Iron deficiency anaemia among apparently healthy pre-school children in Lagos, Nigeria.

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Abstract

Background: Iron deficiency, and specifically iron deficiency anaemia, remains one of the most severe and important nutritional deficiencies in the world today.

Objective: To estimate the prevalence and associated factors for iron deficiency anaemia among pre-school children in Lagos.

Methodology: The study was conducted from December 2009 to February 2010 at the outpatient clinics of Lagos State University Teaching Hospital, Lagos. Serum iron, total iron binding capacity, transferrin saturation and serum ferritin were assayed in subjects. The primary outcome measured was iron deficiency anaemia established based on the following criteria: hemoglobin <11.0 g/dl1 plus 2 or more of the following: MCV <70fl, transferrin saturation <10% or serum ferritin <15ng/dL. Statistical analysis included Pearson Chi square analysis and logistic regression analysis.

Results: A total of 87 apparently healthy subjects were recruited. Only one subject had iron depletion and this child belonged to the ≤ 2 years age category. None of the recruited subjects had iron deficiency without anaemia. Nine of the study subjects (10.11%) had iron deficiency anaemia. The prevalence of iron deficiency anaemia was significantly higher among younger age group than in the older age group (19.1% Vs 2.1%, p = 0.022). The prevalence of iron deficiency anaemia was significantly higher among subjects with weight-for-age, and weight-for-height Z scores below two standard scores (83.3% and 75.0% respectively, p = <0.001 and 0.001 respectively).

Conclusion: The overall prevalence of iron deficiency anaemia among study subjects was 10.11%. Iron deficiency anaemia was more common in children aged two years and below. Weight-for-age and weight-for-height Z scores below minus two standard scores were strongly associated with iron deficiency anaemia.

Keywords: iron deficiency anaemia, iron depletion, iron deficiency

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Introduction

Iron is an important dietary mineral that is involved in various bodily functions, including the transport of oxygen in the blood. This is essential in providing energy for daily life. Iron is also vital for brain development.[1] Preschool children are at higher risk of iron deficiency anaemia, mainly because their increased needs for iron may not be met by their diets.[2] Without supplementation, children whose diets do not provide enough iron are at risk of developing iron deficiency anaemia.

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Iron deficiency is also a leading cause of anaemia[2-4]. Children in the developing world are especially vulnerable because of the increased requirements of growth[5], high helminth burden[4,6] and diets with low iron bioavailability.[2] In Nigeria, the prevalence of iron deficiency anaemia (IDA) among preschool children is estimated at 69%[7].

Iron deficiency anaemia is characterized by deficient haemoglobin synthesis, resulting in red blood cells that are abnormally small (microcytic) and contain a decreased amount of haemoglobin (hypochromic)[8]. The capacity of the blood to deliver oxygen to body cells and tissues is reduced as a consequence of inadequate haemoglobin.

Iron deficiency is a function of the imbalance of iron intake, iron absorption and iron loss.[9-11] Iron metabolism is unusual in that it is controlled by absorption rather than excretion.[9-11] In health, only 5 to 10 percent of dietary iron is absorbed[12]. In states of overload, iron absorption decreases. Conversely, absorption can increase three- to fivefold in states of depletion.[12]

The reduction of body iron has three main stages: (i) iron depletion[13] which refers to a decrease of iron stores, measured by a reduction in serum ferritin concentration; (ii) iron deficiency,[14] when storage iron is depleted and there is insufficient iron absorption to counteract normal body losses (at this time, haemoglobin synthesis starts to become impaired and haemoglobin concentrations fall), measured by a reduction in serum ferritin, mean corpuscular volume (MCV) and mean corpuscular haemoglobin (MCH); and (iii) iron deficiency anaemia,[15] the most severe degree of iron deficiency, which refers to a decrease of iron in the red blood cells, measured by a reduction in serum ferritin, mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH) and haemoglobin level. The distinction between "iron deficiency" and "iron deficiency anaemia" is important. They often go hand in hand, but people can be iron deficient without being anaemic.

Since the prevalence of iron deficiency varies from one country to another and even within the same nation from one region to another, we set out to estimate the prevalence and associated factors for iron deficiency anaemia among pre-school children in Lagos. Lagos is a cosmopolitan State, and the commercial nerve center of Nigeria.

Methodology

This cross-sectional study was conducted at the Children outpatient clinics of the Department of Paediatrics, Lagos State University Teaching Hospital (LASUTH), Ikeja in SouthWest Nigeria from December 2009 to February 2010. Approval for the study was obtained from the Ethics Committee of LASUTH.

The children outpatient clinic runs every week day during working hours of 8:00 am till 4:00 pm and caters for children up to age 15 years presenting for the first time and those who fall ill in between scheduled specialist clinic visits. The clinic attends to patients from the whole state as well as neighbouring towns in Ogun State. On average 2, 234 children are seen in the Children outpatient clinic annually. Those with acute medical problems are managed in the paediatric wards or the children Emergency Room.

Consecutive apparently healthy children whose parents gave consent and met the study inclusion criteria were recruited. The studied sample size consisted of 89 apparently healthy children. Data was summarized for two age categories: age less than two and age two to five years. The sample size calculation was based on estimated prevalence of iron deficiency anaemia (IDA) of 69%[16] among Nigerian children with 90% power and standard deviation 1.96 in a two-tailed test.

Inclusion criteria

a. Age six months to five years, since preschool aged children are at higher risk of development of iron deficiency anaemia[18]

b. Apparently healthy

c. Consent

Exclusion criteria

a. Children on long-term transfusion therapy

b. Children who had received a blood transfusion within three months prior to the study

c. Children with a history of prematurity or low birth weight because they have a higher risk of developing iron deficiency anaemia due to reduced body stores and increased demand.[17]

Procedures

Five millilitres of blood were drawn from a convenient peripheral vein and was transferred into plain tubes. The vacuum tubes were labeled and placed in a cool box containing ice-packs. The samples were protected from light at all times using sheets of black plastic. They were transported to the Research Laboratory of the Department of Paediatrics, LASUTH within 8-12 hours where complete blood count (CBC), and blood film were done by the laboratory scientist.

After centrifugation the serum was separated and stored at -20ºC until assay. The unsaturated or latent iron-binding capacity (UIBC) was measured by spectrophotometric techniques. Transferrin saturation (expressed as percentage of total iron binding capacity) was calculated using the formula: 100 X the serum iron concentration divided by total iron binding capacity.[18] Serum iron was measured using Iron Ferrozine test kit (Biosystems, Spain) while the Total Iron Binding Capacity (TIBC) was measured by using Iron/Total Iron Binding Capacity reagent set (TECO Diagnostics, USA). Serum ferritin was measured by using human ferritin enzyme immunoassay test kit (Diagnostic Automation, USA).

The diagnosis of iron depletion, iron deficiency and iron deficiency anaemia was established based on the following criteria:

- Iron depletion - serum ferritin (SF) 15 - <20ng/dL[19]

- Iron deficiency - 2 or more of the following: MCV <70fl, transferrin saturation (Ts) <10% or serum ferritin (SF) <15ng/dL.[19,20]
- Iron deficiency anaemia - hemoglobin <11.0 g/dl1 plus 2 or more of the following: MCV <70fl, transferrin saturation (Ts) <10% or serum ferritin (SF) <15ng/dL.[19,20]

The prevalence of Iron deficiency anaemia was the primary outcome.

Measurement of height

Children two years of age and older had their heights measured using a stadiometer (SECA 213) while the length of those below two years were measured using an infantometer (QM338, England).

Measurement of weight

Subjects' weights were measured barefoot with children and wearing light clothing. Weight measurements were taken on a Seca 761 series mechanical floor scale to the nearest 0.1Kg.

Social class was determined from occupation and educational attainment of parents using the scheme proposed by Oyedeji.[21] The subjects were classified into one of five classes (I – V) in descending order of social privilege. Classes I and II were grouped together as upper social stratum, class III was taken as the middle stratum and classes IV and V as lower social strata.

Children were identified as underweight, stunted or wasted if their weight-for-age, height-for-age, and weight-for-height Z scores were < -2 standard deviation of the National Center for Health Statistics reference standards, respectively.[22]

The data was analyzed using the Statistical Package for Social Science (SPSS) version 17.0. Level of significance was set at $p < 0.05$. Difference between groups was tested using Pearson Chi square test. All of the predictor variables with p value < 0.05 in the Pearson Chi square analysis had logistic regression analysis performed to calculate their Odds ratio (OR) and their 95% confidence intervals to assess their strength of association with the prevalence of iron deficiency anaemia.

Results

A total of 89 children were recruited. The demographic characteristics of the study subjects are given in Table 1. Overall, the age of the subjects ranged from seven months to five years, with a mean of 30.25 (±15.77) months.

Table 1 – Demographic characteristics of the study population

Characteristics		Frequency	%
Gender			
	Male	49	55.1
	Female	40	44.9
	Total	89	100.0
Age group (years)			
Male			
	=2	24	49.0
	>2 – 5	25	51.0
Female			
	=2	18	45.0
	>2 – 5	22	55.0
Socioeconomic index			
	I	18	20.2
	II	35	39.3
	III	22	24.7
	IV	13	14.6
	V	1	1.1

Mean values of iron status indicators among study subjects

In table 2, the mean values of iron status indicators among study subjects are shown. The mean haemoglobin concentration was comparable among both age categories. The mean serum iron was not significantly higher among >2 – 5 years age category compared to their ≤2 years counterparts ($p = 0.281$). TIBC was higher among subjects ≤2 years than >2 – 5 years subjects but the observed difference was not significant ($p = 0.069$). The mean serum ferritin, transferrin saturation and MCV were significantly higher among >2 – 5 years subjects ($p < 0.05$).

Table 2 – Mean values of iron status indicators among study subjects

Iron metabolism abnormalities	>2 – 5 years Mean (SD)	≤2 years Mean (SD)	p- Value
Haemoglobin concentration (g/dL)	9.44 (2.09)	9.88 (1.03)	0.207+
Serum Iron (mcg/dL)	74.76 (58.09)	87.77 (68.21)	0.281*
TIBC (mcg/dL)	298.74 (94.12)	269.11 (106.40)	0.069*
Serum ferritin (ng/dL)	45.12 (51.36)	64.66 (55.53)	0.007*
Transferrin saturation (%)	25.26 (15.88)	32.02 (17.33)	0.025*
MCV (fl)	71.34 (5.95)	74.52 (5.14)	0.008+

* = Mann-Whitney *U* test + = Student t-test

Distribution of iron metabolism abnormalities among study subjects

Only one subject was identified to have iron depletion and this child belonged to the ≤2 years age category. None of the recruited subjects had iron deficiency without anaemia. The distribution of study subjects with iron deficiency anaemia according to demographic and selected biological characteristics are shown in Table 3. Nine of the study subjects (10.11%) had iron deficiency anaemia.

Table 3 – Distribution of iron deficiency anaemia among study subjects according to demographic and selected biological characteristics

Iron metabolism abnormalities		Iron deficiency anaemia n (%)	p-value
Age group (years)			0.022
	≤2	8 (19.1)	
	>2 – 5	1 (2.1)	
Gender			0.700
	Male	6 (14.0)	
	Female	3 (7.5)	
Weight-for-age status			<0.001
	Underweight	5 (83.3)	
	Normal	4 (5.4)	
Height-for-age status			0.786
	Stunted	0 (0.0)	
	Normal	9 (12.3)	
Weight-for-height status			0.001
	Wasted	3 (75.0)	
	Normal	6 (7.4)	
Birth order			0.746
	1	2 (6.9)	
	>1	7 (11.7)	
Family size			0.920
	<5	6 (11.3)	
	≥5	3 (8.3)	
Socioeconomic strata			0.935
	Lower	2 (14.3)	
	Others	7 (9.3)	
Maternal age (years)			0.836
	➢30	6 (10.2)	
	21 – 30	3 (10.0)	

In the younger age group the prevalence of iron deficiency anaemia was significantly higher (p = 0.022) compared with the older age group. The prevalence of iron deficiency anaemia was significantly higher among subjects with weight-for-age, and weight-for-height Z scores below minus two standard scores (83.3% and 75.0% respectively, p = <0.001 and 0.001 respectively).

The chi-square test showed that age group of subjects and weight-for-height status was significantly associated with iron deficiency anaemia (Table 3). A logistic regression model was used to assess the effects of the significant explanatory variables in order to distinguish predictors of iron deficiency anaemia. The final analysis indicated that aged ≤ 2 years, underweight and wasting were significant predictors for iron deficiency anaemia in the study subjects. The odds ratio showed that age two years and below were about 10 times more likely to developed iron deficiency anaemia as compared to those above two years of age category (OR: 9.60; 95% CI: 1.15 - 80.52). The risk for iron deficiency anaemia was 15 times significantly higher among subjects with underweight compared with the subjects that had normal weight-for-age status. Subjects with wasting status were 19 times more likely to have iron deficiency anaemia as compared to those with normal weight-for-height status (OR: 18.75; 95%CI: 2.61 - 134.87). Iron deficiency anaemia was significantly ten times more common among wasted subjects who are age two years and below (Table 4).

Table 4 – Different factors associated with the risk of iron deficiency anaemia

Characteristics	Odds ratio	95% CI	p-value
Age group ≤2 years	9.60	1.15 – 80.52	0.037
Underweight (WAZ)	15.42	3.25 – 73.07	0.000
Wasting (WHZ)	18.75	2.61 – 134.87	0.004
Age group ≤2 years and wasting	9.90	1.31 – 74.73	0.026
Age group ≤2 years and underweight	10.33	1.67 – 64.00	0.012

WAZ is weight for age z-score and WHZ is weight for height z-score

Discussion

In the present study, the mean values of the three serum iron profiles used for defining criteria of iron deficiency anaemia (serum ferritin, transferrin saturation and mean corpuscular volume (MCV)) showed significant age-dependent differences with mean values lower in the age category two years or below than the age category above two years. It may be due to the fact that the high iron requirements for growth in younger subjects coincides with an age when body iron stores are depleted, dietary patterns are not yet well established and intake of meat is often low.[23]

The mean haemoglobin concentration values in both age categories was below the WHO cut-offs of 11g/dl[20] used to describe study subjects as having anaemia. One possible explanation may be the intense malaria transmission found in Nigeria. It is well known that in areas with intense malaria transmission, malaria is a predominant cause of anaemia in young children.[24]

The reported prevalence value of 10.1% from current study was lower than the 25.0% reported in four selected Local Government Area (LGA) from Ondo State of Nigeria among children aged 0 – 5 years.[17] The observed difference may probably be an effect of study design. The Olufemi et al[17] study was a retrospective one that reviewed records of subjects with iron deficiency anaemia obtained from the Medical Records department of selected hospitals. Similarly, the defining criteria for iron deficiency anaemia was not provided by the Olufemi et al.[17] In variance to reported low prevalence value from this present study a higher prevalence value of 26.7% was reported by Ngui et al[25] among Malaysian children aged one to six years. The observed difference is possibly an effect of diagnostic criteria used. The diagnostic criteria used for identifying children with IDA by Ngui et al[25] was serum ferritin values below 11.5ng/dL as a single parameter in addition to haemoglobin concentration value below 11g/dL.

The current study revealed a higher prevalence of IDA among subjects below two years of age than in the older age group. The findings agree with those of previous authors[20,26] As aforementioned it may be due to the fact that the high iron requirements for growth in younger subjects coincides with an age when body iron stores are depleted, dietary patterns are not yet well established and intakes of meat are often low.[26]
The prevalence of IDA of 19.1% for the subjects under the age of two years was higher than 14.9% obtained by Fajolu et al[20] among children of comparable age. The observed difference is possibly an effect of sample size. Small sample size such as was the case in the current study is known to produce exaggerated prevalence rates. It is not surprising therefore that a higher prevalence rate was observed in the current study.

It is pertinent to address the relationship between iron deficiency anaemia and nutritional status. Regression analysis showed that both underweight and wasting had a strong association with iron deficiency anaemia. Dietary practices may play an important role, since diets poor in both calories and micronutrients may lead to iron deficiency anaemia in combination with either wasting or underweight. These findings call for policy arguments to initiate screening for iron deficiency anaemia at point of care for children with either wasting or underweight to improve the child health outcomes. Contrary to what was observed in the present study, iron deficiency anaemia was reported to be alarmingly high among subjects with weight-for-height classification as overweight among American children aged one to three years.[27] The reason for the disparity between study was not clear. This further emphasizes the need for a larger, collaborative study in order to clarify the situation.

A key finding in the current study show that either wasting or underweight in a simple regression serve as significant factors associated with the risk of iron deficiency anaemia over use of age in combination with either underweight or wasting in multiple regression model. To our knowledge, this is the first study to report an association between age group in combination with either wasting or underweight. The number of study subjects is however too small to make conclusive remarks. Perhaps, a larger pool of study subjects from a collaborative, multicentre study would provide more useful information.

Conclusion

Fndings in the current study corroborated other reports that iron deficiency anaemia is a common problem among children aged two years or below. Children with either wasting or underweight have high risk for development of iron deficiency anaemia; hence, screening for iron deficiency anaemia should form an important component of their treatment protocol.

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