Iron Deficiency Among Non-Anemic Under-Five Children in Enugu, South-East, Nigeria

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Abstract

Background: Iron deficiency has been described as the world most common nutritional deficiency and the commonest cause of nutritional anemia in infancy and childhood. The deleterious behavioral and cognitive deficit associated with iron-deficiency anemia could be irreversible. Therefore, the latter should be prevented by early detection of iron deficiency in the non-anemic groups. **Aim:** To determine the prevalence of iron deficiency in the non-anemic under-five children and to document its variation among the age classes of these children. **Subjects and Methods:** Under-five children presenting at a tertiary hospital were consecutively enrolled, Serum ferritin levels of the subjects were used to assess the iron status and serum ferrritin level of less than 12 ng/ml was considered as iron deficiency. Data were analyzed using SPSS version 15.0. Chi-square tests were employed as necessary for test of significance in each of the characteristics of the population at $P \leq 0.05$. **Results:** A total of 178 non anemic under-five children were studied, their mean hematocrit and serum ferrritin values were 35.5 (2.8%) and 54.9 (76.1) ng/ml respectively. Forty-nine (27.5% [49/178]) of the study population was iron deficient and there was no significant difference in the prevalence of iron deficiency among the age classes ($P = 0.75$). **Conclusion:** This study has documented a high prevalence of iron deficiency in non-anemic under-five children presenting at the outpatient department and emergency room of a tertiary health facility in Enugu. All the age classes were relatively affected. A further research into the causes of iron deficiency in this age group is recommended.

Keywords: Anemia, Deficiency, Ferritin, Iron, Under-five children

Introduction

Iron deficiency has been described as the most common nutritional deficiency in the world.[1,2] It has also been documented as the commonest cause of nutritional anemia in infancy and childhood.[3-6] About 1.2 billion people worldwide demonstrate varying levels of iron deficiency.[7] Prevalence rates vary among countries; it affects 2.4 million children in the USA,[8] 5.4% children in Spain,[9] 14.0% in Estonia,[10] 30.8% under five Brazilian children[11] and 22.3% under-five Nigerian children.[12]

Several parameters of iron homeostasis like serum iron level, Total Iron Binding Capacity, serum transferrin, bone marrow iron staining and serum ferritin level have been used either singly or in combination to assess iron levels in patients. Serum ferritin, being a major form in which iron is stored in the body, and which easily detects early changes in body iron storage, has been favored by many authors as the single best blood test for the diagnosis of iron deficiency.[13-17] It is minimally invasive, with relatively little patient discomfort compared to bone marrow iron studies. This study, therefore, used serum ferritin level to assess the level of iron storage in the study population and to diagnose iron deficiency state when the serum ferritin level is below 12 ng/ml. This is the generally accepted cut-off level for serum ferritin by WHO, below which iron stores are considered to be depleted.[18]

Iron deficiency, if unattended to, leads through a process of iron store depletion and iron deficient erythropoesis to iron-deficiency anemia.

The behavioral deficit, cognitive dysfunction and poor school performance associated with iron deficiency have been documented. These deleterious effects may not be reversible,[19-21] hence, primary prevention by way of screening for iron deficiency in non-anemic individuals is paramount and justifies the necessity for this study.

Subjects and Methods

This prospective study was carried out at the Enugu State University Teaching Hospital, (ESUTH), a tertiary health facility situated in the Enugu Metropolis. ESUTH serves as a referral center for the primary and secondary health facilities in Enugu State and environs. Enugu State is in the South-East geographical zone of Nigeria. It has a population of 3.5 million people, according to the National Population Census of 2006.[22] The study population was patients aged 2-59 months presenting at the children emergency room (CHEM) and children outpatient (CHOP) unit of the Department of Pediatrics whose hematocrits were 30% and above (the normal range of hematocrit for this age group is 30-40%, values below this range is anemia).[7] The nurses' daily attendance register was used for the consecutive recruitment of the patients in their order of presentation. Patients aged 2-59 months were consecutively selected. Their hematocrit was done and those with values of 30 and above were recruited as subjects. An average of 7 patients was recruited every week. To each of the recruited subjects, a pro-forma was administered to the caregiver and information on their personal data (age, sex, residential address and phone number of parents) weight (kg), height or length (cm) and the mid-arm circumference (cm) for age 12-59 months were obtained verbally and documented. Two milliliters of blood was drawn from these subjects and centrifuged to separate the serum for ferritin level estimation. The serum samples were stored in the freezer compartment of the chemical pathology laboratory refrigerator. On the average, ferritin analysis was carried out every 3 weeks to allow for collection of a sample size good enough to run a pack of serum ferritin kit. The hematocrit was done using capillary tubes (75 mm in length and 1 mm internal diameter) with anti-coagulated venous ends. The blood from a finger-prick was allowed to enter the tube by capillary action, leaving about 15 mm unfilled. The end of the tube was quickly sealed off with plasticin, centrifuged for 5 min using micro-hematocrit centrifuge (model SJ8038HA2 Suntronics by Surgifriends Medicals, England) and the hematocrit read, using the hematocrit reader. The study was carried out from December 2009 to June 2010.

Laboratory method for serum ferritin estimation

The assay system (Human Ferritin Enzyme Immunoassay Test Kit) utilizes one anti-ferritin antibody for solid phase (microtitre wells) immobilization and another mouse monoclonal anti – ferritin antibody in the antibody – enzyme (horseradish peroxidase) conjugate solution. The test sample is allowed to react simultaneously with the antibodies, resulting in the ferrritin molecule being sandwiched between the solid phase and enzyme linked antibodies. After 60 min incubation at room temperature, the wells are washed with water to remove unbound labeled antibodies. A solution of TMB is added and incubated for 20 min resulting in the development of bluecolor. The color development is stopped with the addition of 2N HCL and the color is changed to yellow and measured spectrophotometrically at 450 nm. The concentration of ferritin is directly proportional to the color intensity of the test sample.

Ethical clearance

Ethical clearance was obtained from the Ethical Committee of the hospital. Informed consent was obtained from parents or care-givers of the children.

Data management and analysis

Raw data were collected from the pro-forma and stored in a Microsoft Excel file and later transferred to Statistical Package for Social Sciences (SPSS, version 15, Chicago IL, USA) for analysis. The study population was categorized into three groups; Infants (2-12 months), Toddlers (13-23 months) and Preschool-age (24-59 months) groups. The results were analyzed by simple frequency count, percentage and proportion and out-laid in tables, bar and pie charts as deemed necessary. Chi-square tests were employed as necessary for test of significance in each of the characteristics of the population at $P \leq 0.05$.

Results

A total of 178 children with age range of 2-59 months, were recruited for the study. Table 1 shows the age classifications of the study population.

The mean hematocrit of the study population was 35.5 (2.8%) (30.0-43.0%) and the mean serum ferritin level of the study population was 54.9 (76.1) ng/ml with a range value of 0.2-454.0 ng/ml. Figure 1 shows a scatter-gram of the serum ferritin levels of the study population.

Forty-nine patients (27.5% [49/178]) of the study population were iron-deficient, with serum ferritin levels of less

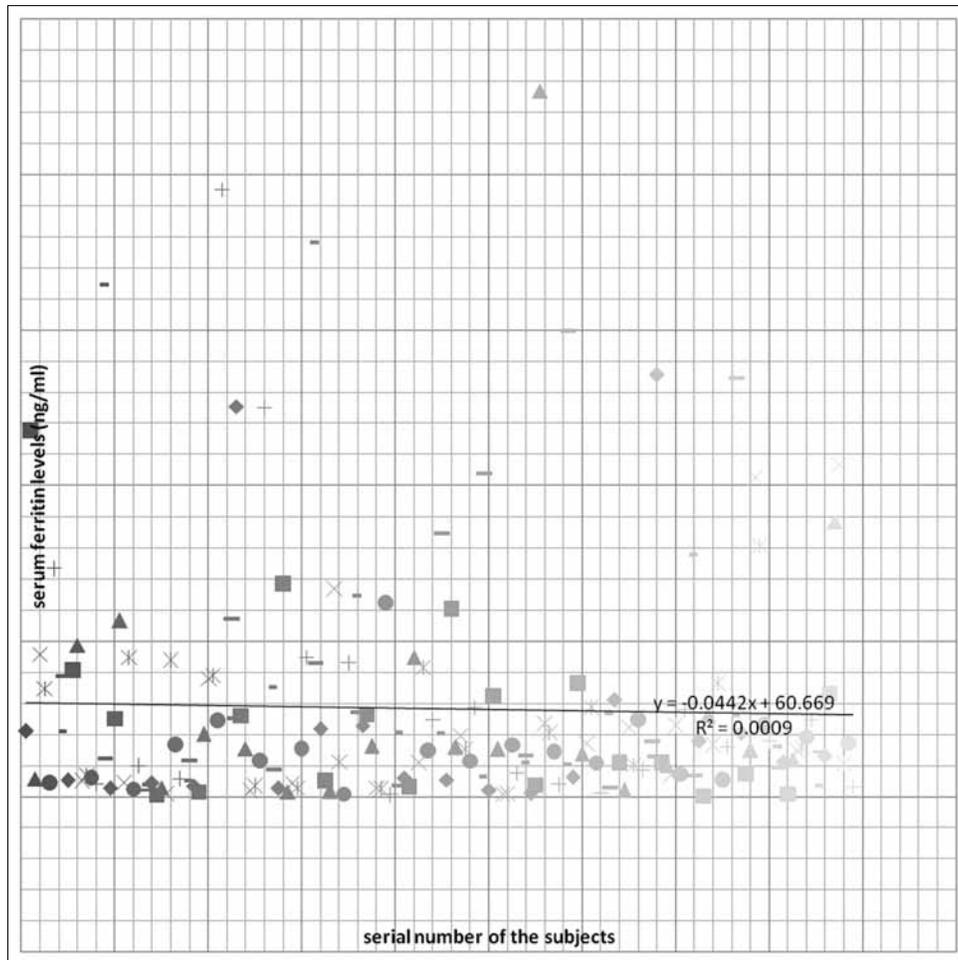| Table 1: The study population by age classification			
	Ferquency (*n*)	**Percentage (%)**	
Infants (2-12) months	65	36.5	χ^2=0.07, *P*=0.99
Toddlers (13-23) months	45	25.3	
Preschool-age (24-59) months	68	38.2	
Total	178	100	

Figure 1: Scatter-gram of the serum ferritin levels of the study population

Table 2: Prevalence of iron deficiency among the age classifications

	Iron-deficient (%)	Non iron-deficient (%)	
Infants *n*=65 (100%)	19 (29.2)	46 (70.8)	χ^2=0.60, *P*=0.74
Toddlers *n*=45 (100%)	11 (24.4)	34 (75.6)	
Preschool-age *n*=68 (100%)	19 (27.9)	49 (72.1)	
Total *n*=178 (100%)	49 (27.5)	129 (72.5)	

than 12 ng/ml. Table 2 below shows the prevalence of iron-deficiency among various age classifications.

Discussion

There was equitable numerical distribution of the various age classes in the study population. The observed numerical difference is not statistically significant (*P* = 0.997).

The mean serum ferritin level of 54.9±76.1ng/ml (0.2-454.0)

ng/ml documented in this study was similar to 50.6 + 52.3 ng/ml documented by Jeremiah, Buseri and Uko in apparently healthy under- five children in Port Harcourt, Nigeria.[23]

The overall prevalence of iron deficiency in this study was 27.5% (49/178), a value which is higher than the 13.5% documented by Jeremiah *et al*.[16] A nationwide survey involving 12 states in Nigeria in 2001[12] using the serum ferritin model as an indicator, reported that 22.3% of children under-5 years of age were iron-deficient. "A prevalence rate of 30.8% was recorded in western Kenya; a fellow developing African country.[24] In a non-African, but developing south-American country like Brazil, a study recorded a prevalence value of 32.4%.[25] These are higher values compared to 5.4% recorded by a study in a developed European country like Spain.[9]"

The prevalence of iron deficiency in all the age classes in this study was high without a significant difference (*P* = 0.741). A similar value was also documented for Kelantanese preschool children in Malaysia.[26] However, in developed countries like the USA[27] and the Republic of Ireland[28] much lower prevalence values were documented.

Conclusion

Iron deficiency is an important public health problem. Its causal role in anemia and development of cognitive deficits in children has been well established. This study has documented a high prevalence of iron deficiency in non-anemic under-five children, with relatively equal affectation of all the age classes. This finding is consistent with the findings in other studies in less developed countries. Therefore, prompt screening for iron deficiency, even in non-anemic under-fives presenting in a health facility in developing countries should be encouraged.

Limitations of the study

We were not able to carry-out laboratory studies (e.g., blood culture) on the subjects to rule out presence of infection (which could apparently raise the serum ferritin level even in iron deficiency state). This was due to limited access to the reagents for such laboratory studies.

Other iron indices like transferrin saturation, total iron binding capacity, bone marrow iron stains, which would have complemented serum ferritin findings were not done due to non-availability of the reagents.

Acknowldgments

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