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FOOD INSECURITY AND MICRONUTRIENT DEFICIENCIES AMONG IN-SCHOOL ADOLESCENTS IN SABON GARI, ZARIA, KADUNA, A PERI-URBAN SETTLEMENT IN NIGERIA

Aliyu Abdulhamid Waziri, *Auwalu Garba, Abdulmalik Abdullahi Salman, Uche Samuel Ndidi, Muhammad Auwal Saliu and Yahya Jibril Isah

Department of Biochemistry, Ahmadu Bello University, Zaria Nigeria

*Corresponding authors' email: garbaauwalu2011@gmail.com

ABSTRACT

Adolescence is characterized by fast pubertal changes and high nutrient needs which are often unmet due to household food insecurity. The prevalence of household food insecurity among in-school adolescents in a peri-urban settlement in Nigeria and its impact on micronutrient deficiencies was determined. Household Food Insecurity Access Scale (HFIAS) questionnaire was used to assess household food insecurity. Zinc, iron, vitamin A, and calcium concentrations were determined. Results were analysed using the EXCEL spreadsheet and presented as percentages and frequencies except where otherwise stated. The study revealed that most in-school adolescents are predominantly males (57.52%) of 16.18±1.75 average age and from households with limited social and economic resources. Eighty-seven percent of the adolescents from households with moderate (76.99%) to large (13.27%) sizes and monthly income below $75 have both the head of household and caregiver with limited educational attainment. Boreholes were the primary drinking water source (66.37%) for the households. About 83.3% of the households experience varied degrees of food insecurity while <30% of adolescents met their recommended dietary diversity. The anthropometric indices, BMI-for-age and Height-for-age z-scores revealed high prevalence of thinness (61.06%) and stunting (57.52%). The mean iron level was significantly (p=0.042) lower than the normal range. The frequency distribution shows iron (95.3%), zinc (54.7%), calcium (33.3%) and vitamin A (40.0%) deficiencies in the adolescents. Our results suggest that large household sizes result in adolescent food insecurity, below normal micronutrient levels, and dietary diversity in the study area, a peri-urban settlement in Northwest, Nigeria.

Keywords: Adolescent, Food insecurity, Micronutrient deficiencies

INTRODUCTION

Worldwide, recent calamities such as Russian-Ukrainian war, flood, and climate change have aggravated the rate of food insecurity with higher prevalence in developing nations of Africa and Southern Asia (Boliko, 2019; Ahmad, 2020; Wossen et al., 2018). Globally, the prevalence of food insecurity was reported to be 54% in 2016 (Lal, 2020), while a prevalence of 20% was reported in Africa (Food Agriculture Organisation, 2023). Accordingly, the number cited by the report stands at approximately 868 million people in Africa to have experienced moderate or severe food insecurity, with more than one-third of them (342 million) facing severe food insecurity (Food Agriculture Organisation et al., 2023). In Nigeria, the prevalence of severe food insecurity was reported to be 58.5% (Ibukun & Adebayo, 2021). This global rise in food insecurity poses a significant threat to adolescents' nutrient intake across age and gender groups leading to inadequate dietary intake and poorer nutrition in several communities (Demeke et al., 2020; Laborde et al., 2021).

Adolescents often face malnutrition due to household food insecurity despite their increased nutrient needs due to physical growth, cognitive development, and sexual maturation (Ahmed et al., 2012; Christian & Smith, 2018; Gupta et al., 2020; Yusuf et al., 2021). The nexus between adolescent development and adequate nutrition is adequate dietary intake (Ersado, 2010; Kawade, 2012; Norris et al., 2022). Poor nutrition hampers the growth and development of these adolescents (Christian & Smith, 2018; Yusuf et al., 2021). Health problems such as anaemia, skin rashes, loss of stamina, obesity, chronic osteoporosis, and a sustained intergenerational cycle of malnutrition are common to adolescents girls (Keats et al., 2018; Saxena, 2017) and generally, it affects musculoskeletal growth, neurodevelopment and immunity of both adolescent boys and girls (Norris et al., 2022). In spite of these effects, numerous countries and sub-regions lack data on these links, especially among adolescents (Ahmed et al., 2012; Nnakwe & Onyemaobi, 2013; Norris et al., 2022). Sabon gari, Zaria in Northern Nigeria is a peri-urban settlement that often face unique challenges and vulnerabilities making them hotpots for food insecurity due to rapid urbanization and the transition between rural and urban food systems. By unravelling the food security conditions of the peri-urban area, this study is essential for policymakers and researchers to rethink and develop all-inclusive food security strategies. It will also provide a systematic research framework for future related studies Thus, this study aims to assess the prevalence of household food insecurity and micronutrient deficiencies among in-school adolescents.

MATERIALS AND METHODS

Chemical, Reagents, and Equipment

Chemicals and reagents used were of analytical grade and were sourced from reputable companies. Equipment used for the study includes adult height measuring device (stadiometer), UNICEF SECA electronic weighing device, marker, questionnaires, syringes, blood collection tubes, hand gloves, water bath, ice packs, centrifuge machine, microplate & microplate reader, spectrophotometer, micropipette, cuvette, sample containers, etc.

Study Area

The study was conducted at selected public and private secondary schools in Sabon Gari LGA (latitude 11° 06' 60.00" N and longitude 7° 43' 59.99" E) of Kaduna State, Nigeria. Sabon Gari has eleven (11) administrative districts, namely; Samaru, Bomo, Jushi, Jama'a, Hanwa, Basawa, Dogarawa, Chikaji, Muchia, Ungwan Gabas, and Zabi (Figure 1).

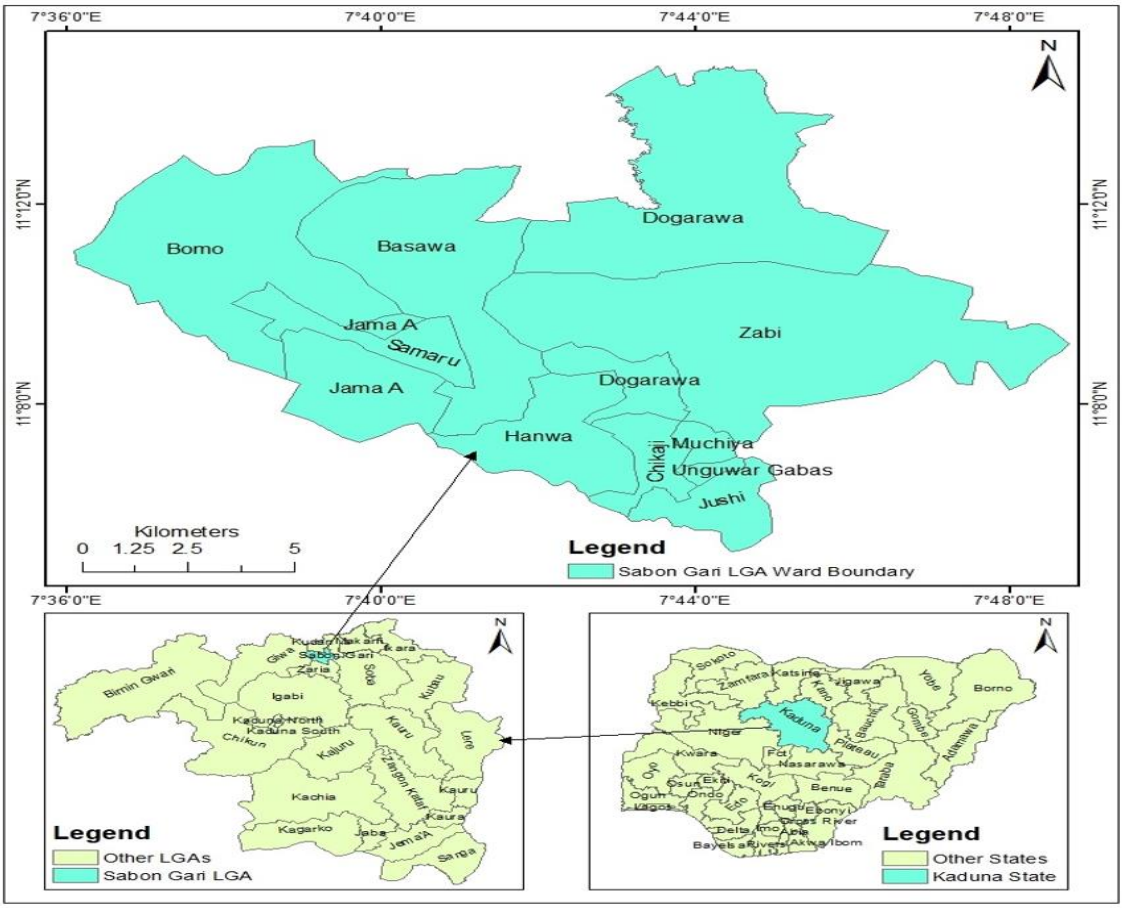

Figure 1: Map of Sabon Gari LGA, Kaduna State Nigeria

Study Design and Sampling

The research study was a school-based cross-sectional study. The study participants, in-school adolescents, were selected at random from randomly selected secondary schools in Sabon Gari LGA.

Exclusion Criteria

Pregnant and fasting adolescents, alongside those who had been treated of infectious diseases in the last two weeks, and non-consenting persons were excluded.

Sample Size

The sample size of the study was calculated using Thrustfield (2005) formular.

$n = z^2pq/d^2$

n = minimum sample size required;

z = standard deviation at 95% confidence level;

P = estimated proportion of variable of interest in the population,

=7.3% [=0.073] prevalence of multiple micronutrient deficiencies (MNDs); (Ahmed et al., 2012)

q = complementary probability of p (q = 1 – p); and

d= tolerable alpha error or precision (d= 0.05)

= 103.986 ≈ 104 participants

Sample size was increased by 10% (=10.4)

Hence, *n*, was 114.4

= 114 adolescents

Ethical Approval

Ethical approval was obtained from Ahmadu Bello University Committee on Use of Human Subject for Research (Approval Number: ABUCUHSR/2023/015), Kaduna State Schools Quality Assurance Agency (KSSQAA) Sabon Gari Local Government Inspectorate, Schools management, and participants' informed consent.

Data/Sample collection

The study involved collecting data and blood samples from 10 - 15 adolescents daily, twice a week. Three research assistants were trained for data collection, while a qualified phlebotomist was employed for blood sample collection. Blood and data collection was conducted from June to August 2023. Blood samples were collected using venipuncture in a clean, light- and dust-controlled building and stored in ice-packed boxes. The sera were separated at 3000 rpm for 5 minutes, transferred to a polypropylene test tube, and stored at -20 °C. The process ensured no contamination or damage to the retinol. Micronutrient assays – iron, zinc, calcium, and vitamin A – were conducted immediately after collection.

Field Procedures and Micronutrient Assays

Collection of Socio-demographic and Food Insecurity Data

To achieve our aim of assessing the prevalence of food insecurity and socio-demographic characteristics of the adolescents, the food and nutrition technical assistance (FANTA) household food insecurity access scale (HFIAS) questionnaire which is the gold standard for the determination of food security was utilized. The semi-structured questionnaire (SSQ) was validated by pretesting it on a similar population outside the study area and observations wre noted and the tool updated. The validated HFIAS questionnaire is a set of nine occurrence and nine frequency-of-occurrence questions, which seeks to evaluate the experiences of its respondents about sustained access to

adequate and quality diet over four (4) weeks i.e. 28 days. The HFIAS questionnaire focuses on these three domains of food security (access): food quality, food quantity, and anxiety about food.

Assessment of food consumption pattern and anthropometric indices

The food consumption pattern of the study participants was determined using a non-quantitative food frequency questionnaire (FFQ) and 24-hour dietary recall. It was assessed based on consumption of the best food sources of these micronutrients and dietary diversity score (DDS), respectively. Dietary diversity scores were calculated by summing up the number of food groups consumed over a 24-hour period by the study participants. Participants with DDS ≥ 5 were considered to have met their minimum dietary requirement for the day (Shenka et al., 2018).

The nutritional status of the participants was determined using their body mass index (BMI)-for-age (BAZ), and Height-for –age z-score (HAZ). Firstly, the weight (kg) and height (m) of each participant were taken according to WHO/UNICEF standard. Additionally, the WHO AnthroPlus software (v 1.0.4) was used to evaluate the BMI-for-age z-scores (BAZ), and Height-for-age z-scores (HAZ) of the participants. The HAZ was then categorized according to the WHO/CDC classification.

Determination of the Levels of Serum Micronutrients

The prevalence of micronutrient deficiencies of iron, zinc, vitamin A, and calcium were assessed by determining the non-fasting serum concentrations of these micronutrients in the adolescents. Nitro-PAPS method assay kit as described by Centronic Company Ltd (2021) was used to assay for iron, zinc fluid monoreagent (ZMR) assay kit as described by Centronic Company Ltd (2021) for zinc, Shimadzu UV-VIS 2550 Spectrophotometer for vitamin A, and modified O-cresophthalein complex (OCPC) methodology as described by ChemCHEK^{Tm} AGAPPE (2023) for calcium.

Statistical Analysis

The data for socio-demographic characteristics, food insecurity, and food consumption pattern were expressed in frequencies and percentages using IBM SPSS (version 25). The package (SPSS) was used to conduct a chi-square analysis between micronutrient deficiency and dietary diversity. P-values < 0.05 were considered statistically significant except where otherwise stated. The anthropometric indices were gotten using WHO Anthro-plus software and data were expressed as mean z-scores. All values for biochemical parameters were expressed as mean ± SD except where otherwise stated.

RESULTS AND DISCUSSION

Socio-demographic Characteristics of Adolescents

In the current study, Table 1 (both a & b) is the result of an assessment of in-school adolescents' socio-demographic variables which reveals that majority (57.52%) of the adolescents are males aged 15-19 years. The majority (over 70%) are from Hausa/Fulanis, while Yorubas, Igbos, and other ethnic groups makes up the minority. Over 40% of adolescents do not work, and 82.30% trek to school. Over two-thirds of household heads are between 40-59 years old, with 46.90% having completed secondary education. Most heads are civil servants or businessmen. Most caregivers are mothers aged 25-54, with 69.91% having completed secondary education. Only 13.27% of adolescents come from households earning over ₦100,000, while 13.27% come from households with more 15 members.

Table 1a: Socio-demographic Characteristics of Household In-School Adolescents in Sabon Gari LGA, Kaduna State, Nigeria (n=113)

Variable	Frequency (*n*=113)	Percentage (%)	Variable	Frequency (*n*=113)	Percentage (%)
Gender			**Family type**		
Male	65	57.52	Polygamous	49	43.36
Female	48	42.48	Monogamous	64	56.64
Age			**Marital status**		
10 - 14 years	27	23.89	Single	113	100
15 - 19 years	86	76.11	Married	0	0
	*16.18±1.75	**11.58-19.58			
Ethnicity			**Source of drinking water**		
Hausa/Fulani	80	70.8	Well water	16	14.16
Igbo	4	3.54	Borehole	75	66.37
Yoruba	13	11.5	KSWC	9	7.96
Others	16	14.16	Sachet/Bottle water	13	11.5
Type of accommodation			**Means of transportation to school**		
Mud/Hut housing	13	11.5	Legs	93	82.3
Modern bungalow	54	47.79	Bicycle	3	2.65
Compound housing	45	39.82	Motorcycle/Tricycle	11	9.73
Mansion	1	0.88	Car	6	5.31
Household monthly income (₦)			**Household size**		
less than 10 000	0	0	less than 5	11	9.73
11 000 to 20 000	16	14.16	5 to 10	73	64.6
21 000 to 50 000	60	53.1	10 to 15	14	12.39
51 000 to 100 000	22	19.47	above 15	15	13.27
above 100 000	15	13.27			

Head of household [HH]			**Primary caregiver**		
Father	94	83.19	Mother	100	88.5
Mother	9	7.96	Sister	8	7.08
Uncle	2	1.76	Aunt	2	1.77
Others	8	7.08	Others	3	2.65

Values marked (*****) are expressed in Mean±SD while those marked (******) indicate range of values. **KSWC** stands for Kaduna State Water Corporation.

Table 1b: Socio-demographic Characteristics of Household In-School Adolescents in Sabon Gari LGA, Kaduna State, Nigeria (n=113)

Variable	Frequency (*n*=113)	Percentage (%)	Variable	Frequency (*n*=113)	Percentage (%)
HH age			**Caregiver's age**		
30 to 39 years	4	3.54	25 to 34 years	25	22.12
40 to 49 years	41	36.28	35 to 44 years	57	50.44
50 to 59 years	44	38.94	45 to 54 years	24	21.24
60 years & above	24	21.24	55 to 64 years	6	5.31
			65 years & above	1	0.88
HH occupation			**Caregiver's occupation**		
Artisan	4	3.54	Artisan	7	6.19
Farmer	14	12.39	Farmer	4	3.54
Civil servant	46	40.71	Civil servant	15	13.27
Military personnel	2	1.77	Full housewife	44	38.94
Businessman	41	36.28	Trader	43	38.05
Others	6	5.31			
HH educational level			**Caregiver's educational level**		
Islamic (Arabic) education	2	1.77	Islamic (Arabic) education	6	5.31
Primary education	4	3.54	Primary education	10	8.85
Secondary education	53	46.90	Secondary education	79	69.91
Tertiary education completed	54	47.79	Tertiary education completed	18	15.92

Researchers in separate studies across the globe have demonstrated how social, economic, and demographic variables influence food sufficiency, dietary consumption, nutritional status, and healthcare delivery (Adeyanju et al., 2017; Corsi et al., 2011; Mazur et al., 2003; Wu et al., 2020). The socio-demographic analysis of in-school adolescents in the current study reveals that 3 in 5 single adolescents are males. The poor enrolment of girls is facilitated by cultural and economic hardships faced by low-income families that cannot afford to sponsor both genders to school. Considering the monthly income, our findings show that only about 1 in every three (3) households earn above the poverty line of USD1.90/day (about ₦50 000 monthly). Earning below $75 in Nigeria meant that such an individual cannot afford adequate healthcare including three meals in a day that is sufficient in energy, protein, and micronutrient. This was postulated by Socio-Economic Rights and Accountability Project (SERAP) in a report by Premium Times (Premium Times, 2021). However, this depends on the household size as more individuals in the household implies more food consumed by the household and more money spent on food items. This situation could be worsened with food inflation and stagnated minimum wage.

Household Food Security Situation of Adolescents

This study found only 19 adolescents representing 16.7% to be food secure, while approximately 83% are at varying levels of food insecurity (Figure 2). The result of the study based on household food Insecurity Access Prevalence (HFIAP) measurement also found 73.7% to be mildly food insecure (MFI), 5.2% were moderately food insecure (MoFI), and 4.4% of the adolescents were severely food insecure (SFI) (Figure 2). The mean household food Insecurity Access Score (HFIA-S), based on the average of all frequency-of-occurrence questions, was found to be 6.395±4.89.

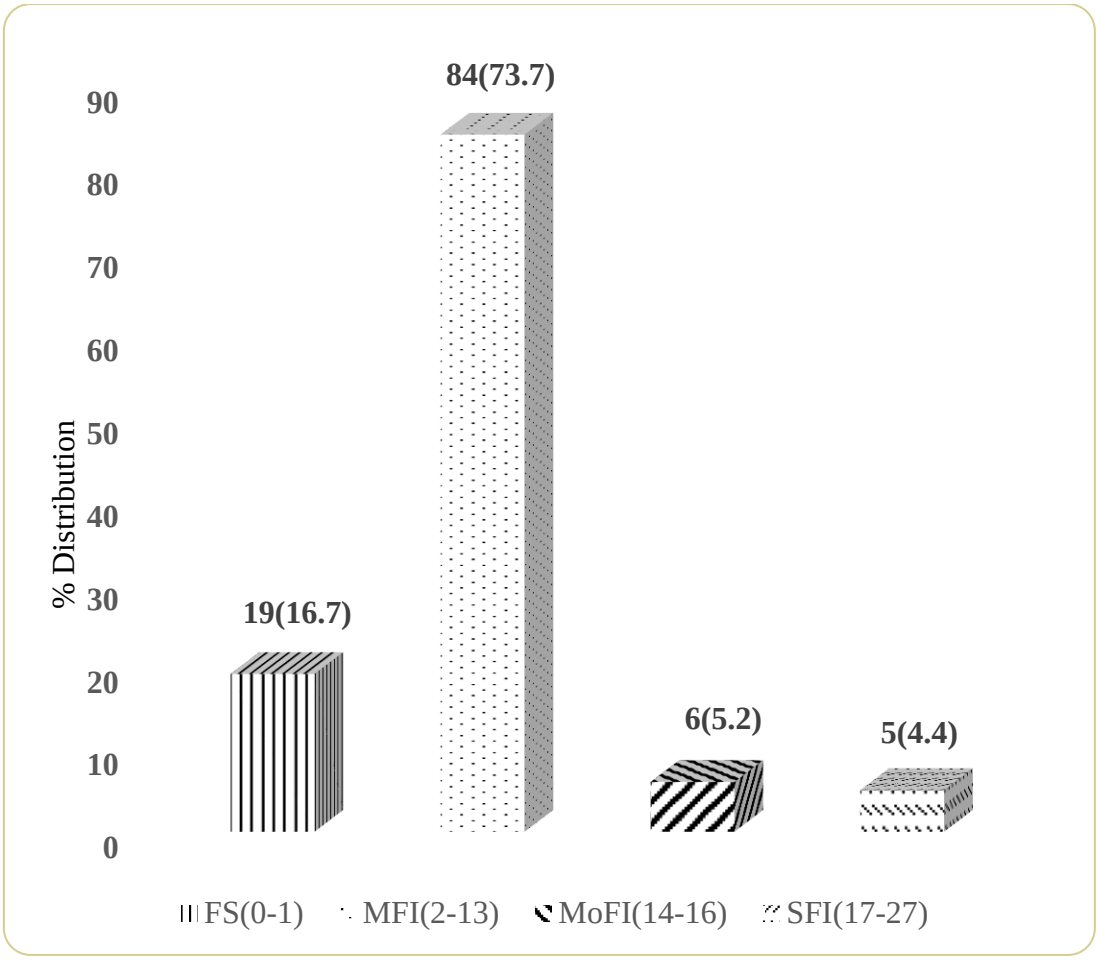

Figure 2: Status of Food Security among Households In-School Adolescents in Sabon Gari LGA, Kaduna State, Nigeria (n=114)

According to HFIAS guidelines (Coates et al., 2007) FS = food secure, MFI = mildly food insecure, MoFI = moderately food insecure, and SFI = severely food secure.

Much higher than the 47.3% prevalence reported by Adeomi (Adeomi et al., 2022) and 58.5% by Ibukun (Ibukun & Adebayo, 2021), the current study found only about one-seventh to be food secure while greater number (above 80%) of them are food insecure. The adolescents face food insecurity, with 49% experiencing insufficient dietary quality, 19% experiencing inadequate intake, and over 30% experiencing anxiety or worry about food access. The majority (73.7%) are mildly food insecure, with consequences including not meeting the recommended minimum dietary diversity (MDD) due to poor dietary consumption and nutrient adequacy for key micronutrients of public health importance.

Food Insecurity Coping Strategies Used by Adolescents

The result of strategies put forward by the adolescents to cope with food insecurity experiences (Figure 3) and its impacts on health and well-being shows that among the strategies; eating less preferred, lower quality or less expensive foods is the most adopted strategy and selling of assets is the least practiced coping strategy. Over 70% of adolescents practice eating less quality and less expensive foods, while only about 8% practice selling assets to cushion the effect of food insecurity.

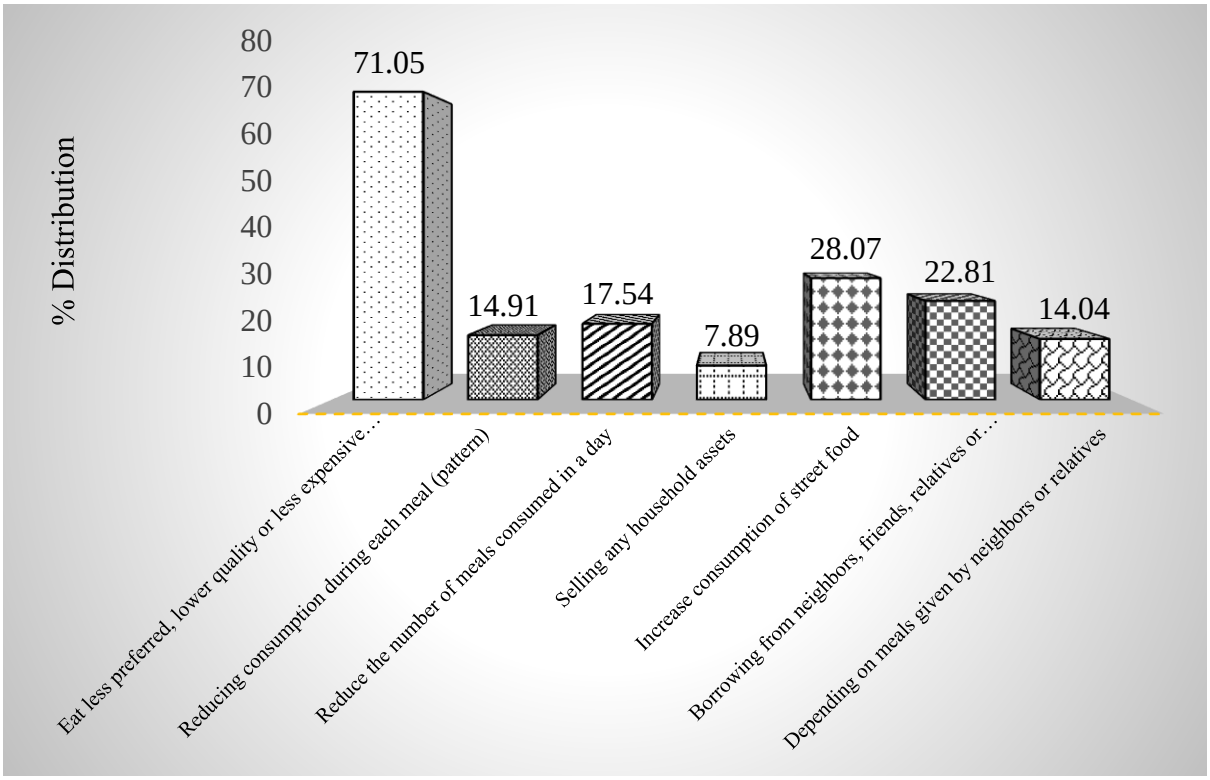

Figure 3: Frequency Distribution of Food Insecurity Coping Strategies Used by Household In-School Adolescents in Sabon Gari LGA, Kaduna State, Nigeria (n=114)

Other strategies employed by the adolescents arranged in order of decreasing frequency are: increasing consumption of street foods (28.07%), borrowing from neighbours, friends, relatives or workplace (22.81%), reducing the number of meals per day (17.54%), and reducing consumption during each meal (pattern) (14.91%), and depending on meals given by neighbours or relatives (14.04%).

Anthropometric Indices, Food Consumption Pattern and Micronutrient Levels

Table 2 shows that a good number of the adolescents have normal height (42.48%) and normal weight (38.94%). Assessment of the nutritional status of adolescents is tedious due to their growth spurt which leads to wide variability in weight, height, and body composition. The findings of this study indicate an alarming pooled prevalence of stunting (57.52%) and thinness (61.06%). This corresponds with the high rate of food insecurity (~83%) affecting the adolescents.

Table 2: Distribution of Anthropometric Indicators of In-School Adolescents in Sabon Gari LGA, Kaduna State, Nigeria (n=113)

Anthropometric Indicator	*n* (%)
HAZ	
Normal	48(42.48)
Mild Stunting	33(29.2)
Moderate Stunting	24(21.24)
Severe Stunting	8(7.08)
BAZ	
Normal	44(38.94)
Thinness	36(31.86)
Moderate Thinness	23(20.35)
Severe Thinness	10(8.85)

The result for thinness is higher than the 10.3% reported by (Adeomi et al., 2022) in a study conducted in Osun and Gombe States. Stunting and thinness in adolescents can lead to negative effects such as reduced learning, poor school performance, emotional imbalance, and low work output, indicating acute and chronic malnourishment. Thinness increases the risk of osteoporosis, fertility issues, and decreased immune function. Food insecurity is associated with a higher prevalence of stunting and thinness, suggesting long- and short-term effects on adolescents' height and weight respectively.

Table 3 shows the food consumption patterns of adolescents, with cereals, grains, root and tubers, and plantain being the two most consumed food groups. Eggs are the least consumed, followed by pulses with over 30% and 52% daily and weekly consumption. Dark green leafy vegetables and other vitamin A-rich fruits and vegetables are the third and fourth most consumed food groups, with consumption ranging from 1 to 3 times daily.

Table 3: Frequency of Food Groups Consumed by the In-School Adolescents in Sabon Gari LGA, Kaduna State, Nigeria (n=114)

Food Group	1-3 times daily	1-3 times per week	4 or more times per week	4 or more times monthly	Never
			n (%)		
Grains, cereals, white roots and tubers, and plantains	79 (69.3)	30 (26.32)	5 (4.39)	0 (0.0)	0 (0.0)
Pulses (beans, peas and lentils)	35 (30.7)	60 (52.63)	14 (12.28)	4 (3.51)	1 (0.88)
Nuts and seeds	11 (9.65)	40 (35.09)	4 (3.51)	53 (46.49)	6 (5.26)
Dairy	9 (7.89)	29 (25.44)	8 (7.02)	40 (35.09)	28 (24.56)
Meat, poultry, and fish	15 (13.16)	48 (42.11)	5 (4.39)	45 (39.47)	1 (0.88)
Eggs	4 (3.51)	29 (25.44)	1 (0.88)	64 (56.14)	16 (14.04)
Dark green leafy vegetables	26 (22.81)	52 (45.61)	16 (14.04)	19 (16.67)	1 (0.88)
Other vitamin A-rich fruits and vegetables	18 (15.79)	54 (47.37)	14 (12.28)	26 (22.81)	2 (1.75)
Other vegetables	9 (7.89)	56 (49.12)	21 (18.42)	27 (23.68)	1 (0.88)
Other fruits	11 (9.65)	38 (33.33)	16 (14.04)	46 (40.35)	3 (2.63)

The study reveals that adolescents primarily consume a monotonous diet, mainly plant-based micronutrient sources like dark-green leafy vegetables and vitamin A-rich foods, which predispose them to micronutrient deficiencies and poorer nutritional status. Seventy percent of them fail to meet their recommended daily intake of five food groups. These findings corroborate with a study by Corsi (Corsi et al., 2011) who found a higher prevalence of undernutrition among Bangladeshi children from poorer households, neighborhoods, living environments, or geographic regions and with poor food consumption. The current study also reports a higher prevalence of stunting and thinness than a similar study by Oladosu (Oladosu Gbenga et al., 2022) conducted in Abeokuta, Nigeria.

Accordingly, Figure 4 represents the frequency distribution (in percentage) of micronutrient deficiency of iron, zinc, vitamin A, and calcium in the in-school adolescents. A remarkably high percentage of the adolescents were deficient in iron (95.3%) and zinc (54.7%). While a significant percent of them were calcium (33.3%) and vitamin A (40.0%) deficient. The figure also carries the mean levels of calcium, iron, zinc, and vitamin A with values being 9.35±0.85 µg/dL, 30.90±11.90 µg/dL, 121.95±67.75 µg/dL, and 38.40+4.15 µg/dL respectively. The normal ranges were 8.8-10.2 µg/dL, 60-170 µg/dL, 80-120 µg/dL, and 20-70 µg/dL for calcium, iron, zinc, and vitamin A respectively.

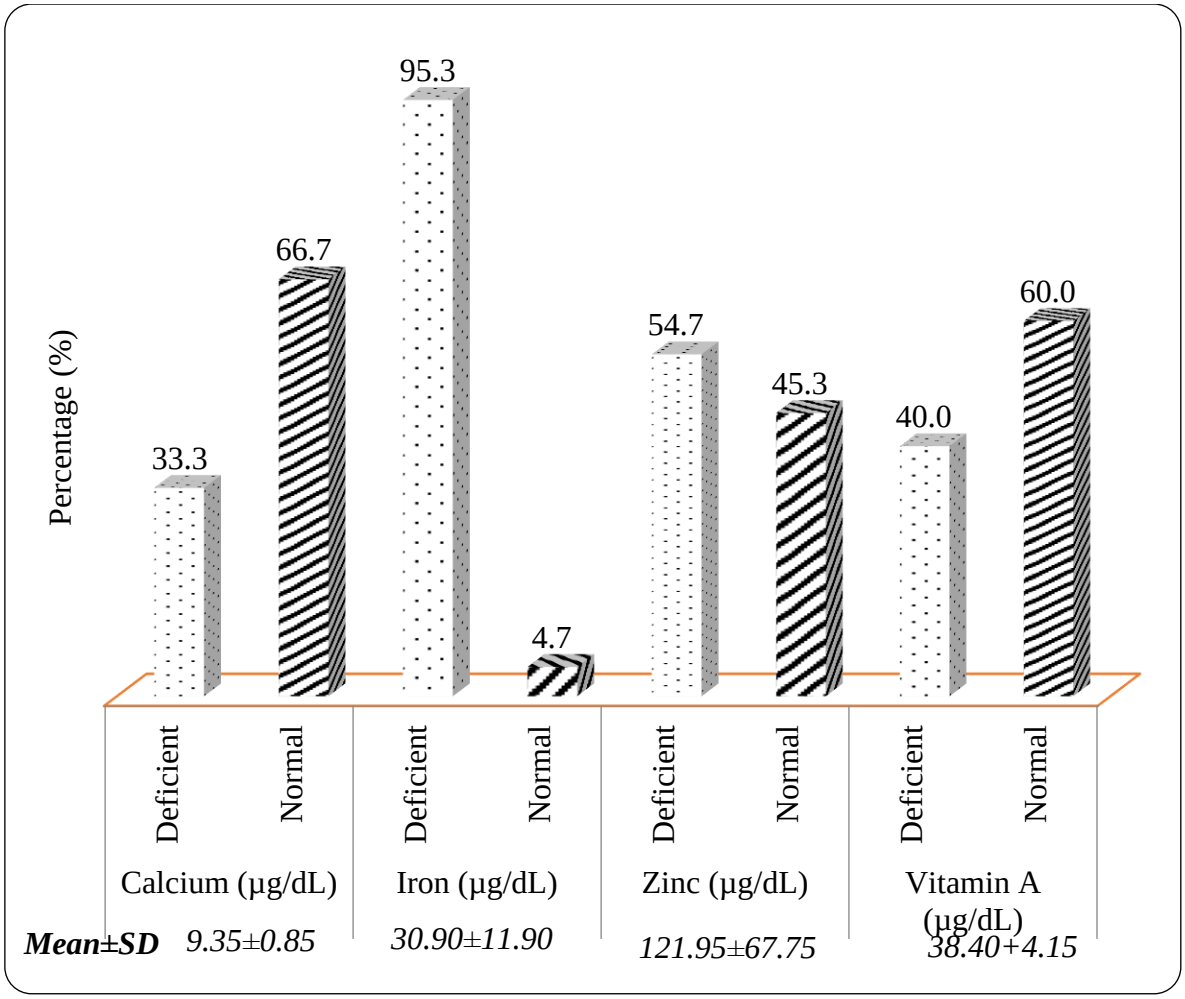

Figure 4: Frequency Distribution (in percent) of Micronutrient Deficiencies among In-school Adolescents in Sabon Gari Local Government Area, Nigeria

An independent sample t-test shows only the mean level of iron to be significantly (p = 0.042) lower than the normal range. However, the distribution of participating adolescents based on the mean levels of four micronutrients (calcium, iron, vitamin A, and zinc) shows that there were remarkably higher percentages of adolescents that were deficient in iron and zinc and substantial percentages of the same adolescents that were deficient of calcium and vitamin A. The prevalence of iron, zinc, vitamin A, and calcium were mostly higher than reported prevalences in studies by Oladosu, (Oladosu Gbenga et al., 2022) Awasthi, (Awasthi et al., 2022) and Pullakhandam (Pullakhandam et al., 2021). However, they (Pullakhandam et al., 2021) reported higher inadequacies of calcium and vitamin A than the current study.

The result of Table 4 shows the association between micronutrient status and minimum dietary diversity. The Table reveals that iron (p=0.004) and calcium (p=0.042) are significantly associated with dietary diversity of the adolescents.

Table 4: Association between Micronutrient Deficiencies and Minimum Dietary Diversity of In-school Adolescents in Sabon Gari LGA, Kaduna State

Micro- Nutrient		Diversified (%)	Not Diversified (%)	Chi-square test p-value
Calcium (µg/dL)	Deficient	38.7	61.3	**0.042***
	Normal	54.8	45.2	
Iron (µg/dL)	Deficient	49.2	50.8	**0.004***
	Normal	66.7	33.3	
Zinc (µg/dL)	Deficient	54.3	45.7	0.451
	Normal	44.8	55.2	
Vitamin A (µg/dL)	Deficient	50.0	50.0	0.133
	Normal	55.6	44.4	

Furtherance to that, an evaluation of the association between micronutrient levels and dietary diversity (Table 4) conforms to an earlier suggestion by Gómez (Gómez et al., 2020) that poor dietary diversity is a risk factor for micronutrient deficiency, with two out of four deficiencies significantly associated with dietary diversity. Hence, adolescents with limited diet diversification have higher percentages of these deficiencies.

CONCLUSION

In conclusion, the adolescents are predominantly male and are in their late adolescent stage. They are from low-income households with poorer access to social care and health services. Our results suggest that large household sizes result in adolescent food insecurity, below normal micronutrient levels, and dietary diversity in the study area, a peri-urban settlement in Northwest, Nigeria. The high prevalence of food insecurity is linked to poor dietary choices, resulting in adolescents consuming high-energy and low-micronutrient-rich foods. As a result, many are thin and stunted, probably due to higher iron and zinc deficiencies. We hope that this study will help in developing effective policies and interventions at the local government level, state level and national level to ensure food security and improve nutrition in these areas and in Nigeria as a nation.

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