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ASSESSMENT OF ANTHROPOMETRIC INDICES, FOOD CONSUMPTION PATTERN AND IRON STATUS OF ADOLESCENT GIRLS ATTENDING SECONDARY SCHOOLS IN SABON GARI LGA, KADUNA STATE, NIGERIA

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ABSTRACT

This study was cross-sectional study where adolescent girls between 10 and 18 years were selected using a multistage sampling technique. The anthropometric indices, food consumption patterns and iron status of the school girls attending secondary schools in Sabon Gari Local Government Area, Kaduna State, Nigeria was assessed. Serum iron, ferritin, hemoglobin, total iron binding capacity (TIBC) and transferrin saturation (TSAT) were measured using standard procedures. The results of the study showed that majority of the girls are mid (14-16 years) adolescents. BMI-for-age showed that 81.7% of the girls have normal BMI-for-age, 6.1% were overweight and 3.9% were obese. Cereals, soft drinks and sugar are highly consumed; legumes, milk and products, fruits and vegetables, tea and beverages are moderately consumed while meat, fish and sea foods and eggs have low consumption pattern. Dietary diversity showed that 81.1% did not meet minimum dietary diversity while 18.9% met the minimum dietary diversity. Mean serum ferritin of adolescent girls is 34.4±2.2ng/ml, hemoglobin is 10.08±1.7g/dl, mean serum iron is 55.85±9.2µg/dl, mean TIBC is 322.98±22.7, while mean TSAT is 24.73±12.1%. Increase in adolescents age, (p=0.03), increase in family size (p=0.041) and low education level of parents (p=0.047) have significant association with serum ferritin. Attending public school (p=0.041) and low education level of parents (p=0.03) have significant association with hemoglobin. The findings of this study show that iron deficiency anemia is of moderate public health significance while anemia is of high public health significance among adolescent girls attending secondary schools in Sabon Gari LGA of Kaduna State.

Keywords: Anemia, Adolescent school girls, BMI-for-age, Dietary pattern

INTRODUCTION

Adolescence is a stage of transition from childhood into adulthood (Patton *et al*., 2016). Adolescence is a period of rapid growth and maturation, second only to the first 1000 days of life (Patridge *et al*., 2022). It is a period of enormous physical and psychological changes that involves individuals between 10 and 19 years and is characterized by increase in nutrient requirements (WHO, 2014a; Azupogo et al., 2021). During adolescence, an individual acquires the physical, emotional, cognitive, social and economic development; that are foundation for later life, future health and wellbeing (Patton *et al*., 2016). Some cultural practices, traditions, ignorance and taboos affect food consumption as well as the general well-being of adolescent girls (Shahhosseini *et al*., 2013). Due to low socio-economic power, adolescent girls in low and middle income countries experience food insecurity and malnutrition; which suggests that their food is less likely to meet their nutritional needs and adequacy; these factors could predispose them to risk of nutritional deficiencies which include anemia (Shahhosseini *et al*., 2013). Anemia is the reduction in the oxygen carrying capacity of the blood; which is characterized by reduced levels of hemoglobin concentration and red cell mass (WHO, 2011). The most common cause of anemia is iron deficiency. However, other conditions which cause anemia include deficiencies of some micronutrients like vitamin B12, folate, protein, congenital factors and diseases such as malaria and helminth infection (Pollock and Muduma, 2017). Iron is an important mineral required for various functions in the body which include, proper functioning of proteins and enzymes (Zhang, 2014). In adolescent girls, there is increased requirement for iron which is due to growth spurt, onset and blood loss during menstruation, as well as sexual maturation (Das *et al*., 2017). Low iron status predisposes adolescent girls to iron deficiency anemia (IDA) which is associated with significant morbidity, especially for girls from rural, poor and illiterate parents who have their first pregnancies as teenagers with low iron stores (Kassa *et al*., 2018). About 1.5 million people are affected by iron deficiency and anemia across Nigeria yearly, with a big impact on female's health (NSN, 2022). There are life-long adverse reproductive and poor socioeconomic outcomes among women with adolescent birth; especially those with repeated births during adolescence (Amongin *et al*., 2021). There is paucity of data on adolescent girls' nutritional status. Therefore, this study provides information on the nutritional and Iron status of adolescent girls attending secondary schools in Sabon gari LGA of Kaduna State Nigeria. .

MATERIALS AND METHODS

Study Area

Sabon gari Local Government Area is one of the 23 LGAs of Kaduna State. It has a boundary with Ikara and Kudan, Giwa, Zaria and Soba Local Government areas in the North, West, South and East respectively. Sabon gari is located between the latitude 110 06' 60.00' N and a longitude of 70 43' 59.99' E and covers a land area of about 60,000 Km^2 (Official health data and records, 2010, as cited in Igboanusi, *et al.*, 2019).

Study Design and Sampling Technique

The study was a school-based cross-sectional study where data was collected at a point in time. Multistage sampling technique was used. Stratified sampling was used to select 4

wards in the Local Government, where the LGA was stratified into four (North, South, East and West) and one ward was selected from each stratum by balloting. One public secondary school and two private schools were selected from each of the selected wards and proportionate sampling was used to select study participants in each school. Girls who showed interest were given written consent forms to seek for their parents' consent and only girls whose parents signed the consent forms were recruited into the study

Sample Size Determination
Sample size was calculated using the conventional formula (Hamed, 2017).

$$n = \frac{Z^2 pq}{d^2}$$

Where: n = The desired sample size;
z = Confidence level at 95% which is usually 1.96;
p = The prevalence of malnutrition among adolescents in Kaduna State;
q = 1-p;
d = Degree of accuracy desired, set at 0.05.

Data Collection
Anthropometric measurements were obtained as described in the food and nutrition technical assistance guide (Cogill, 2003). Socio-demographic characteristics and food consumption pattern were obtained using semi structured and food frequency questionnaires respectively.

Blood Sample Collection
Blood samples were collected through venous puncture using standard procedures as described by Oguizu (2015) using the services of a professional phlebotomist.

Determination of Hemoglobin Concentration
Hemoglobin concentration was determined using hemoglobin meter and readings were recorded within 15 seconds.

Determination of Serum Ferritin
Serum ferritin was spectrophotometrically determined using AccuBind ELISA commercial assay kit.

Determination of serum iron
Serum iron was determined using iron Nitro-PAPS KIT according to manufacturer's instructions.

Total iron Binding Capacity (TIBC)
TIBC is determined using Centronic GmbH Iron TIBC commercial kit.

Transferrin Saturation
Transferrin saturation is calculated by dividing value of serum iron by TIBC and multiplying by 100. That is; Serum Iron / TIBC ×100.

Statistical Analysis
The data obtained from the survey was analyzed using SPSS version 22.0. Descriptive statistics was used to summarize data using tables and charts. Anthro-plus software was used to analyze anthropometric indices. P-values ≤ 0.05 was considered significant.

Compliance with Ethical Standards
Study was performed in line with the principle of the declaration of Helsinki. Ethical clearance for this study was obtained from the Ethics and research committee, Ahmadu Bello University, Zaria and approved by Ministry of Health Kaduna State with approval numbers ABUCUHSR/2022/005 and NHREC/17/03/2018 respectively. Permission was obtained from the Zonal Education Boards principals of various schools selected for the study. Informed consent was sought from adolescents who were 18 years and from parents of adolescents less than 18 years using standard protocols. Assent was also sought from adolescents less than 18 years.

RESULTS AND DISCUSSION
Table 1 describes the socio-demographic characteristics of the study population. A total of 82 (46%) girls from 6 private schools and 98 (54%) girls from 5 public schools were studied. Among the girls from private schools, 44 (53.7%) were in early adolescence age of 10 to13 years, 34 (41.5%) were in mid adolescence age of 14 to 17 years, only 4 (4.9%) were in late adolescence age of 18 years and above. Among the girls from public schools, 34 (34.7%) were in early adolescence, 48 (49%) were in mid adolescence while 16 (16.3%) were in late adolescence. The major ethnic group among the adolescent school girls is Hausa, in which 43 (52%) were in private schools and 71 (72%) from public schools. Among the respondents from private schools, 45 (54.9%) are Muslims while 37 (45%) are Christians. In public schools, 81 (82.7%) are Muslims while 17 (17.3%) are Christians. The larger percentage 77 (42.8%) of the parents of the adolescent school girls are civil servants, 68 (37.8%). Majority of the parents of the adolescent school girls have secondary school education 88 (48.9%), those with tertiary education are 82 (45.6%), those with primary education are 6 (3.3%) and 4 (2.2%) have informal education. The larger percentage of the adolescent girls 111 (61.7%) are from family size of 6 to 10.

Table 1: Socio-demographic Characteristics of Adolescent School Girls in Sabon Gari LGA, Kaduna State (n=180)

Characteristics		School Type		
		Private	Public	Total
		n(%)	n(%)	n(%)
Age (Years)	Early (10-13)	44(53.7)	34(34.7)	78(43.3)
	Mid (14-16)	34(41.5)	48(49.0)	82(45.6)
	Late (17-19)	4(4.9)	16(16.3)	20(11.1)
Ethnicity	Hausa	43(52.4)	71(72.4)	114(63.3)
	Yoruba	8(9.8)	7(7.1)	15(8.3)
	Igbo	10(12.2)	0(.0)	10(5.6)
	Others	21(25.6)	20(20.4)	41(22.8)
Class	Junior Secondary School	39(47.6)	28(28.6)	67(37.2)
	Senior Secondary School	43(52.4)	70(71.4)	113(62.8)
Religion	Islam	45(54.9)	81(82.7)	126(70.0)
	Christianity	37(45.1)	17(17.3)	54(30.0)

Characteristics		**School Type**		
		Private	**Public**	**Total**
		n(%)	**n(%)**	**n(%)**
Living With	Parents	70(85.4)	89(90.8)	159(88.3)
	Guardian	12(14.6)	9(9.2)	21(11.7)
Occupation	Farmer	3(3.7)	13(13.3)	16(8.9)
	Trader	35(42.7)	33(33.7)	68(37.8)
	Civil Servants	35(42.7)	42(42.9)	77(42.8)
	Artisan	2(2.4)	6(6.1)	8(4.4)
	Others	7(8.5)	4(4.1)	11(6.1)
Parent Education level	Primary	0(.0)	6(6.1)	6(3.3)
	Secondary	40(48.8)	48(49.0)	88(48.9)
	Tertiary	40(48.8)	42(42.9)	82(45.6)
	Informal Education	2(2.4)	2(2.0)	4(2.2)
	None	0(.0)	0(.0)	0(.0)
Family Size category	1 - 5 members	22(26.8)	10(10.2)	32(17.8)
	6 - 10 members	49(59.8)	62(63.3)	111(61.7)
	11 - 15 members	7(8.5)	14(14.3)	21(11.7)
	16 - 20 members	3(3.7)	5(5.1)	8(4.4)
	>20 members	1(1.2)	7(7.1)	8(4.4)

Table 2 shows that grains and cereals 70 (85.4%), fats and oil 62 (75.6%), soft drinks and sugar 35 (42.7%), beverages 29 (35.4%) are highly consumed (5-7 times a week). There was moderate consumption (2-4 times a week) of legumes 46 (56.1%), meat 32 (39.0%), milk and milk products 27 (32.9%), fruits 36 (43.9%), vegetables 29 (35.4%), roots and tubers 30 (36.6%). There was low consumption (one time or less in a week) of fish and seafood 31 (37.8%) and eggs 27 (32.9%) among girls in private schools. There is significant increase in consumption of legumes (p=0.025) and vegetables (0.01) among respondents from public schools; while significant increase in consumption of meat and poultry products (p=0.003) and fats and oil (p=0.002) was recorded among respondents from public schools.

Among girls in public schools, grains and cereals 80 (81.6%) and fats and oil 49 (50.0%), are highly consumed (5-7 times a week). There was moderate consumption (2-4 times a week) of legumes 51 (52.0%), milk and milk products 33 (33.7%), fruits 48 (49.0%), vegetables 42 (42.9%), roots and tubers 43 (43.9%), soft drinks and sugar 39 (39.8%), tea and coffee 32 (32.7%). There was low consumption (one time or less in a week) of meat 35 (35.7%) fish and seafood 34 (34.7%) and eggs 40 (40.8%).

Table 2: Food Consumption Pattern of Adolescent School Girls in Sabon Gari LGA, Kaduna State (n=180)

Food Groups	**School Type**	**n**	**Once in a week**	**2-4 times per week**	**5-6 times per week**	**Daily**	**not at all**	**P-Value**
			n(%)	**n(%)**	**n(%)**	**n(%)**	**n(%)**	
Legumes	Private	82	13(15.9)	46(56.1)	7(8.5)	9(11.0)	7(8.5)	*0.025**
	Public	98	7(7.1)	51(52.0)	12(12.2)	25(25.5)	3(3.1)	
Meat and Poultry	Private	82	10(12.2)	32(39.0)	14(17.1)	13(15.9)	13(15.9)	*0.003**
	Public	98	35(35.7)	32(32.7)	7(7.1)	9(9.2)	15(15.3)	
Fish or Seafood	Private	82	19(23.2)	22(26.8)	6(7.3)	4(4.9)	31(37.8)	*0.941*
	Public	98	28(28.6)	26(26.5)	6(6.1)	4(4.1)	34(34.7)	
Eggs	Private	82	21(25.6)	26(31.7)	2(2.4)	6(7.3)	27(32.9)	*0.126*
	Public	98	32(32.7)	23(23.5)	2(2.0)	1(1.0)	40(40.8)	
Milk and milk products	Private	82	17(20.7)	27(32.9)	5(6.1)	15(18.3)	18(22.0)	*0.494*
	Public	98	23(23.5)	33(33.7)	3(3.1)	11(11.2)	28(28.6)	
Fruits	Private	82	19(23.2)	36(43.9)	6(7.3)	3(3.7)	18(22.0)	*0.538*
	Public	98	25(25.5)	48(49.0)	8(8.2)	5(5.1)	12(12.2)	
Vegetables	Private	82	12(14.6)	29(35.4)	9(11.0)	31(37.8)	1(1.2)	*0.001**
	Public	98	12(12.2)	42(42.9)	29(29.6)	14(14.3)	1(1.0)	
Cereals and Grains	Private	82	0(0.0)	6(7.3)	6(7.3)	70(85.4)	0(0.0)	*0.631*
	Public	98	1(1.0)	6(6.1)	11(11.2)	80(81.6)	0(0.0)	
Roots and tubers	Private	82	23(28.0)	30(36.6)	5(6.1)	8(9.8)	16(19.5)	*0.592*
	Public	98	31(31.6)	43(43.9)	3(3.1)	7(7.1)	14(14.3)	
Fats and Oils	Private	82	1(1.2)	4(4.9)	15(18.3)	62(75.6)	0(0.0)	*0.002**
	Public	98	9(9.2)	13(13.3)	27(27.6)	49(50.0)	0(0.0)	
Soft drinks and Sugars	Private	82	9(11.0)	22(26.8)	8(9.8)	35(42.7)	8(9.8)	*0.285*
	Public	98	8(8.2)	39(39.8)	13(13.3)	32(32.7)	6(6.1)	
Beverages	Private	82	11(13.4)	14(17.1)	4(4.9)	29(35.4)	24(29.3)	*0.137*

Food Groups	School Type	n	Once in a week	2-4 times per week	5-6 times per week	Daily	not at all	P-Value
			n(%)	n(%)	n(%)	n(%)	n(%)	
	Public	98	15(15.3)	32(32.7)	4(4.1)	23(23.5)	24(24.5)	

Figure 1 shows the dietary diversity of the adolescent girls. Among the adolescent girls, 34 (18.9%) have diversified consumption while 146 (81.1%) have undiversified consumption.

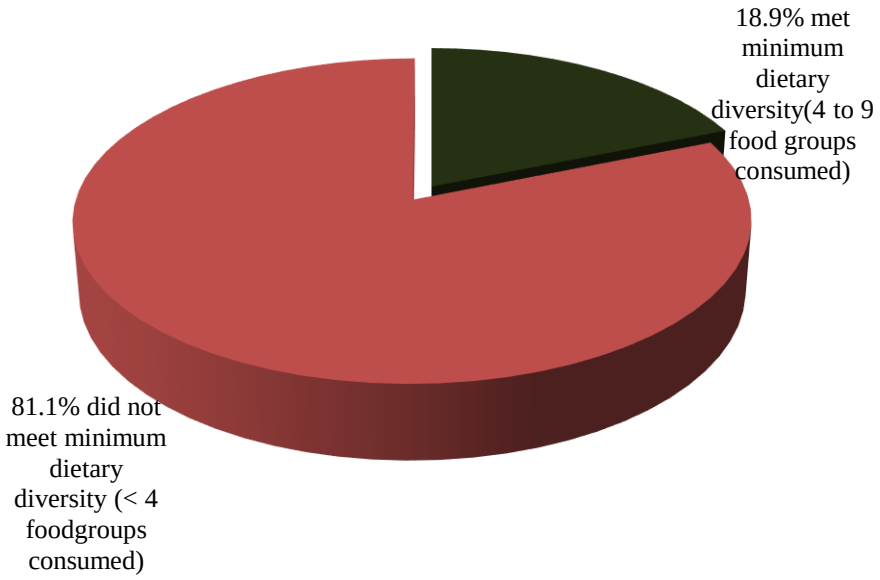

Figure1: Dietary Diversity of Adolescent School Girls in Sabon Gari LGA, Kaduna State

Figure 2 shows the BMI-for-age of adolescent school girls. Girls with severe thinness (<-3SD) were 1.7% while 6.7% were thin (<-2SD), 81.7% were normal, 6.1% were overweight (>+ 1SD) and 3.9% were obese (>+2SD).

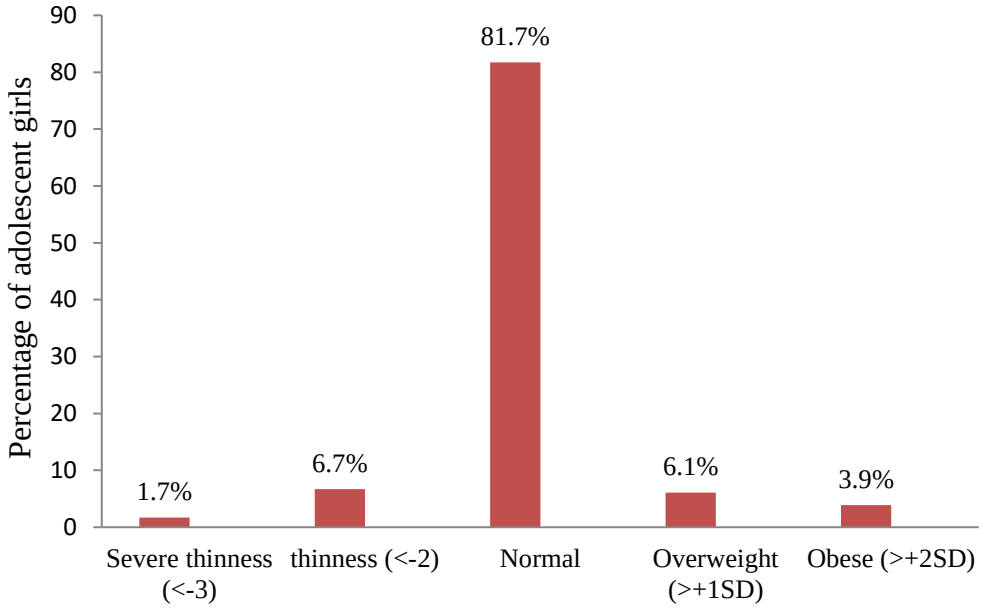

Figure 2: BMI-for-age of Adolescent School Girls in Sabon Gari LGA, Kaduna State

Table 3 describes the BMI-for-age of adolescent girls based on school type. Among girls from private schools, 5 (41.7%) were thin (<-2 SD), 68 (46.3%) were normal, 5 (45.5%) were overweight (>+1SD) and 4 (57.1%) were Obese (>+2SD). In public schools, 3 (100%) were severely thin (<-3SD), 7 (58.3%) were thin (<-2 SD), 79 (53.7%) were normal, 6(54.5%) were overweight (>+1SD) and 3 (42.9%) were obese (>+2SD) (p>0.05).

Table 3: BMI-for-age Distribution of Adolescent School Girls in Sabon Gari LGA, Kaduna State According to School Type

BMI-for-age	School Type		Chi square test
	Private	Public	
	n(%)	n(%)	
Severe thinness (<-3)	0(0.0)	3(100)	χ^2=2.992
thinness (<-2)	5(41.7)	7(58.3)	*df=4*
Normal	68(46.3)	79(53.7)	*p=0.559*
Overweight (>+1SD)	5(45.5)	6(54.5)	
Obese (>+2SD)	4(57.1)	3(42.9)	

*n= 180, χ^2= Chi square, df= Degree of freedom, p= Probability value, SD= Standard deviation

Table 4 describes distribution of the dietary diversity of adolescent school girls in Sabon Gari LGA of Kaduna State according to school type and age group. A total number of 34 (18.9%) of the adolescent girls have diversified consumption (have consumed between 4 and 9 food groups); 21 (25.6%) of them from private schools while 13 (13%) from public schools. The remaining adolescent girls who did not meet the minimum dietary diversity were 146 (81.1%); among which 61 (74.4%) were from private schools while 85 (86.7%) are from public schools. There is significant increase in diversified consumption of girls from private schools (p=0.035) and mid adolescent girls (p=0.042).

Table 4: Distribution of Dietary Diversity of Adolescent School Girls in Sabon Gari LGA, Kaduna State According to School and Age Category

Variable		Dietary Diversity		Chi-Square Test
		Met minimum dietary diversity (4 to 9 food groups consumed) n= 34	Minimum dietary diversity unmet (< 4 food groups consumed) n=146	
		n (%)	n (%)	
School Type	Private	21(25.6)	61(74.4)	χ^2=4.440 *df=1*
	Public	13(13.3)	85(86.7)	*p=0.035**
Age (Years)	Early (10-13)	9(11.5)	69(88.5)	χ^2=6.323 *df=2*
	Mid (14-16)	22(26.8)	60(73.2)	*p=0.042**
	Late (17-18)	3(15.0)	17(85.0)	

*Results are significant at p<0.05

Table 5 shows that 14 (24.1%) girls were iron deficient (SF <15ng/mL), among which 10 (17.2%) were from public schools and 4 (6.9%) were from private schools. A total of 58(76.3%) were anemic; out of which 40(52.6%) were from public schools and 18(23.7%) were from private schools. A total of 13 (22.4%) girls had iron deficiency anemia (Hemoglobin <12g/dl, Serum Ferritin <15ng/mL, Serum Iron <37µg/dL, TIBC>400µg/dL and TSAT <15%). Among which 9(15.5%) were from public schools while 4(6.9%) were from private schools.

Table 5: Prevalence and Classification of Iron Status of Adolescent School Girls in Sabon Gari LGA, Kaduna State According to School Type

Iron Status	Indicator(s)	Prevalence			
		Public n(%)	Private n(%)	Total n(%)	Chi square Test (χ^2)
Iron Deficiency	Serum Ferritin <15ng/mL[1]	10(17.2)	4(6.9)	14(24.1)	0.043*
Anemia	Hemoglobin <12g/dl	40(52.6)	18(23.7)	58(76.3)	
Iron Deficiency Anemia	Hemoglobin <12g/dl,[2] Serum Ferritin <15ng/mL, Serum Iron <37µg/dL, TIBC>400µg/dL and TSAT <15%	9(15.5)	4(6.9)	13(22.4)	

[1]WHO. (2020). [2] Peng and Uprichard. (2017)

Table 6 shows the association between serum ferritin and some socio-demographic characteristics of adolescent girls. There is significant association between adolescent age group (χ^2 = 11.471, p=0.03), parents' level of education (χ^2 = 17.174, p=0.47) and family size (χ^2 = 15.089, p=0.041) with serum ferritin.

Table 6: Association of Serum Ferritin and Some Socio-demographic Characteristics of Adolescent School Girls in Sabon Gari LGA, Kaduna State

Socio-demographic Characteristics		Serum Ferritin		
		Low %	Normal %	Chi-Square Test χ^2 (p-value)
School	Private	13.0	87.0	0.167(0.067)
	Public	17.0	83.0	
Age (Years)	Early (10-13)	14.3	85.7	11.471(0.03*)
	Mid (14-16)	16.7	83.3	
	Late (17-19)	20.0	80.0	
Occupation	Farmer	22.2	77.8	2.720(0.060)
	Trader	22.2	77.8	
	Civil Servants	15.4	84.6	
	Artisan	0.0	100.0	
	Others	0.0	100.0	
Parent Education level	Primary	66.7	33.3	17.174(0.047*)
	Secondary	9.7	90.3	
	Tertiary	17.5	82.5	
	Informal Education	0.0	100.0	
	None	0.0	0.0	
Family Size category	1 - 5 members	0.0	100.0	15.089(0.041*)
	6 - 10 members	15.6	84.4	
	11 - 15 members	30.0	70.0	
	>15 members	33.3	66.7	

*Results are significant at p<0.05

Table 7 shows the association of hemoglobin level and some socio-demographic characteristics of the adolescent girls. There is significant association between type of school (χ^2 = 10.029, p=0.041), and parents' level of education (χ^2 = 18.573, p=0.03), with hemoglobin level of adolescent girls. Adolescent age group, parents' occupation and family size do not have significant association with level of hemoglobin (p>0.05).

Table 7: Association of Hemoglobin Level and Some Socio-demographic Characteristics of Adolescent School Girls in Sabon Gari LGA, Kaduna State

Socio-demographic Characteristics		Hemoglobin		
		Low %	Normal %	Chi-square χ^2 (p-value)
School	Private	91.3	8.7	10.029(0.041*)
	Public	92.5	7.5	
Age (Years)	Early (10-13)	91.4	8.6	
	Mid (14-16)	91.7	8.3	
	Late (17-19)	100.0	0.0	
Occupation	Farmer	100	0	5.675(0.225)
	Trader	100	0	
	Civil Servants	89.7	10.3	
	Artisan	85.7	14.3	
	Others	66.7	33.3	
Parent Education level	Primary	100	0	18.573(0.030*)
	Secondary	90.3	9.7	
	Tertiary	92.5	7.5	
	Informal Education	100	0	
	None	0	0	
Family Size	1 - 5 members	92.9	7.1	2.032(0.730)
	6 - 10 members	93.3	6.7	
	11 - 15 members	90	10	
	>15 members	75	25	

*Significant at p<0.05

Table 8 shows the association between serum ferritin and hemoglobin with BMI-for-age of adolescent girls. There is significant association between severe thinness and serum ferritin (χ^2= 1.254, p=0.04) as well as with hemoglobin (χ^2 = 10.623, p=0.031).

Table 8: Association of some Iron Status Indicators (Serum Ferritin and Hemoglobin) and BMI-for-age of Adolescent School Girls in Sabon Gari LGA, Kaduna State

BMI-for-age	Serum Ferritin		
	Low	Normal	Chi-Square Test
	%	%	χ^2(p-value)
Severe thinness (<-3)	100	0	1.254(0.040*)
Thinness (<-2)	20	80	
Normal	16.9	83.1	
Overweight (>+1SD)	0	100	
Obese (>+2SD)	0	100	
	Hemoglobin		
Severe thinness (<-3)	100	0	10.623(0.031*)
Thinness (<-2)	100	0	
Normal	6.2	93.8	
Overweight (>+1SD)	50	50	
Obese (>+2SD)	50	50	

Discussion

The socio-demographic characteristics of the adolescent girls showed that majority of the secondary school girls are mid adolescents (45.6%). This may be due to the fact that most late adolescents have completed secondary education. This is in agreement with studies carried out by Olumakaiye (2013) and Drenkat (2016). The predominant ethnic group among the adolescent school girls is Hausa (63.3%) and this is because Sabon Gari LGA majorly comprises Hausa ethnic group while other ethnic groups are almost mixture of equal proportion. This is in agreement with the report by Official health data and records of Sabon gari (2010). The major religion of the school girls is Islam (70%) while Christianity is 30%. This may be due to predominance of Hausas. Majority of adolescent girls are from families comprising of 6-10 family members. This is similar to that reported by Turki *et al.* (2018) where factors influencing the nutritional status of adolescent girls in Riyadh/Saudi Arabia was assessed.

The results of food consumption pattern of adolescent school girls showed that in general, majority of the girls highly consume cereal grains and starchy foods. This may be due to financial constraints or lack of nutrition education. Legumes, vegetables, milk and dairy products are consumed moderately while meat, fish, seafood, eggs and fruits are not adequately consumed, this may be due to financial constraints. This is in par with reports by Drenkat (2016). Orange was the most commonly consumed fruit and soups such as okro, tomato and baobab were the major sources of vegetable consumption. This may be due to accessibility, availability and affordability of the mentioned fruit and vegetables. The inadequate consumption of meat, consumption of beverages and tea with meals; may contribute to iron deficiency anemia because tea and beverages are sources of iron absorption inhibitors (Rati and Jawadagi 2014).

The mean weight, height and BMI of adolescent girls in private schools were lower than those of girls from public schools with significant increase in height. This may be due to higher proportion of mid and late adolescents found in public schools. Majority of the adolescent school girls have normal BMI for age; this is in agreement with Onabanjo and Balogun (2014) and Drenkat (2016). 1.7% of the girls had severe thinness while 6.7% were thin; which is an indication of severe energy deficiency. This is lower than reports by (Gebregyorgis *et al*., 2016), where 21.4% of adolescents were thin. From the same study, there was higher proportion of thinness was found in public schools (22.8%) compared to the private schools (8.5%) and this is similar to pattern of results obtained from this study. From this study, 6.1% of the adolescent girls were overweight while 3.9% were obese. This is similar to reports by Atoh *et al*. (2023), where 8.9% and 2.7% were overweight and obese respectively. Obesity have been reported as risk factor for iron deficiency (Aigner *et al*., 2014), this suggests that obese or overweight adolescents are at higher risk of iron deficiency anemia compared to their non-obese counterparts. Umar *et al.* (2018) reported higher prevalence of overweight and obesity among females compared to male in his studies, this indicate that risk of iron deficiency anemia is higher in adolescent girls than their male counterparts. Tesfaye *et al*. (2015), in his study found that female adolescents were 3.04 times more likely to be anemic than male adolescents. Severe thinness was only recorded among adolescents attending public schools; none was recorded for adolescents in private schools, which is in agreement with findings by Drenkat (2016). Affluent kids or children of high income earners are mostly found in private schools, they consume high amount of junks, which is connected to adolescence and urbanization (Pengpid and Peltzer, 2019); they do not engage in adequate physical activities which may be the reason for higher prevalence of obesity in private schools when compared to public schools. Similar to the reports by Umar *et al.* (2018), prevalence of overweight and obesity in the subjects in high social class as 15.6% and 7.0% respectively, while the prevalence in the subjects from the low social class was 5.1% and 1.1% respectively. The total number of girls with severe thinness and thinness (8.4%) are less than the total girls found with overweight and obesity (10%). Similar reports was observed by Ejike *et al*. (2013). This is also in agreement with reports by Wariri *et al*. (2020) where 6.0% of adolescents were thin and 9.6% were overweight and obese. Reports by Abdullahi, *et al*., (2021) have a higher percentage of underweight among adolescents in Dankande community. This may be multiple factors including education, and gender as majority of the participants in the study is males

The results of dietary diversity of adolescent school girls shows that only 18.9% met the minimum dietary diversity (they consumed between 4 and 9 food groups) while majority (81.1%) did not meet the minimum dietary diversity (less than 4 food groups were consumed). The larger percentage of adolescent girls with undiversified food consumption was from public schools (58.2%), and girls with undiversified consumption were found with higher proportion malnutrition in form of severe thinness and even obesity. This may be as a result of common consumption of monotonous diet, high consumption of starchy and oily foods, as well as consumption of junks as seen in their food consumption

pattern. The results of this study show both obesity and thinness in population of adolescents with undiversified dietary consumption. Similar result was reported by Adeomi *et al*. (2022) where diversified dietary pattern had an inversely significant association with thinness and overweight/obesity; while the traditional dietary pattern (that is undiversified dietary pattern) had a positively significant association with overweight/obesity therefore, contributing to the double burden of malnutrition.

There are reports of double burden of malnutrition in many low and middle-income countries. It is not uncommon that overweight and under nutrition co-exist in populations, households or even individuals (Blaak, 2020). This double burden of malnutrition is high among female especially adolescent girls, which may lead to poor health outcomes for the adolescents and sustained intergenerational effects (Keats *et al*., 2018). The global malnutrition crisis includes hunger and under-nutrition and then diet-related non-communicable diseases (NCDs) – mainly overweight, obesity, diabetes, cardiovascular disease and cancer. This double burden of malnutrition has vast health, economic and environmental implications, affecting every country of the world in one form or the other (GNR, 2020). Non-communicable diseases are prevailing public health concern among adolescents globally, majority of the burden of NCDs in adulthood are related to modifiable factors and lifestyle that start in adolescence (Askeer *et al*., 2020).

The result of this study shows that most of the adolescents were anemic (76.3%), which is similar to reports by Turki *et al*. (2018) in Riyadh, Saudi Arabia where 77.6% of adolescent girls had low hemoglobin (Hb) and 22.4% had normal hemoglobin levels. Rati and Jawadagi (2014) reported 80% anemia prevalence among adolescent school girls in Nidoni, India. In contrast, reports of adolescents study by Onabanjo and Balogun, (2014) in Ogun State shows 24.4% anemia, this may be due to difference in socio-demographic characteristics and dietary pattern. Mild anemia was the most prevalent (43.4%) and among mid adolescents (22.4%) in this study. This is similar to reports by (Rati and Jawagadi, 2014). Severe anemia was only recorded among girls from public schools. Among the reasons for high prevalence of anemia among adolescent girls is menstrual iron loss superimposed on them by nature, thereby becoming an unavoidable risk for them (Kumari *et al*., 2017). The high iron needs for hemoglobin formation, low intake of iron containing foods, bad eating habits, consumption of tea and other iron absorption inhibitors are other possible reasons for high prevalence of anemia (Rati and Jawagadi, 2014). In this study, anemia was more prevalent in public secondary schools (52.6%) than private schools (23.7%) and this may be due to higher sample size obtained from public schools. Although it corroborated the food consumption pattern and dietary diversity in which girls from private schools had better food consumption pattern and dietary diversity than those from public schools. There was no case of high serum ferritin (SF) identified (SF >150 µg/L) among the adolescent girls, this is similar to the reports by Onabanjo and Balogun (2014). The prevalence of iron deficiency (SF<15ng/mL) in this study was 24.1% which is of moderate public health significance. Iron deficiency can result due to less nutritional supply, consumption iron absorption inhibitors, increased iron demand or blood loss as observed in most adolescent girls (Kumari *et al* ., 2017). Some dietary components affect iron bioavailability. A study by Chaturvedi *et al*. (2017) reported increased association on consumption of tea and coffee post meals ('r'=0.892) with iron deficiency anemia. The absorption of non-heme iron found in plant based diets (common source of iron for most respondents in this study) is increased by meat and ascorbic acid and inhibited by calcium, phytates and polyphenols, mostly found in beverages, local herbs and tea (Beck, 2016).

Prevalence of iron deficiency anemia (low Hb, low SF, low serum iron, low TSAT and high TIBC) was 22.4% in this study. This suggests that the cause of anemia in this study is not only iron deficiency. Out of the 76.3% adolescent girls who were anemic, 22.4% was due to iron deficiency, while 53.9% was due to other causes. There are several other causes for low hemoglobin levels especially in malaria endemic areas like Nigeria. Dawaki *et al.* (2016) reported 60.6% prevalence rate of malaria for studies carried out in Kano, this is in agreement with the report by Onyiri (2015), whose reports on malaria showed prevalence ranging from 20% to 70% in different parts of the Nigeria. From reports by Kao *et al.* (2019) in a children's study in Kenya; children currently infected with hookworm, malaria or any other infection had a significant decline in hemoglobin. According to reports by Starck *et al*. (2022), malaria caused a substantial decrease in hemoglobin levels among children which make them susceptible to severe anemia The etiology of anemia is multifactorial, so prevalence estimates of iron deficiency anemia based on hemoglobin alone are overestimations, because they fail to account for other causes of anemia, such as nutritional deficiencies of vitamin A, vitamin B_{12}, folic acid, infectious disorders and diseases (particularly malaria and helminth infections), hemoglobinopathies and ethnic differences in normal hemoglobin distributions (Pollock and Muduma, 2017). Ayogu *et al*. (2015) reported malaria, parasitic infections, consumption of food with low bioavailability, large household size and frequent illness bouts are causes of poor iron status and low hemoglobin levels among 6-15 year olds in a rural area of Nsukka, Nigeria. The major contributing factors for anemia among different age groups are malaria and helminth infections (Ayogu *et al*.. 2015; Starck *et al*., 2022) Hookworm infection was associated with higher odds of anemia (Grimes et al., 2017). Studies on pregnant women also revealed that coffee consumption and hookworm infection were factors significantly associated with anemia (Kumera *et al*., 2018). Periodic deworming, chemoprophylaxis preventive treatment and oral iron supplementation are courses for prevention and cure of anemia on immediate measures (WHO, 2014b; Gopalakrishnan *et al*., 2018). There are various factors associated with adolescent iron deficiency and anemia. In this this study, being a late adolescent, larger family size, low parents' level of education and being in public school have positive significant associations with adolescent girls' serum ferritin and hemoglobin levels. Similar results have been reported by Ayogu (2015), Turki (2018) and Wiafe (2020). This implies that late adolescents from larger households, attending public schools, having parents with low education level are most likely to be anemic compared to their private schools counter parts from smaller households with more educated parents.

CONCLUSION

This study gives insight on the socio-demographic characteristics and nutritional status of adolescent girls attending secondary schools in Sabon gari LGA of Kaduna State. Majority of the adolescent girls are mid adolescents from family size of 6 to 10 whose parents are civil servants with secondary school and tertiary education. Most girls have normal BMI and BMI-for-age. There is significant increase in height of girls in public schools. Most adolescent girls do not consume up to four food groups in their diet hence their minimum dietary diversity was unmet (81.1%). Also their

dietary diversification is in line with the differences observed in food consumption pattern which shows significantly higher consumption of animal protein by girls from private schools when compared to their public school counterparts. There was high prevalence of anemia (76.3%) which is a public health hazard and iron deficiency anemia accounts for 22.4%. The larger percentage of the anemia was from public school (52.6%) while 23.7% was accounted for by girls in private schools. A significant association was found between family size, parents' level of education, type of school, adolescents' age, as well as being severely thin with iron status indicators (hemoglobin and ferritin). Base on this study, it is therefore recommended that advocacy and awareness creation for both parents and girls on ways to improve iron status is essential; this includes compliance with interventions of iron supplementation, consumption of iron-rich foods. In the same vein, the results from this study can help the Sabon Gari LGA in decision making about the adolescent girls nutrition intervention.

REFERENCES

Abah, S. O., Aigbiremolen, A. O., Duru, C. B., Awunor, N. S., Asogun, A. D., Enahoro, F O., and Akpede, M. E. (2012). Prevalence of overweight and obesity among students in private and public secondary schools in a peri-urban Nigerian town. *Journal of Biology, Agriculture and Healthcare* 2(11), 51-57. URL: https://www.iiste.org/Journals/index.php/JBAH/article/view/3662/3883

Abdullahi, H., Anigo, M.K., Owolabi, A.O., Alhassan U, Sallau, A. B., Awal, M. I., Abubakar, Y. S., Saliu, M. A., Hassan, S. M., Jajere, U. M., and Luka J. (2021). Nutritional Status of Adolescents of Dankande Community of Kaduna Metropolis. FUDMA Journal of Sciences (FJS) 5, (2), 351-357. DOI: https://doi.org/10.33003/fjs-2021-0502-624

Aigner, E., Feldman, A. andDatz, C. (2014). Obesity as an emerging risk factor for iron deficiency. *Nutrients*, 6, 3587-3600. DOI: https://dx.doi.org/10.3390/nu6093587

Amongin, D., Kagasten, A., Tuncalp, O., Nakimuli, A., Nakafeero, M., Atuyambe, L., and Benova, L. (2021). Later life outcomes of women by adolescent birth history analysis of the 2016 Uganda Demographic and Health Survey. *British Medical Journal Open*, 11(2), 1-10. DOI: https://doi.org/10.1136/bmjopen-2020-041545

Azupogo, F., Abizari, A., Osendarp, S. J. M., Feskens, E. J. and Brouwer, I. D. (2021). Ten 2 Twenty- Ghana: study Design and methods for an innovative randomized controlled trial with multiple- micronutrient- fortified biscuits among adolescent girls in North Eastern Ghana. *Current Developments in Nutrition*, 5(184). DOI: https://doi.org/10.1093/cdn/nzaa184

Beck, K.L. (2016). Anemia: Prevention and Dietary Strategies, In: Caballero, B., Finglas, P. M. and Toldrá, F. *Encyclopedia of Food and Health*, Academic Press, 164-168. DOI: 10.1016/B978-0-12-384947-2.00030-1

Blaak, E. E. (2020). Current Metabolic Perspective on Malnutrition Approaches. *Nutrition Society*, Cambridge University Press. 331-337. URL: https://www.cambridge.org/core/journals/proceedings-of-the-nutrition-society/article/current-metabolic-perspective-on-malnutrition-in-obesity-towards-more-subgroupbased-nutritional-approaches/E5BD230558703F542010C1C9CEA0FAD2

Chaturvedi, D., Chaudhuri, P. K., Priyanka and Chaudhary, A. K (2017). Study of correlation between dietary habits and anemia among adolescent girls in Ranchi and its surrounding area. *International Journal of Contemporary Pediatrics*, 4(4), 1165-1168. DOI: http://dx.doi.org/10.18203/2349-3291.ijcp20172022

Cogill, B. (2003). Anthropometric Indicators Measurement Guide: FANTA Project, A Guide for Educational Development.URL: www.fantaproject.org

Das, J. K., Salam, R. A., Thornburg, K. L., Prentice, A. M., Campisi, S., Lassi, Z. S., ... and Bhutta, Z. A. (2017). Nutrition in adolescents: physiology, metabolism, and nutritional needs. *Annals of the New York Academy of Sciences*, *1393*(1), 21-33. DOI: https://doi.org/10.1111/nyas.13330

Dawaki, S., Al-Mekhlafi, H. M., Ithoi, I., Ibrahim, J., Atroosh, W. M., Abdulsalam, A. M.,… and Lau, Y. (2016). Is Nigeria winning the battle against malaria? Prevalence, risk factors and KAP assessment among Hausa communities in Kano State. *Malaria Journal*, 15(351) 1-14. DOI: https://doi.org/10.1186/s12936-016-1394-3

Drenkat, M. N. (2016). *Evaluation of dietary pattern, anthropometic characteristics and micronutrient status of adolescents attending secondary schools in Jos South LGA, Plateu State.* Thesis, Department of Biochemistry, ABU, Zaria, Nigeria.

Global Nutrition Report. (2020). *Global Nutrition Report; Action on equity to end \malnutrition*. Bristol, UK.: Development Initiatives. URL: https://reliefweb.int/report/world/2020-global-nutrition-report-action-equity-end-malnutrition

Gopalakrishnan, S., Eashwar, V. M. A., Muthulakshmi, M. and Geetha, A. (2018). Intestinal parasitic infestations and anemia among urban female school children in Kancheepuram district, Tamil Nadu. *Journal of Family Medicine and Primary Care*. 7(6), 1395-1400. DOI: https://doi.org/10.4103/jfmpc.jfmpc_89_18

Grimes, J. E. T., Tadesse, G., Gardiner, I. A., Yard, E., Wuletaw, Y., Templeton, M. R.… and Drake, L. L. (2017). Sanitation, hookworm, anemia, stunting, and wasting in primary school children in southern Ethiopia: Baseline results from a study in 30 schools. *PLoS Neglected Tropical Diseases*, 11(10). DOI: https://doi.org/10.1371/journal.pntd.0005948

Hamed, T. (2017). Determining sample size; how to calculate survey sample size. *International Journal of Economics and Management Systems*, 2. URL: https://hal.science/hal-02546796/

IGBOANUSI, C. J. , SABITU, K. , GOBIR, A. A. , NMADU, A. G. , and JOSHUA, I. A. (2019). Factors Affecting the Utilization of Postnatal Care Services in Primary Health Care Facilities in Urban and Rural Settlements in Kaduna State, North-western Nigeria. *American Journal of Public Health Research*, *7*(3), 111-117. DOI: https://doi.org/10.12691/ajphr-7-3-4

Kassa, G.M., Arowojolu, A. O., Odukogbe, A., and Yalew, A. W. (2018). Prevalence and determinants of adolescent pregnancy in Africa: A systematic review and Meta-analysis. *BioMed Central Reproductive Health*, 15 (195). DOI: https://doi.org/10.1186/s12978-018-0640-2

Keats, E. C., Aviva, R. I., Shailjah, S., Christina, O., Jain, R., & Bhutta, Z. A. (2018). The Dietary Intake and Practices of Adolescent Girls in Low-and Middle-Income Countries: A systematic review. Journal of Nutrients, 1-14. DOI: https://doi.org/10.3390/nu10121978

NSN (2022). Nutrition Society of Nigeria. 90 percent of Nigerian

Women sufferAnemia. URL: https://papermacheonline.com/90-percent-of-nigerian-women-suffer-anaemia-nsn/

Oguizu, A.D. (2015). Assessment of Iron, Selenium and Zinc status of Pregnant Women in Obio Akpor Local Government Area of River State. *Pakistan Journal of Nutrition*, 14(1), 1-5. DOI: https://doi.org/10.3923/pjn.2015.1.5

Olumakaiye, M. F. (2013). Adolescent girls with low dietary diversity score are predisposed to iron deficiency in Southwestern Nigeria. *Infant, Child and Adolescent Nutrition*. 5(2), 85-91. DOI: https://doi.org/10.1177/1941406413475661

Onabanjo, O. O. and Balogun, O. L. (2014). Anthropometric and Iron status of adolescents from selected secondary schools in Ogun State, Nigeria. *Infant, Child and Adolescents Nutrition*, 6(2), 109-118. URL: https://doi.org/10.1177/1941406414520703

Onyiri, N. (2015). Estimating malaria burden in Nigeria: a geostatistical modeling approach *Geospatial Health*, 10(2), 163-170. URL: https://www.researchgate.net/publication/284770943_Estimating_malaria_burden_in_Nigeria_A_geostatistical_modelling_approach#fullTextFileContent

Onimawo, I. A., Ukegbu, P. O., Asuugha, V. U., Anyika, J. U., Okudu, H., Echendu, C. A.,… and Emebu, P. (2010). Assessment of Anemia and Iron Status of school age children (Aged 7-12 years) in rural communities of Abia State, Nigeria. *African Journal of Food, Agriculture, Nutrition and Development*, 10(5), 2570-2586. DOI: https://doi.org/10.4314/ajfand.v10i5.56340

Partridge, S. R., Sim, K. A., Armaghanian, N., Steinbeck, K.S. and Cheng, H. L. (2022). Adolescence and young adulthood: an untapped window of opportunity for obesity prevention. *Public Health Research and Practice*, 32(3), 121-5. DOI: https://doi.org/10.17061/phrp3232223

Patton, G. C., Sawyer, S. M., Santelli, J. S., Ross, D. A., Afifi, R., Allen, N. B.,… and Viner, R. M. (2016). Our Future: a Lancet Commission on adolescent health and wellbeing. *Lancet*, 2423-2478. DOI: https://doi.org/10.1016/S0140-6736(16)00579-1

Peng, Y. Y. and Uprichard, J. (2017). Ferritin and iron studies in anaemia and chronic disease. *Annals of Biochemistry*, 54(1), 43-48. DOI: https://doi.org/10.1177/0004563216675185

Pollock, R. F. and Muduma, G. (2017), A budget impact analysis of parenteral iron treatments for iron deficiency anemia in the UK: reduced resource utilization with iron isomaltoside 1000. *ClinicoEconomics and Outcomes Research*, 9(2017), 475-483. DOI: https://doi.org/10.2147/CEOR.S139525

Rati, S. and Jawadagi, S. (2014). Prevalence of Anemia among Adolescent Girls Studying in selected schools. *International Journal of Science and Research* (IJSR), 3(8), 1237-1242. DOI: https://dx.doi.org/10.21275/2015611

Shahhosseini, Z., Simbar, M., Ramezankhani, A., Majd, H.A. and Moslemizadeh, N. (2013).The Challenges of female adolescents' health need. *Community Mental Health Journal* 49: 774780. DOI: https://doi.org/10.1007/s10597-013-9606-6

Starck, T., Dambach, P., Rouamba, T., Tinto, H., Osier, F., Oldenburg, C. E., Adam, M., Barnighausten, T., Jaenisch, T. and Bulstra, C. A. (2022). Effect of malaria on childhood anemia in a quasi-experimental study of 7,384 twins from 23 sub-saharan african countries. *Frontiers in Public Health*, 10. DOI: https://doi.org/10.3389.fpubh.2022.2009865

Tesfaye, M., Yemane, T., Adisu, W., Asres Y., & Lealem, G. (2015). Anemia and iron deficiency among school adolescents: burden, severity and determinant factors in southwest Ethiopia. *Adolescent Health, Medicine and Therapeautics*, Dove press, 189-196. DOI: https://doi.org/10.2147/ahmt.s94865

Turki, M., Osman, A. K., Alajmi, B. M., Almutairi, R. K., Almutairi, A. S. and Sudersana das, K. (2018). Factors influencing the nutritional status of adolescent girls in Riyadh/ Saudi Arabia. *Research Journal of Life Sciences, Bioinformatics, Pharmaceutical and Chemical Sciences*, 4(6), 262-275. DOI: http://dx.doi.org/10.26479/2018.0406.20

Umar, I. U., Kakale I. M., Gwarzo, G. D. and Ibrahim, M . (2018). Prevalence of Childhood and Adolescent Overweight and Obesity in Kano State, Nigeria. *EC Paediatrics*, 7(4), 231-238. URL: https://www.researchgate.net/publication/363040828_Prevalence_of_Childhood_and_Adolescent_Overweight_and_Obesity_in_Kano_State_Nigeria

WHO. (2011). Hemoglobin concentrations for the diagnosis of anaemia and assessment of severity vitamin and mineral nutrition information system. Geneva: World Health Organization. URL:http://www.who.int/vmnis/indicators/haemoglobin. https://www.who.int/publications/i/item/WHO-NMH-NHD-MNM-11.1

WHO. (2014a). Health for the world's adolescents: a second chance in the second decade. *World Health Organization report*. URL: https://www.who.int/publications/i/item/WHO-FWC-MCA-14.05

WHO. (2014b). Global nutrition targets 2025: anaemia policy brief (WHO/NMH/14.4). Geneva: World Health Organization. URL: https://www.who.int/publications/i/item/WHO-NMH-NHD-14.4

WHO. (2020). Guideline on use of ferritin concentrations to assess iron status in individuals and populations. Geneva: World Health Organization URL:: https://www.who.int/publications/i/item/9789240000124

Zhang, C. (2014). Essential functions of iron-requiring proteins in DNA replication, repair and cell control. *Protein Cell*. 5,750-760. DOI: https://doi.org/10.1007/s13238-014-0083-7