Assessment of anemia among rural children in Kaduna State, Nigeria by determining hemoglobin and serum ferritin levels

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Abstract

Background and objective: Children in the developing world are vulnerable to iron deficiency (ID) and iron deficiency anemia (IDA) because they grow fast and consume diets low in iron. Thus, this study assessed anemia in children aged 6 - 12 years in rural Nigeria, using hematological indices and serum ferritin as diagnostic tools.

Materials and methods: This cross-sectional study was carried out in two primary schools in Kumin Masara Kataf village in Kaduna state, Nigeria. School children aged 6 - 12 years were enrolled. Personal information and laboratory data were collected. Hemoglobin and serum ferritin concentration was estimated to determine anemia and iron status. Data analysis was done using IBM-SPSS Inc., Chicago, IL, USA, version-25.0.

Results: A total of 191 school-age children aged 6 - 12 years were enrolled in the study. The overall serum ferritin was 16.51±5.20 mg/L, but the children aged 6 - 9 years had significantly (p<0.05) higher serum ferritin (17.23±5.57 mg/L), compared to children aged 10-12 years (15.62±4.62). The mean hemoglobin concentration and serum ferritin were significantly (p<0.05) more elevated among males (11.17±2.53g/dl and 19.01±5.06 mg/L, respectively) than females (10.18±2.46 g/dl and 14.03±4.02 mg/L respectively).The overall rate of anemia was 51.3%, while IDA was 70.4% (69/98). Iron deficiency was present in 47.3% (44/93) children. Also, anemia was significantly (p<0.001) more prevalent among females (66.7%), than males (35.8%), and a higher proportion of females (87.5%) than males (26.2%) were iron deficient (p<0.05), but more males (44.1%) had IDA, p<0.05.

Conclusion: This study found a high prevalence of IDA and ID among rural school children in Nigeria. It is recommended that healthcare providers focus more on preventing IDA right before childhood.

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Introduction

Anemia is one of the significant public health issues across the world. According to the World Health Organization (WHO), children and non-pregnant women have the highest prevalence of anemia worldwide at 42.6% and 29.0%, respectively [1]. Anemia is defined as a condition in which the number of red blood cells (RBC) or the hemoglobin (Hb) concentration is lower than what is expected for age, sex and geographical location or inadequate to meet the physiological needs of an individual [1,2]. Hemoglobin is required to transport oxygen in the body system. But, if the RBC is abnormal or too few, or the hemoglobin level is insufficient, it will be difficult for blood to transport oxygen to the body tissues, which usually leads to fatigue, weakness, dizziness, shortness of breath, etc. [1].

The most common micronutrient deficiency and commonest anemia worldwide are iron deficiency and iron deficiency anemia [3-5]. Children in the developing world are highly vulnerable to ID because they are growing fast and consume diets low in iron [6,7]. Africa and Asia have extreme public health significance of anemia, with an estimated 67.6% of children below five years suffering from anemia in Africa and 65.5% in Southeast Asia [8]. The results of studies on the prevalence of anemia among Nigerian children vary. A recent data from Nigeria Demographic and Health Surveys showed that 67.01% of children aged 6-59 months were anemic [9], whereas a study conducted in rural Nigeria among school children aged 6-15 years found a higher prevalence of 85.5% [10]. Another study conducted in South-East Nigeria found a prevalence of 49.2% among children below five years old [11]. However, among 87 pre-school children in Lagos, South-West Nigeria, the prevalence of iron deficiency anemia was reported as 10.11% [12].

There are three sequences of events in iron deficiency anemia. The first stage is iron depletion, also called the "decrease in iron stores," and can be caused by insufficient serum ferritin concentration [13,14]. The second stage is an iron deficiency, when the absorption of iron in the body is inadequate to meet up with depleted iron stores; this also implies that the hemoglobin concentration reduces due to impaired synthesis [11,15]. This stage can be determined by decreased serum ferritin, mean corpuscular volume (MCV), and mean corpuscular hemoglobin (MCH). The third and most severe of the three stages is iron deficiency anemia, which reduces iron in the red blood cells [3,16,17]. This stage can also be measured by serum ferritin decline, MCV, MCH, and hemoglobin levels [12].

Studies revealed that iron deficiency could affect motor and cognitive skills if present early in childhood and can lead to irreversible behavior disorders in children [18,19]. Iron deficiency anemia in children often affects physical, social, and cognitive capacities and performance [20]. In childhood, screening and detecting ID and IDA are crucial, particularly in areas where malnutrition rates are high (predominantly rural). As a result, this study was essential because it assessed hematological indices and serum ferritin as a diagnostic marker for anemia. Also, the study is important because studies on the prevalence of IDA in school children are still limited in the northern villages of the country. This is why this study was undertaken to assess ID and IDA among the primary school pupils in Kummin Masara Kataf village in Kaduna State, Nigeria.

Materials and methods

Study area and population: This cross-sectional study was carried out from February to August 2020. The study population comprised of primary school pupils from two schools in rural Masara Kataf village in Kaduna State, Nigeria. The school-age children involved male and female pupils aged 6 to 12 years. A total of 191 school-age children were recruited as the study participants. Children with hematological problems (infection, inflammation, malignancy) or chronic diseases that could significantly affect the analyzed parameters were excluded from the study. The exclusion was based on their hematological history. Also, children with a history of blood transfusion within three months before the study were excluded, and those who received iron therapy or had raised high-sensitivity C-reactive protein.

Sample size calculation: Based on the 85.5% prevalence of anemia among children aged 6-15 years in Nigeria [10], the sample size was calculated using the formula: $\frac{Z^2 \text{ p q}}{d^2}$

where: n is the initial sample size, Z= 1.96 for a 95% confidence level. p is the prevalence of anemia (85.5% = 0.855), and q = 1-p (1-0.855) = 0.145; d is the accepted bias for p in the sample, and it equals 0.05.

$$n = \frac{1.96^2 \text{ x } 0.855\ (0.145)}{0.05^2} = 190.50 = 191$$

Therefore, total sample size was 191.

Sample and data collection: Five milliliters of venous blood samples were collected aseptically from each child after taking their history for the estimation of hemoglobin and serum ferritin. Iron deficiency anemia was determined using WHO standards of a low hemoglobin concentration based on age: Hb <11.5 g/dL for age 6-9 years and <12.0 g/dL for 10-12 years [10,21] with ferritin <15 mg/L [22]. Iron deficiency without anemia was described as normal hemoglobin concentration according to age and serum ferritin <15 mg/L [10,22] while iron depletion - serum ferritin 15 - <20mg/L with normal Hb [12]. Normal hemoglobin concentration was taken as ≥11.5 g/dL. Hemoglobin concentration of 10.0 - 11.4, 7- 9.9 and < 7.0 g/dL was considered as mild, moderate and severe anemia respectively [10].

Statistical analysis: Data were analyzed using IBM-Statistical Package for the Social Sciences (SPSS) version 25.0 for Windows. The Chi-square test was used to establish the association between categorical variables. An independent t-test was conducted to determine the mean values of hematological parameters and serum ferritin of children based on age and gender. A p-value of less than 0.05 was considered statistically significant.

Results

The study comprised of 191 school children from two different primary schools aged 6-12 years. The mean age of the study subjects was 9.04 ± 2.07 years, including 95 (49.7%) males and 96 (50.3%) females; the majority, 105 (55.0%),were within the age group 6-9 years and 86 (45.0%) were between 10-12 years.

The mean hemoglobin concentration of the study subjects was 10.67 ± 2.54 g/dL with a significantly higher value among children aged 6-9 years (11.03 ± 2.63 g/dL) than 10-12 years (10.24 ± 2.37 g/dL; p<0.05). The overall serum ferritin was 16.51 ± 5.20 mg/L but the children aged 6-9 years had significantly higher serum ferritin (17.23 ± 5.57 mg/L) than 10-12 years (15.62 ± 4.62 mg/L; p<0.05). The results show that mild and severe anemia was more prevalent among children aged 10-12 years (16.3% and 9.3%) than 3.8% and 6.7% among children aged 6 - 9 years. On the other hand, a higher proportion of those aged 6-9 years

Table-1: *Hemoglobin, serum ferritin and anemia status of the study population according to age groups*

Variables	Age in years		Total (n=191)	p-value
	6-9 (n=105)	**10-12 (n=86)**		
Haemoglobin (g/dl)	11.03±2.63	10.24±2.37	10.67±2.54	0.032*
Serum ferritin (mg/L)	17.23±5.57	15.62±4.62	16.51±5.20	0.033*
Anemia and iron deficiency prevalence n (%) (N = 191)				
Normal	46 (43.8)	47 (54.7)	93 (48.7)	
Mild anemia	4 (3.8)	14 (16.3)	18 (9.4)	
Moderate anemia	48 (45.7)	17 (19.8)	65 (34.0)	<0.001*
Severe anemia	7 (6.7)	8 (9.3)	15 (7.9)	
Overall anemia	59 (56.2)	39 (45.3)	98 (51.3)	0.136
IDA	37 (62.7)	32 (82.1)	69 (70.4)	0.040*
Iron deficiency	14 (30.4)	30 (63.8)	44 (47.3)	0.001*

*IDA: Iron deficiency with anemia; * significant at p<0.05* had moderate anemia (45.7%, p<0.001). A total of 98 (51.3%) had anemia; IDA was more prevalent among 10-12 years, 82.1% (32/39), than 62.7% (37/59) of children aged 6-9 years (p<0.001). Similarly, among the 93 children without anemia, 47.3% had iron deficiency, mostly among children aged 10-12, (63.8%, 30/47) than age 6-9 (30.4%,14/46; p<0.001 (Table-1).

As shown in Table-2, the mean hemoglobin concentration and serum ferritin were significantly higher among males (11.17±2.53g/dl and 19.01±5.06) than females (p<0.05). Anemia was significantly (p<0.001) more prevalent among females (66.7%) than males (35.8%), with an overall anemia prevalence of 51.3%. However, a higher proportion of males, 44.1% (15/34) had anemia with iron deficiency than females, 21.9% (14/64), p<0.05. On the other hand, a higher proportion of females without anemia were iron deficient, 87.5% (28/32), than males, 26.2% (16), p<0.001, with an overall iron deficiency of 47.3%.

The mean hemoglobin and serum ferritin concentration of the male study children aged 6-9 and 10-12 years were not significantly (p>0.05) different (Table-3). The results show that normal and severe anemia were more prevalent among male children aged 10 -12 years (75% and 11.1%) than 57.6% and 5.1% among male children aged 6 - 9, p>0.001. A total of 34 (35.8%) male children had anemia; There was no significant difference of

Table-2: *Hemoglobin concentration, serum ferritin and anemia status of the study population according to the gender*

Variables	Male (n=95)	Female (n=96)	Total (n=191)	p-value
Hemoglobin (g/dl)	11.17±2.53	10.18±2.46	10.67±2.54	0.007*
S. ferritin (mg/L)	19.01±5.06	14.03±4.02	16.51±5.20	<0.001*
Anemia and iron deficiency prevalence, n (%)				
Normal	61 (64.2)	32 (33.3)	93 (48.7	
Mild anemia	3 (3.2)	15 (15.6)	18 (9.4)	
Moderate anemia	24 (25.3)	41 (42.7)	65 (34.0)	<0.001*
Severe anemia	7 (7.4)	8 (8.3)	15 (7.9)	
Overall anemia	34 (35.8)	64 (66.7)	98 (51.3)	<0.001*
IDA	15 (44.1)	14 (21.9)	29 (29.6)	0.022*
Iron deficiency	16 (26.2)	28 (87.5)	44 (47.3)	<0.001*

*IDA: Iron deficiency with anemia; * significant at p<0.05*

Table-3: *Hemoglobin, serum ferritin and anemia status in male children of different age groups*

Variables	Age in years		Total (n=95)	p-value
	6-9 (n=59)	10-12 (n=36)		
Haemoglobin (g/dl)	11.40±2.64	10.78±2.31	11.17±2.53	0.246
S. ferritin (mg/L)	19.29±5.57	18.53±4.29	19.00±5.06	0.482
Anemia and iron deficiency prevalence n (%) N = 95)				
Normal	34 (57.6)	47 (75)	61 (64.2)	
Mild anemia	2 (3.4)	1 (2.8)	3 (3.2)	
Moderate anemia	20 (33.9)	4 (11.1)	24 (25.3)	0.079
Severe anemia	3 (5.1)	4 (11.1)	7 (7.4)	
Overall anemia	25 (42.4)	9 (25)	34 (35.8)	0.087
Iron deficiency	4 (11.8)	12 (44.4)	16 (26.2)	0.004*
IDA	14 (56)	5 (55.6)	19 (55.9)	0.982

*IDA: Iron deficiency with anemia; * significant at p<0.05*

Table-4: *Hemoglobin, serum ferritin and anemia status in female pupils of different age groups*

Variables	Age in years		Total (n=96)	p-value
	6-9 (n=46)	**10-12 (n=50)**		
Haemoglobin (g/dl)	10.54±2.56	9.85±2.34	10.18±2.46	0.168
S. ferritin (mg/L)	14.57±4.47	13.52±3.53	14.03±4.02	0.202
Anemia and iron deficiency prevalence n (%) N = 95)				
Normal	12 (26.1)	20 (40)	32 (32)	
Mild anemia	2 (4.3)	13 (26)	15 (15.6)	
Moderate anemia	28 (60.9)	13 (26)	41 (42.7)	0.001*
Severe anemia	4 (8.7)	4 (8)	8 (8.3)	
Overall anemia	34 (73.9)	30 (60)	64 (66.7)	0.149
Iron deficiency	10 (83.3)	18 (90)	28 (87.5)	0.581
IDA	23 (67.6)	27 (90)	50 (78.1)	0.031*

*IDA: Iron deficiency with anemia; * significant at p<0.05*

prevalence of IDA in male children between aged 6-9 and 10-12 years (56% vs. 55.6%; p=0.982) while ID was significantly (p=0.004) more among the male children aged 10-12 (44.4%) compared to those aged 6-9 years (11.8%, Table-3).

As shown in Table-4, the mean hemoglobin and serum ferritin concentration of the female study children aged 6-9 and 10-12 years were not significantly (p>0.05) different. The results show that normal and mild anemia were significantly (p<0.005) more prevalent among female children aged 10-12 years (40% and 26%) than 26.1% and 4.3% among female children aged 6-9 years. IDA was significantly (p=0.031) more prevalent among female children aged 10-12 years, than children aged 6-9 years (90% vs. 67.6%). No significant difference was observed regarding ID in two groups.

Discussion

Iron deficiency anemia and iron deficiency without anemia are common nutritional problems among different age groups worldwide. The overall prevalence of anemia in this study was 51.3%, which was similar to 50% obtained among children aged 6 to 59 months in Kaduna [23] but lower than the findings from similar studies in Anambra (66,7%) and Enugu (57.1%) in the Eastern parts of Nigeria [24,25]. However, this study's overall prevalence of anemia was higher than another study conducted among children in Sokoto, North-Western Nigeria (34.8%) [26]. Studies in other countries have also shown varying rates of the prevalence of anemia. It is13.0% in Indonesia [21], 11.8% among six months old children in Beijing, China [27], 30.61% in Chittagong, Bangladesh [28], 66.6% among children 6 to 23 months old in Northeast Ethiopia [8], and 18.7% in Pakistan [16]. The high prevalence of anemia in our study is not unusual because Nigeria was declared an anemic nation by the WHO [1], with a higher prevalence of anemia among children in Northern Nigeria, ranging from 66% in North Central to 71% in North East [23]. The issue of concern is that the situation remains unchanged, which calls for interventions to save our children from the effects of malnutrition.

The mean hemoglobin concentration of our study children (10.67 ± 2.54 g/dL) was comparatively lower than the WHO standard [29]. The overall anemia in our study was not significantly associated with age though severe anemia was more prevalent among those aged 10-12 years; this finding supports a previous report that age is not a determinant of anemia [13]. However, a study conducted in south-east Nigeria reported that younger ages were more likely to be anemic due to malaria infection, poor complementary feeding practices in body demand due to rapid growth, and increased activity due to achieved motor milestones [11]. This might be why over 50% of children aged 6 to 9 years in our study were anemic compared to 45% of those aged 10 to 12 years. It has been reported that anemia is more prevalent among children in the vulnerable age groups of newborns to 15 years [26].

This study's overall anemia for male children was 35.8% and 66.7% for female children. This shows that anemia was more prevalent among female children than male children. This was similar to a the findings of a study undertaken in Brazil which found a higher prevalence of anemia among female children than in male in a hospital in Recife, Brazil [30]. Nevertheless, a study in Haiti showed a contrary result in which male children had a higher prevalence than female children [31].

There have been various reports on the association between anemia and gender [24,32]. Our study showed that females were more anemic than males, which might be attributed to growth, diet and menstruation. It has been reported that the onset of menstruation imposes additional iron needs on females, which may be challenging to meet with low consumption of iron-rich foods [32]. However, the high prevalence of anemia among females might not be due to the low consumption of iron-rich foods or menstruation alone since many study participants were below the age for onset of menstruation. Instead, it may be due to inadequate dietary intake and parasitic infections that The Federal Ministry of Health has identified as significant causes of iron deficiency anemia in Nigeria [33].

The finding from this study showed that overall ID among male children was 26.2% and IDA (55.9%) while the female children had ID of 87.5% and IDA of 78.1%.. This was contrary to the findings, regarding the burden of iron deficiency on African children [34]. The study reported that male infants were more iron deficient than female infants for each of the different measures of iron status. Other studies also reported similar findings [35-37]. Also, a study among school children in Morocco found that iron deficiency anemia was more prevalent among boys than girls [38].

Before developing anemia, the sequences of events leading to iron deficiency anemia includes iron depletion and iron deficiency [22]. Early detection of ID to prevent unwanted complications is vital since all these stages can lead to permanent problems, particularly growth and development [3,17,21]. ID and IDA were higher among females than males and children between 6-9 years old. Studies have shown that girls, particularly adolescent girls, are more prone to iron deficiency anemia because, unlike male children, they are more prone to iron loss [2,33]. The higher IDA and ID found among children aged 6-9 years in our study might be due to more subjects in this age group than those aged 10-12 years (105 vs 86). It may also be due to insufficient iron in mothers during pregnancy. We only assessed iron deficiency as a cause of anemia, while other factors such as malaria, helminthic infection, thalassemia trait, gastritis, and duodenitis were not considered. Although iron deficiency is the most common cause of anemia, other studies have significantly associated these factors with anemia [10-12,39-41].This study was conducted in the village among school children with low socioeconomic status. Studies have established that low socioeconomic condition is a risk factor for ID and IDA [7,12,21,33]. Since our research focuses on hemoglobin and iron ferritin as determinants of anemia in children, further studies can be conducted to determine other factors associated with anemia among primary school children.

This study found a high prevalence of anemia, IDA, and ID among primary school children in rural Masara Kataf village of Kaduna State, Nigeria. Therefore, it is advised that healthcare providers, particularly at primary healthcare centers, should focus more on preventing IDA in childhood and adolescence rather than during pregnancy. We also recommend giving iron supplementation as directed by the World Health Organization [28] to children aged 5 to 12 years in Nigeria as it is in some other countries such as Indonesia [21].

The limitation of this study was that other causes of anemia apart from iron deficiency were not assessed. Besides, the study was conducted in a rural area among children of low socioeconomic status only. Further studies may be needed to compare children of high socioeconomic status with that of low status or compare children aged 6-12 years and adolescents up to 18 years.

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Nil

Authors' contributions

ANY: study conception and design;
OLA and IO: definition of intellectual content;
DYO, AAO and AOF: literature search and data collection;
FOS and OBB: data and statistical analysis;
BYA and MOD: manuscript preparation;
TA, ZTG, IO and IC: experimental studies.

Competing interests

The authors have declared that no competing interests exist.

Ethical consideration

Written consent was obtained from the children, parents, teachers, or guardians. The research ethics committee also approved this research of the National Hospital, Abuja, Nigeria, with approval number NHA/PER/0412/V.1/137.

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