% being moderately underweight and 5.2% being severely underweight. The prevalence of overweight among the study population was 2.7%. This percentage is the percentage whose weight-for-height exceeded +2 SD from the reference median.

The highest prevalence of underweight (14%) was observed among children from Abia Central, followed by Abia South (11.3%), whereas the lowest prevalence (10.6%) was observed in Abia North. The findings of this study revealed that there was no association between nutritional status and zone (P> 0.05). Analysis of nutritional indicators among the zones across genders revealed that female children had the highest prevalence of each of the three zonesthus, i.e., North China (13.4%), South China (16%), and Central China (16.6%), whereas for male children, the distributions were North China (7.9%), South China (4.5%) and Central China (11.1%), respectively.

The analysis of differences in nutritional status among age groups in the entire state revealed that children aged 37–42 months had the highest prevalence of underweight (22%), followed by those aged 50–59 years. The lowest prevalence of underweight (6.2%) was observed among children aged 24–36 months.

Stunting

According to the UNICEF report, the largest malnutrition body in Africa is stunting. The prevalence of stunting in Africa was 37%. Stunting is defined as low height-for-age at Z<-2 standard deviations (SDs) of the median value of the NCHS/WHO international growth reference [17,18].

The Nigerian National Nutrition and Health survey conducted by the National Bureau of Statistics in 2018 revealed that the national prevalence of stunting was 32% among children 0–59 months old, with male children having a higher prevalence of 34.8% than female children with 29.2%, which is lower than the 2008 report reporting a national prevalence of 41%. The findings of this study are greater than those of Akubugwo et al., who reported a 6.93% prevalence of stunting among preschool-aged children from Abia North District, Abia State, Nigeria [19]. Similarly, our findings indicate higher values than those of Umuokonkwo et al. (9.9%) in terms of the prevalence of stunting among school-aged children in Abakiliki, Ebonyi State, and lower values than those of Kpurkpur et al.(19.1%) among school-aged school-aged children in the semiurban area of Benue State, Nigeria [6, 16].

Analysis of stunting among the three zones revealed a 21.7% prevalence for Abia North, 41.3% for Abia South and 23.6% for Abia Central. There was a significant difference (P<0.05) in the prevalence of stunting among the zones. Analysis by age group revealed that stunting increased as age increased, with the peak occurring at ages 37--42 years (52.9%). This may be attributed to the fact that children at this age find it difficult to change from being fed to feeding themselves, especially as they are kept in daycare centres, away from homes. This finding is in line with that of Ezeh et al. who reported that keeping children away from their homes affects their growth, probably because most operators of educational/daycare centers may not attend to the quality, quantity and timing of feeding these children [8].

Wasting

Wasting is defined as a low weight for height at <-2 SD of the median value of the WHO reference standard. It is sometimes referred to as acute malnutrition [20, 21]. The present study revealed a 4.1% overall prevalence of wasting among the 450 preschool-aged children from Abia State. This finding is lower than the national prevalence of wasting of 7.0%, as reported by the Nigerian National Health Survey conducted by the National Bureau of Statistics in 2018, Akubugwo et al. for Abia North (10.8%), and Umeokonkwo et al. (7.2%) for school children in Abakiliki Ebonyi State, Nigeria [16, 19]. The results of our study therefore indicate an improvement in the nutrition of school-age children in Abia State compared with earlier studies.

Analysis of nutritional status across the zones by sex revealed that the highest prevalence of wasting was 10% among female children from Abia Central. Overall, female children had a greater prevalence of wasting in the three zones under study. This finding calls for more attention to the nutrition of the girl child. The findings of the present study suggest that more attention should be given to the feeding of male children than to that of their female counterparts within the state.

Overweight

The weight for height measurement also provides data on overweight. According to the WHO (UNICEF, 2021), overweight is defined as high weight for height at +2 SD from the reference median. These are children whose weight-for-height is above two standard deviations (+2SD) from the reference median [20].

The Nigerian National Nutrition Health Survey conducted by the National Bureau of Statistics in 2018 revealed that the proportion of overweight children aged 6--59 months was 1.2%, with male children having a higher prevalence of 1.5% than female children, 0.9%. However, the same source was observed in 0.7% of children of the same age from Abia State.

In the present study, an overall prevalence of 1.1% overweight with a 0.9% prevalence of obesity among school-age children aged 6–59 months from Abia State was obtained via the WHO reference standard (GNR, 2020). The highest prevalence of overweight was 1.9% among male children compared with 0.4% among female children. The findings of the present study are lower than those reported by the National Bureau of Statistics in 2008 and those of Umeokokwo et al., which revealed a 1.4% prevalence of overweight [16].

This trend of male children having a greater prevalence of overweight than female children followed the same trend as the prevalence of wasting, confirming our earlier assertion that male children are nutritionally fed better than their female counterparts in the area under study.

Analysis of the prevalence of overweight among the zones revealed that Abia Central had the highest 4.0% prevalence, followed by Abia South at 2.7%, while Abia North had the lowest 2.0%. Similarly, the highest prevalence of obesity was 1.3% in Abia South, whereas Abia North and Abia Central had the same prevalence of 0.7% each. This observation could be attributed to the urban nature of Abia Central, which is the state capital. In 2013, the UNICEF, WHO and World Bank estimated that the global prevalence of childhood overweight increased from 5–7% in high-income homes and countries. Our findings indicate that Abia state has started to record the problem of overweight, which was not observed in earlier studies [19, 22].

Obesity was observed in three age groups: 0.6% at 24–36 months, 1.7% at 37–42 months, and 1.9% at 43–49 months. The other age groups, 6–12 months, 13–24 months and 50–59 months, had a zero percent prevalence of obesity. Our findings suggest that overweight and obesity increase with age among children. We opine that this observed trend among the study population could be attributed to the frequency of school meals that these preschool children have access to each day. It may also be credited to food preference and overdependence on highly processed foods such as noodles, rice, bread and beverages. This finding is similar to the findings of Bello et al. on the snacks and nutrient intake of secondary school girls [12].

The proximate composition of the fifteen selected ready-to-eat foods consumed by preschool-aged children in Abia State under study revealed that most of the diets had high moisture contents, ranging from 40.1±0.03% (fried plantain) to 84.6±0.01% in Pap/maize gruel (Akamu).

This finding is similar to earlier findings of studies by Akubugwo et al. and Okeke and [19, 23]. The highest carbohydrate content was observed in fried plants (50.25±0.05%), followed by fried potatoes (49.61±0.01%), with the lowest carbohydrate content in steamed bean cake (moi–moi), which was 9.45±0.02%. This trend is similar to the findings of other online literature [24]. A detailed description of the content of the various ready-to-eat foods consumed by school-age children in Abia state is presented in Table 5.

The major local weaning/complement food often used by nursing mothers in Abia State is Pap/maize gruel Akamu. Findings from the analysis show that the energy content of Akamu is below the recommended energy intake per serving of meal (FAO/WHO, 1985). Additionally, the protein content of Akamu is below the recommended value for children; therefore, we strongly recommend that it be complemented or mixed with oil (red oil) before serving to provide more energy [24].

The protein contents of the foods examined in this study are relatively high in six foods—Jollof rice × beans, okpa, yam mixed with vegetables, Akidi, Akara and Moi-Moi—based on the FAO/WHO joint committee, 1985. The high protein content could be attributed to the basic ingredients used in their preparations and the macronutrients inherent in them. The elevated protein content indicates that these foods can contribute to the daily requirements for children and even adults suffering from protein deficiency disorders. Ukaegbu, recommended that protein should contribute 6–20% of total energy intake for children aged 1–3 years and 10–30% for children aged 4–8 years [25].

The results of the anthropometric study revealed that malnutrition is very low among the study population compared with the WHO 2012 global estimate for Africa and the estimate by the Nigerian Demographic Health Survey for preschool children. This observation strongly suggests that these foods and other foods, which the children complement with at home, are good; hence, low prevalence values are observed for malnutrition.

Albumin

The albumin distribution revealed that 8.44% of the study population (7.31% boys and 9.47% female children) had hypoalbuminemia (serum albumin <3.8 g/dL). Additionally, 12.89% of the children had hyperalbuminemia (serum albumin >4.4 g/dL), 10.63% male and 14.81% female. The findings of this study are lower than those of Abdullahi et al. (2018), who reported 24.2%, and Nolla et al. (2014), who reported a higher prevalence of hypoalbuminemia (49.52%) and hyperalbuminemia (25%) among preschool children in Zaria Nigeria and Cameroun, respectively [26, 27]. The values for serum ALB are presented in Table 6.

The presence of hypoalbuminemia in this study calls for concern. Findings from other earlier studies (Diouf et al. 2000, Amare et al., 2012, Nolla et al., 2014) and recently Abdullahi et al. (2021) revealed that hypoalbuminemia results in children suffering from protein caloric insufficiency and severe malnutrition 28, 29, 27.

Our findings from the proximate analysis of the ready-to-eat food commonly consumed by the children revealed that the daily protein requirements were met[23]. Amadi et al. reported that pretreatment (cooking more often) could affect the nutritional value, digestibility and bioavailability of proteins, which could lead to lower levels of albumin in the blood of some of the study population [30].

However, low serum ALB could also be caused by an inflammatory process initiated by interleukin-1 secretion, which results in an increase in C-reactive protein.

Findings from the study revealed that the level of C-reactive protein in the study population was within the normal range (<6 mg/L and >6 mg/L). These rules suggest the possibility of inflammatory processes in the study population. These findings suggest that there was no acute infection or inflammation among the study population.

Micronutrient deficiency

Stevens et al. reported that micronutrient deficiency compromises the immune system and hinders child growth and development [31]. They estimated that the global prevalence of deficiency in at least one or three micronutrients per individual globally is 56%. Ene-Obong et al. reported that limited data are available to adequately assess micronutrient conditions in Nigeria [32]. These authors further agreed that micronutrient deficiency exists among the Nigerian populace as hiding hunger as observed in the present study [31]. The percentage of children with micronutrient deficiency varied according to the micronutrients examined. The results indicated that 7.78% and 60% of the pediatric population exhibited hypomagnesemia (with reference to normal magnesium levels) and hypermagnesemia, respectively. Approximately 9% and 3% of the children displayed hypophosphatemia (with reference to normal phosphate levels) and hyperphosphatemia, respectively. The prevalence of hypocalcemia was 10.89%, whereas the prevalence of hypercalcemia was 2.2%. Similarly, 11.78% had hypozincemia, while 2.4% had hyperzincemia reference values of zincemia.

Amare et al. demonstrated that magnesium deficiency commonly occurs in various clinical conditions, such as protein energy malnutrition, malabsorption, hypoalbuminemia, and sepsis, which are frequently observed in children in developing nations [29]. Our findings indicate a lower prevalence than that reported by Nolla et al., who reported a 45.96% prevalence of hypomagnesemia [27]. Similarly, our findings are also lower than those of Rodriguez et al. who reported a 51.9% prevalence of hypomagnesemia [33].

The current investigation revealed that a portion of the children exhibited hypophosphatemia. This may be attributed to insufficient nutrition or inadequate absorption of phosphorus. Conversely, hyperphosphatemia was observed in some children, which could be attributed to excessive intake of phosphorus in their diet. Many phosphorus-rich foods, especially cereals and legumes, contain phytates that hinder the absorption of phosphorus [34]. This could explain the low levels of phosphorus observed in some children, as their primary food sources were found to be grains and legumes.

The prevalence of hypocalcemia noted in the current study was lower than other online literatures [27, 35, 36]. Fong and Khang proposed that hypocalcemia may be attributed to vitamin D deficiency, inadequate parathyroid hormone levels, or resistance to these hormones, along with insufficient dietary intake [37]. They also indicated that low levels of vitamin D (specifically, low 25-hydroxyvitamin D and 1,25-hydroxyvitamin D) can result in a decrease in the gastrointestinal absorption of calcium by as much as 50%, leading to only 10–15% of intestinal calcium from food sources being absorbed. Conversely, the hypercalcemia observed in the present study could be explained by high calcium intake, sun exposure, and infection.

The analysis of C-reactive protein results ruled out the possibility of infection, as CRP levels were within the normal range for all the children included in the study. It has been demonstrated that prolonged exposure to sunlight (abundant radiation) can increase the levels of 25-hydroxyvitamin D3 in the serum, potentially leading to hypercalcemia. Additionally, most of the children trek long distances under the sun to return home after school, as we observed. The current study revealed a lower prevalence of zinc deficiency than the 20% prevalence rate established by the International Zinc Nutrition Consultative Group [34]. Furthermore, the findings of this study indicate a lower prevalence of zinc deficiency in children than in previous studies conducted [38, 27, 29, 39,40]. The implications of zinc deficiency in children are significant, as it can lead to growth retardation, immune disorders, skin alterations, and neuropsychological impairments and hinder academic achievement among school children.

The observed high prevalence of hypozincemia could be attributed to the heavy reliance on plant-based diets rather than animal-based diets [41, 42].

It is well documented that foods rich in zinc are primarily of animal origin, such as meat, fish, and dairy products; however, the children included in this study exhibited low consumption of these types of foods. Instead, a significant portion of their diet consists of cereals and legumes, which are high in dietary fibre and phytates. These compounds can bind to zinc, forming insoluble complexes that hinder zinc absorption. Since albumin is a key transport protein for zinc, the fact that most subjects have normal serum ALB levels suggests that their zinc deficiency is likely a result of inadequate dietary intake[26]. Furthermore, the study findings indicate a significant positive correlation ($P<0.05$) between zinc levels and stunting. Therefore, it is plausible that the socioeconomic status of the study population may have played a role in the observed prevalence of hypozaemia.

V. Conclusion

The current research evaluated the nutritional status of young children in Abia State. The anthropometric results revealed 7.6%, 20.8%, 4.1% and 1.1% prevalence rates of underweight, stunted, wasting and overweight, respectively, when the WHO 2006 reference standard was used. The most common form of malnutrition discovered was stunting (20.8%). The nutrient composition of the ready-to-eat food commonly consumed by preschool children indicated that the food/diet meets the international daily energy/nutrient requirements for children. Most foods contain high moisture contents, which calls for care during preparation to avoid much moisture.

The mean serum ALB concentration for the children was 3.8±0.66 mg/L, with 3.66±0.47 mg/L for male children and 3.91±0.76 mg/L for female children, whereas the mean C-reactive protein concentration was 5.4±3.05 mg/L, with 5.01±2.69 mg/L for male children and 4.84±3.29 mg/L for female children. The findings revealed a low prevalence of deficiencies in micronutrients such as zinc, phosphorus, calcium and magnesium among the study subjects. Our findings suggest that there is improvement in the nutrition of school-aged children in the state, although effort has to be made to overcome stunting, which persists compared with other nutritional indicators. Stunting is a manifestation of insufficient nutrition over an extended duration and is influenced by persistent and long-standing illnesses. This, therefore, calls for concern about the findings of our study (which revealed a high prevalence of stunting among the study population). Much consorted effort should be made to ensure that much care is given to children right from onset because any insufficient dietary intake from breastfeeding will definitely manifest.

This study revealed that malnutrition is still a problem among the school children of Abia State. The observations of both undernutrition and overnutrition in this study indicate an imbalance in Nigeria. The observed malnutrition is attributed to problems such as poor cooking methods, poor eating habits, food insecurity, overeating, poor sanitary conditions and others. There is an urgent need for food diversification for these children, fortification/supplementation of common foods with essential minerals and the sustenance of one meal per child introduced by the government for these school children.

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Conflict of Interest
The authors declare no conflict of interest

Data Availability Statement
The data will be made available on request.

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