



Dietary Intake and Micronutrient Status of School Children in Enugu-South L.G.A., Enugu State, Nigeria

J. I. Ugwu^{1*}, N. C. Ejiofor², I. E. Ezeagu², C. P. Okorie² and N. E. Nwankwo³

¹*Renaissance University Ugbawka, Enugu State, Nigeria.*

²*Department of Medical Biochemistry, Faculty of Basic Medical Sciences, University of Nigeria, Enugu Campus, Nigeria.*

³*Department of Biochemistry, Faculty of Biological Sciences, University of Nigeria, Enugu, Nsukka, Nigeria.*

Authors' contributions

This work was carried out in collaboration among all authors. Author JIU designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author IEE supervised the entire work. Author NCE managed the analyses of the study, wrote the revised draft and was also involved in laboratory work. Authors CPO and NEN managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/AFSJ/2020/v15i130145

Editor(s):

(1) Dr. Aneta Popova, University of Food Technologies, Bulgaria.

Reviewers:

(1) Arthur Chuemere, University of Port Harcourt, Nigeria.

(2) Larissa da Cunha Feio Costa, Universidade Federal da Fronteira Sul, Brazil.

Complete Peer review History: <http://www.sdiarticle4.com/review-history/55261>

Received 24 January 2020

Accepted 29 March 2020

Published 20 April 2020

Original Research Article

ABSTRACT

This study sought to assess the dietary intake and serum Zinc, Iron and Copper status of primary school children aged 5-13 years living in Enugu- South Local Government Area of Enugu State, Nigeria. This study is a community-based cross-sectional study, adopting multistage random sampling techniques. Dietary intakes of the micronutrients were assessed using the 24 hours dietary recall. The micronutrient intakes of the children were evaluated using Dietary Requirement Intake as a reference. Two milliliters (2 ml) of non-fasting venous blood was taken from the children for serum micronutrient analysis. Three hundred and thirty (330) children were analyzed for serum micronutrient status; 155 (47%) were male while 175 (53%) were females, with their mean age 8 ± 1.09 . The mean micronutrient intakes of the subjects were 4.98 ± 3.7 , 4.53 ± 1.63 ,

*Corresponding author: Email: joshuaizuchukwu8@gmail.com;

and 0.42 ± 0.20 mg/d for Fe, Zn and Cu respectively. Only the male group aged 5-9 years met 100% of the DRI for Zn while the 5-9 years females, 10-13 years males and 10-13 years female did not meet up with the DRI for Zn, Fe and Cu. The mean serum micronutrients of the total children were 63.16 ± 18.06 , 62.27 ± 17.3 and 69.9 ± 14.99 $\mu\text{g}/\text{dl}$ for Fe, Zn and Cu respectively. Of the 330 children studied, 32%, 43% and 23% of them seem to be deficient in Fe, Zn and Cu respectively. The food intakes of the children did not supply the recommended Dietary Requirement Intake for school children. There is, therefore, an urgent need to educate the public on good eating habits and the need for diversification of diets with animal products, fruits and vegetables to ensure adequate intake of these essential micronutrients.

Keywords: Dietary intake; zinc; iron; copper; micronutrients.

1. INTRODUCTION

Micronutrients are nutrients that are only needed by the body in minute amounts, which are involved in the production of enzymes, hormones and other substances, helping to regulate growth activity, development and the functioning of the immune and reproductive systems [1].

Micronutrient malnutrition is a condition that results from eating diets that lack one or more of micronutrients, that is required by the body for proper growth and development [2]. Micronutrient deficiencies have been a major nutritional problem in developing countries like Nigeria and have adversely affected people's health, performance and income, thereby becoming major impediments to economic development [3]. Micronutrient deficiencies have become more prevalent following economic stress and food insecurities faced by populations in these countries. Most at-risk groups include children less than 5 years of age, adolescents, women of childbearing age, particularly the pregnant and lactating, refugees, internally displaced persons and victims of famine [4] (Dairo et al. 2009). Micronutrient deficiencies can exist in populations even where the food supply is adequate in terms of meeting energy requirements [5]. In these situations, people are not considered "hungry" in the classical sense, but their diets may be grossly deficient in one or more micronutrients and they are not aware. It is for these reasons that micronutrient deficiencies have been referred to as "hidden hunger" [6].

Iron deficiency anaemia is the most common micronutrient problem in the world as it affects more than 2 billion people globally [7]. Prevalence of iron deficiency anaemia varies between countries, affecting 5.4% children in Spain, 30.8% and 22.3%, 84.6% [8], 30.8% under five Brazilian children [9] and 22.3% under-five Nigerian children [10]. Iron deficiency

anaemia is associated with adverse health conditions including permanent behavioural and cognitive impairments. Therefore, early detection and prompt treatment are necessary to prevent these complications.

Zinc is one of the trace mineral essential to human nutrition and metabolism, participating in all biochemical pathways and playing multiple roles in the gene expression, cell development and replication [11]. Zinc deficiency is largely related to inadequate intake or absorption of zinc from diet. Because of these inadequate intakes billions of people are at risk of zinc deficiency. More than 400,000 children die each year due to zinc deficiency [12]. An estimated 17.3% of the global population is at risk of inadequate zinc intake [10]. The prevalence of zinc deficiency in sub-Saharan Africa is 50% [10]. And in Nigeria, the prevalence of zinc deficiency is 21% [13].

Copper is one of the essential trace elements in humans. Acquired copper deficiency is mainly attributable to nutritional deficiency, and may be seen in malnourished low-birth-weight infants, newborns, and small infants. Several reactions essential to the normal function of the brain and nervous system are catalyzed by cuproenzymes [14]. It was reported that 4.1% of primary school children from South East and 32.1% of primary school children in West, Nigeria were copper deficient [13,15].

The copper-dependent enzyme, cytochrome c oxidase, plays a critical role in cellular energy production by catalyzing the reduction of molecular oxygen (O_2) to water (H_2O), cytochrome c oxidase generates an electrical gradient used by the mitochondria to create a high energy proton gradient required for adenosine triphosphate (ATP) synthesis. This copper enzyme is particularly abundant in tissues of greatest metabolic activity including heart, brain, and liver [16]. Improving school children's

nutrition will improve their cognitive function and linear growth. Nutritional programs in resource-poor settings mainly focus on children under the age of five years. This has resulted in limited information on nutritional and micronutrient status of school-aged children. This work was aimed at providing information on dietary intakes and serum Fe, Zn and Cu status of primary school children in Enugu-South LGA, in Enugu State, Nigeria.

2. METHODOLOGY

2.1 Study Location and Sampling Technique

The study was carried out in Enugu state, South Eastern Nigeria. The study was designed as a community-based cross-sectional study carried out among school children by adopting a multistage random sampling technique in Enugu State. Enugu State has 17 Local Government Areas (LGAs). Enugu South was randomly selected. Enugu South has forty two (42) public primary schools with a population of 8,841 pupils aged 5-13 years as at the time of this research. These schools are distributed in the LGA wards. Four wards were randomly selected in the L.G.A. A school was selected from each of the wards to give a total of four schools. One hundred and six (105) pupils per school were objectively selected, to give a total of four hundred and twenty (420) pupils that will participate in the research.

2.2 Sample Size Calculation

The sample size was calculated as follows: [17]

$$Ss = \frac{z^2 p(1-p)}{C^2}$$

Where Ss is the sample size, z is the z score at 95% confidence limit (1.96), p is the (estimated) proportion of the population, which has the attribute in question, and c is confidence level.

The values for population >10,000 and <2,000 are given as follows:

$$z = 1.96, c = 0.05, P = 0.5,$$

$$Ss = \frac{1.962 \times 0.5 \times (1-0.5)}{0.052}$$

$$Ss = 384.$$

330 subjects were recruited for the study. This number was 55 short of the calculated sample

size. This shortfall was a result of difficulties (unwillingness of some subjects to consent to the study) encountered at certain locations during the sample collection.

2.3 Inclusion Criteria

Only u-5 children (aged 36–60 months) attending registered nursery schools in Enugu State were involved in the study.

2.4 Exclusion Criteria

Children with high temperature ascertained with the aid of clinical thermometer and those their caregivers refused to sign the consent letter were excluded from the study.

2.5 Ethical Clearance

Ethical clearance was obtained from Enugu State Ministry of Health and from the University of Nigeria Teaching Hospital Ethical Committee. Written and signed informed consents were obtained from all parents or caregivers of u-5 children enrolled for the study. Also, permission was obtained from Enugu State Universal Basic Education Board (ENSUBEB). Head Teachers of the selected schools and the Parents Teachers Association (PTA), the School-Based Management Board (SBMB), were sensitized about the project and its importance to children. Thereafter the parents that consented to be part of the research were given an informed consent form to fill and submit. The dietary intakes of the respondents were assessed using the 24-hour dietary recall protocol. Subjects were asked to recall and describe all foods, drinks and snacks (including amount) eaten in the previous 24 hours. Usually, these recall protocols were made on Tuesdays of the week. The participants usually were fed at home, hence results points to their home feeding structure. Portion sizes were established using standard household measures quantified in grams. The micronutrient intakes of the subjects were evaluated using dietary requirement intake (DRI).

2.6 Blood Collection and Analysis

The pupils that consented to be part of the work were recruited, and non-fasting venous blood (2 ml) was collected from each subject with the assistance of a Board Certified Laboratory Scientist. Serum was separated by centrifuge and stored at 4°C until analysis at the parasitological laboratory of Enugu State

Teaching Hospital. The sera were separated from cells and stored at 0°C until analysis. The conventional wet Acid method of [18] was adopted. The digests were cooled and the precipitates were separated, the filtrates were diluted with distilled water to 4 ml. The worked up samples were stored in polyethylene container at 4°C prior to Atomic Absorption Spectroscopy (AAS) analysis.

Sera were analyzed for Zn using thermal atomic absorption spectrophotometer.

3. RESULTS AND DISCUSSION

Table 1 showed the gender and age distribution of the children. The males who were between the ages of 5 to 9 years were eighty three (83) and the females who were between the ages of 5 to 9

years were ninety three (93). The nutritional requirement of children is higher in proportion to body weight compared with adults. The period of childhood between ages 4 and 13 years is characterized by continued physical growth and rapid cognitive, emotional, and social development [19]. Many children especially girls undergo their pubertal growth spurt between ages 4 and 13, therefore inadequate intake of micronutrients can impair growth and development in children.

Only 233 (70%) of the children took three serving meals per day, 165 (15%) took two serving meals per day, 20 (6%) took one serving meal per day and 28 (9%) took up to four serving meals per day (Fig. 1). This could be attributed to poverty and food insecurity in households as was observed in North-Central Nigeria [19].

Table 1. Gender and age distribution of school children

Age group	Male (n = 155)	Female (n = 175)	Total (n = 330)
5 – 9	83	93	176
10 – 13	72	82	154

Table 2. Frequency distribution of food types consumed by children of Enugu-South L. G. A. in 24 hours (n = 991 meals)

Food Type	Frequency	Percentage (%)
Cereals	255	38.9
Tuber & plantain	198	30.2
Legumes	81	12.3
Fats & Oil	64	9.8
Soups	135	20.6
Animal products	56	8.5
Vegetables	120	18.3
Fruits	14	2.1
Dairy	36	5.5
Others	32	4.9

Table 3. Micronutrient composition of major foods and drinks

Dishes/ Drink	Iron (mg/100 g)	Zinc (mg/100 g)	Copper (mg/100 g)
Rice & Tomatoes stew	7.43	8.46	8.46
Rice & Banga Soup	28.76	3.39	0.89
Noodle	5.52	3.01	0.85
Garri & Egusi Soup	5.20	4.41	0.15
Jellof Rice	7.22	5.62	0.92
Garri & Okro Soup	4.14	4.31	0.12
Akpu & Ora Soup	3.95	5.31	0.23
Pap & Sugar	1.10	1.18	0.03
Okpa	2.27	3.33	0.15
Garri & Better leaf soup	4.36	4.7	0.15
Akara	2.85	3.77	0.17
Bread	4.57	2.05	0.37
Chocolate tea & Milk	4.09	2.39	0.11

Sources: [13,20,21]

Table 4. Micronutrient daily intakes and the mean serum level of Enugu-South children

Micronutrients	Sex (Age)	Mean intake(mg/d±SD)	% DRI	Mean serum (µg/dl±SD)
Fe	M (5-9)	3.94±0.96	39.40	57.55±17.66
	M (10-13)	5.71±5.40	71.40	63.61±19.14
	F (5-9)	5.48±4.87	54.80	67.48±18.63
	F (10-13)	4.80±2.50	60.00	64.00±16.03
Zn	M (5-9)	5.02±1.70	100.40	61.91±16.99
	M (10-13)	4.14±1.60	89.20	61.36±18.13
	F (5-9)	4.46±1.87	51.75	57.93±16.83
	F (10-13)	4.49±1.63	56.10	67.88±16.53
Cu	M (5-9)	0.25±0.14	62.50	62.33±16.38
	M (10-13)	0.51±0.12	72.85	64.36±13.17
	F (5-9)	0.32±0.19	80.00	74.43±16.41
	F (10-13)	0.58±0.26	82.50	76.05±14.16

F: Female, M: Male; Figures in parenthesis indicate age bracket.

DRI for: Fe 5-9 years=10 mg, 10-13 years = 8.0 mg, Zn 5-9 years= 5.0 mg, 10-13 years=8.0 mg, Cu 5-9 years = 0.4 mg, 10-13 years = 0.7 mg. Source: Food and Nutrition Board [22] M: Male, F: Female; Figures in parenthesis indicate age bracket. Normal Range: Fe = 50 - 120 µg/dl, Zn = 60 - 110 µg/dl, Cu = 70 - 150 µg/dl. [12]

Table 5. Frequency distribution of serum Fe level (n= 330) of Enugu-South school children

Range (µg/dl)	5-9 years (M/F)	10-13 years (M/F)	Total subjects (n = 330)
0-49	40 (48%) / 25 (27%)	18 (25%) / 24 (29%)	107
50- 120	43 (52%) / 68 (73%)	54 (75%) / 58 (71%)	223
>120	0 / 0	0 / 0	0

M: Male, F: Female. Figures in parenthesis indicate the percentages. Normal range: 50-120 µg/dl [12]

Table 6. Frequency distribution of serum Zn level (n= 330) of Enugu-South school children

Range (µg/dl)	5-9 years (M/F)	10-13 years (M/F)	Total subjects (n = 330)
0-50	28(34%) / 45(48%)	38(53%) / 33 (40%)	142
51-110	55 (66%) / 48 (52%)	36(47%) / 49 (60%)	188
>110	0/0	0/0	0

M: Male, F: Female. Figures in parenthesis indicate the percentages. Normal Range: 60-110 µg/dl [12]

Table 7. Frequency distribution of serum Cu level (n= 330) of Enugu-South school children

Range (µg/dl)	5-9 years (M/F)	10-13 years (M/F)	Total subjects (n = 330)
0- 69	25(30%) / 16 (17%)	20 (28%) / 16 (20%)	77
70- 150	58 (70%) / 77 (83%)	52 (72%) / 66 (80%)	253
>150	0 / 0	0 / 0	0

M: Male, F: Female. Figures in parenthesis indicate the percentages. Normal range: 70- 150 µg/dl [12]

Following the result of the daily meal intake of these children, it can be inferred that 68 (21%) of the children do not have adequate calorie for their active and healthy life. Food insecurity can affect children's health and brain development years before they enter a classroom, such children often are cognitively, emotionally and physically lag behind their food-secure peers. Studies have shown that food insecurity harms children's health in a variety of ways such as mental retardation, learning difficulties, compromised immune systems, low work capacity [23,24].

Also food-insecure young children are nearly twice as likely to be in fair or poor health when compared to food-secure young children and significantly more likely to be hospitalized [25]. Food-insecure children are also more likely to suffer from common illnesses such as stomachaches, headaches, and colds when they reach preschool age [26]. The stress that family hardships, like food-insecurity, place on young children physically alters the development of crucial brain structures controlling memory and psychosocial functioning [27]. Early childhood is the narrow window during which one builds the basic capacity to learn and interact productively

with their peers, disrupting this brief period diminishes children’s ability to acquire complex school skills as they grow, and later job skills [28]. Examining the role of food insecurity in cognitive outcomes showed that food-insecure 6-11 year-olds scored lower than their food-secure peers on a measure of child intelligence and were more likely to have seen a child psychologist [29]. The same study also found that these children had a harder time getting along with others and more likely to have repeated a class and had lower arithmetic and general achievement test scores than food-secure children in the same age group [30].

Table 2 showed that the main diet taken by these children were mostly from plant sources. The major food taken by at least 10% of the respondents were tuber based vegetables, cereals, legumes and soup, only 56 (8.5%) of them took animal source foods. The implication is that the micronutrients (Fe, Cu and Zn) in the diets will not be completely bio available for absorption, because of the presence of phytates [18,30].

Table 3 showed the micronutrient values of the food intakes of the children and it was used to estimate their daily micronutrient intakes, which were obtained from published data. The result of the micronutrient intake of the children shows the mean micronutrient intakes of the subjects were

4.98±3.70, 4.53±1.63, and 0.42±0.20 mg/d for Fe, Zn and Cu respectively.

Table 4 showed that the males 5-9 years met 100% of the DRI for Zn, but not for Fe and Cu. None of the males 10-13 years met 100% of DRI for Fe, Zn, and Cu. Also, none of the females 5-9 and 10-13 years met 100% of DRI for Fe, Zn and Cu. Fe deficiency is obvious since only 8.5 percent of the children consumed animal source foods and only 2.1 percent took fruits, which contains ascorbic acid that aids in non-heme iron absorption in the GIT. Plant source of Fe are mostly non-heme iron, which are not completely absorbed because of the chelating effects of plants phytic acids on the micronutrient, impairing the absorption of Fe and may make it unavailable or in short supply for absorption, thereby promoting Fe deficiency. Dietary Fe intake, therefore, could not meet their physiological requirements [31]. The mean daily Zn intake of the children ranged from 1.25-8.46 mg/d with a mean of 4.53 ± 1.63 mg/d (Table 4). Only the males 5-9 years group met 100% of the DRI for Zn. Zinc seems deficient since the majority of the food ingested by this children where cereals and tuber crops. These foods contain phytic acids, and another potent inhibitor that inhibits the absorption of Zn from the GIT [32]. Zinc supply from the meal may be unavailable for uptake into the system due to the chelating effects of these inhibitors.

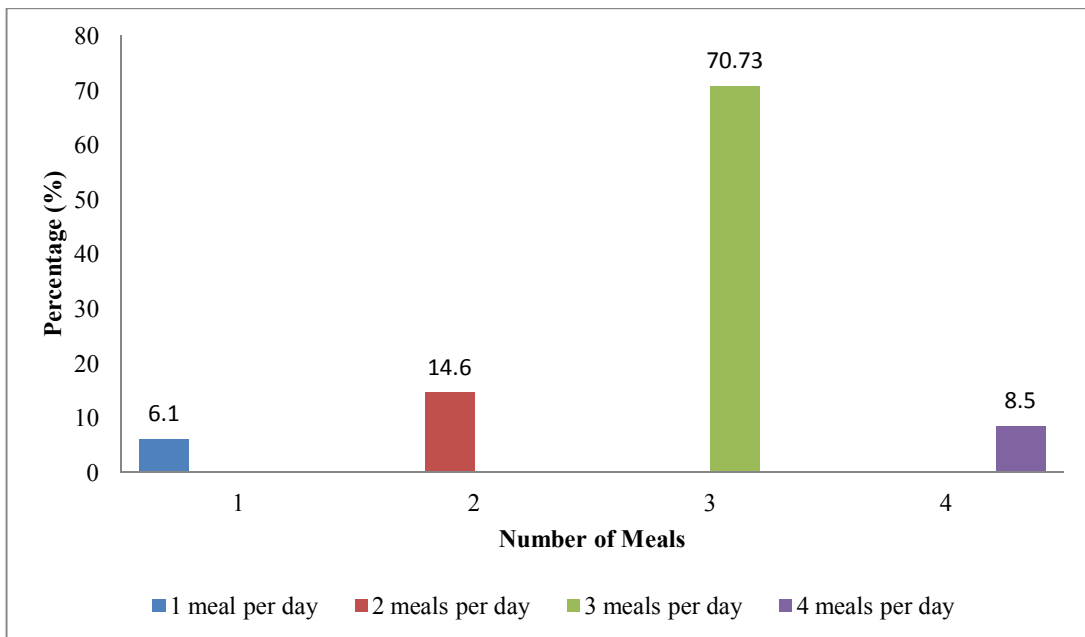


Fig. 1. Distribution of Daily Meal Intake of children

The DRI of the children shows that the Cu requirement of the subjects increased as the age increased among the males and the females. The major meals taken by these children were mostly cereal and tuber based (Table 3), which do not supply an adequate amount of Cu required by the body. Dietary sources of copper include; organ meats, sea foods, nuts, and seeds, which were lacking in the diet of the school children. The Cu intake results showed that none of the children in the different age groups met the DRI for Cu as shown in Table 4. The implication is that the children will be deficient in Cu. The dietary intake of the children ranged between 0.04 and 1.15 mg/d with a mean of 0.31 mg/d. The results showed that the females 5-9 years group had higher Cu intake (0.32±0.19) than the males 5-9 years (0.25±0.14) and the females 10-13 years group had higher Cu intake (0.58±0.26) than the males 10-13 years (0.51±0.12). Overall, the females of the groups consumed foods high in Cu than the males.

Table 4 shows the mean serum micronutrient levels of the subjects, the mean serum Fe for the subjects is 63.16±18.06 µg/dl. There is no statistical difference between the different age groups ($P > 0.05$). The female 5-9 years had the highest mean serum Fe level (67.48±18.63µg/dl), while the 5-9 years male group had the lowest mean serum Fe level (57.55±17.66µg/dl).

The mean serum Zn level for the subjects was 62.27±17.31µg/dl. There is no statistical difference between the different age groups in serum Zn level ($P > 0.05$). The males 5-9 years group had the highest serum Zn level (67.88±16.53µg/dl), while the female 5-9 years group had the lowest serum Zn level (57.93±16.83µg/dl). The serum Zn levels of the children ranged between 31 and 107µg/dl, with a mean value of 62.27±17.31 µg/dl. This value is adequate using the lower cut-off value of 60µg/dl (Table 4). The mean serum Zn values obtained in this study is lower than the mean serum Zn, reported for school children in South African (66.4µg/dl) [30]. Also in a similar study conducted on school children living in Northwest Ethiopia mean Zn level was 86.40µg/dl [32], showing that Zn deficiency was not severe among school children. School children in North Central Nigeria had a mean serum Zn concentration 22.4µg/dl [33], which is very low when compared to the Zn concentration obtained in this study.

The mean serum Cu level of the subjects was 69.29±14.99µg/dl. There is no statistical difference between the groups in serum Cu level ($P > 0.05$). The mean serum Cu shows that the children were deficient in Cu, based on the cut-off value for serum Cu concentration (70µg/dl). The males 5-9 years group were the most deficient in Cu (62.33±16.38µg/dl), while the females 10-13 years had the highest Cu level (76.05±14.16µg/dl).

The Fe intakes of the children compared with their serum level shows that the males 5-9 years met only 39.4% of DRI for Fe, while the females met only 54.8% of the DRI for Fe (Table 4). Therefore the estimated dietary Fe intake of the 5-9 years children were reflected in their serum Fe level. The females 10-13 years had a higher mean serum Fe level (64.00±16.03 µg/dl) than the males 10-13 years (63.61±19.14 µg/dl). But the older males (10-13 years) had a higher dietary Fe intake meeting 71.4% of the DRI, while the females 10-13 years met only 60% of the DRI for Fe. Comparing the micronutrient intake of this group (10-13years) with their serum Fe shows that their Fe intake did not appear in their serum level. It can therefore be inferred that the intake of iron-containing diets by most of the males 10-13 years on the day of sample collection was higher than that on the day the 24 hours recall interview was conducted, or that they may be infested with intestinal worms such as hook worm, which causes physiologic Fe loss or that there was a degree of exaggeration or underreporting during the interview.

Since the micronutrient intake of individuals contributes to the serum micronutrient levels, the micronutrient intake of the children in this study could have been affected by the type of meal taken in Nigeria. A report on the Zn intake and the serum Zn concentration of the children in Lagos showed that their mean Zn intake met 92% of the DRI for Zn, and their serum zinc concentration as 84.58µg/l [13], linking serum concentration as a reflection of meal intake. The dietary Zn intake of the South African children is 4.6 mg/day, while their mean serum concentration was within the normal range [30]. The males 5-9 years had a higher serum Zn level (61.91 ± 16.99µg/dl), than the females 5-9 years (57.93 ± 16.83µg/dl). Comparing this with the dietary Zn intake of the children reveals that the females had a lower zinc intake meeting only 51.75% of the DRI for zinc, while the males 5-9 years group had intake up to 100% of the DRI. The daily Zn intake of the male 5-9 years was not reflected in their serum Zn, because their serum

Zn concentration is within the normal range (60-120µg/dl). It can be inferred that the total Zn in their food was not absorbed due to the presence of phytates. The females 10-13 years had a higher serum Zn level ($67.88 \pm 16.53\mu\text{g/dl}$), than the males 10-13 years ($61.36 \pm 18.13 \mu\text{g/dl}$). This was also not reflected in their Zn intake since the male 10-13 years met 89 % of DRI for Zn and the females 10-13 years met only 56% of the DRI, there might be a possibility of underreporting during the interview.

Comparing the micronutrient dietary intakes and the mean serum concentration of Cu in the children shows a similarity between the Cu intake and the serum levels. The males of 5-9 years met 62.5% of Cu DRI and the serum concentration of $62.33\mu\text{g/dl}$, while the females of 10-13 years that met 82.50% of the DRI for Cu, had a serum concentration of $76.05\mu\text{g/dl}$. The mean serum Cu level of the children reflects their Cu intake, which shows deficiency existing mostly among the males of different groups. The reason is likely to be, because the females of the groups had appreciable higher intake of Cu than the males as shown in Table 4. A similar study in Ethiopia showed that the children who were normal had a Cu concentration of $200\mu\text{g/dl}$, while those that were severely and mildly stunted had their Cu concentrations as 152.55 and $186.89\mu\text{g/dl}$ respectively [32]. This value is higher than the result obtained in this study. It was observed that the water and diets of the children in Ethiopia were very high in Cu indicating that the mineral contents of the soil can accumulate in the plants and also in the water of a particular environment. Thus mineral from the soil can contribute to Cu deficiency or its fortification [32]. Another study carried out among malnourished children and well feed children showed that, the serum Cu concentration of the malnourished children were lower than that of the well feed group [34]. This indicates further that, the dietary intake of Cu refracted in the serum concentration.

The result of the serum Fe quantification shows that, the serum Fe concentration of the children ranged between 31 and $108 \mu\text{g/dl}$, with a mean of $63.16 \mu\text{g/dl}$. The serum Fe tolerable value for school aged children is 50-120 µg/dl. The result of this study shows that the mean serum Fe of the children is higher than the lower cut-off value for Fe ($50\mu\text{g/dl}$). This value is because the children that had normal value tend to have high Fe intake values compared to those that are deficient. Out of 330 children, one hundred and

seven (107) of them were deficient, while two hundred and twenty three (223) of them were normal. This may have contributed to their mean value being normal.

The mean serum Fe level obtained for school children in this study is lower than the mean serum Fe level of $69.84 \mu\text{g/dl}$, found among school children in Lagos, Nigeria [13] and $328.19 \mu\text{g/dl}$, reported for school children living in North West Ethiopia [32]. The disparity in the serum Fe can be associated with the dietary Fe intake of the children. The children in Lagos which had their main dietary intake for iron as $10.66 \pm 12.44 \text{ mg/d}$ (106% of DRI) were not deficient in Fe [13].

Table 5 shows that males 5-9 years were mostly deficient in serum Fe, because 40 of them were Fe deficient with a prevalence rate of 48%, while the females 5-9 years had 25 of them deficient in Fe and a prevalence rate of 27%. Twenty four (24) of the females 10-13 years were deficient in Fe with a prevalence rate of 29%, while among the males 10-13 years 18 of them were deficient in Fe with and the prevalence of 25%. This result is in agreement with the report on the prevalence of Fe deficiency in anaemic under five children in Enugu State, which shows that Fe deficiency was higher among the males than the females [35]. Also a similar study conducted in Lagos, Nigerian, shows that the males 9- 13 years had a higher prevalence rate of Fe deficiency than the females [13], which is contrary to this study.

The serum Fe level of the children was higher among the males across the age than the females, this could be attributed to the fact that many children, especially girls who undergo their pubertal growth spurt between ages 10 and 13 and may be undergoing their monthly menstruation which contributes to physiologic Fe loss. The females 5-9 years had a higher mean serum Fe level ($67.48 \pm 18.63 \mu\text{g/dl}$), than the males 5-9 years ($57.55 \pm 17.66 \mu\text{g/dl}$).

The male children, especially the 5-9 years were mostly at risk of Fe deficiency in Enugu – South which could lead to anemia and may expose them to illnesses thereby affecting their performance at school. The females 5-9 years had a higher serum Fe level than the females 10-13 years, the difference in the serum Fe concentration of the female pupils suggests that the older females may have been menstruating, which increases the risk of iron lost in the system. The implication here will be that more of the females (10-13 years) may be predispose to

iron deficiency. Pregnant girl with iron deficiency anemia is prone to have pregnancy complications and its related problems [15]. The low level of serum iron concentration in this study, especially with the males indicates that Fe deficiencies will be obvious, which may lead to iron deficiency anemia and associated with reduced immunity, impaired mental development, physical coordination skills and impaired school achievement in older children. It also lowers resistance to disease and weakens a child's learning ability and physical stamina. It slows mental and motor development and reduces work performance if not attended to [36].

The frequency distribution of Zn deficiency among the children in this study (Table 6), shows a high level of Zn deficiency among the females 5-9 years and a prevalence rate of 48% (45 children), compared to the males 5-9 years who had 34% (28 children) deficiency rates. The males 10-13 years were more at risk of Zn deficiency than the females because the females who were deficient were 33 (40%), when compared to the males that had only 38 (53%) who were deficient.

Zinc plays an important role in growth and development, the immune response, neurological function, and reproduction, so its deficiency may lead to episodes of sickness, stunting and delayed onset of puberty among the males. This study does not agree with the report that boys have greater vulnerability to Zn deficiency than the girls [37]. However reports showed that 13% boys and 14% girls were Zn deficient in Iran (n = 350) [38] and that 51% boys and 58% girls were Zn deficient in Sri Lanka(n = 400) [39]. This study demonstrated the existence of Zn deficiency among school aged children and adolescence in developing countries. The serum Zn of the subjects shows a deficiency rate high above normal and the mean Zn intakes did not met the DRI for Zn except for the males 5-9 years. The implication will be a risk of growth retardation, delayed onset of puberty, impaired immunity against diseases, abnormal cognitive development and poor performance at school [40]. However this could be prevented by advocating for foods that are rich in Zn, such as red meats and shellfish especially for the older subjects.

Results from Table 7 shows that the males 5-9 years had a deficiency rate of 30% (25 children) and the females 5-9 years had a deficiency rate of 17% (16 children). The males 10-13 years had

a deficiency rate of 28% (20 children) and the females 10-13 years had a deficiency rate of 20% (16 children). The result shows that the males of all the age groups were more at risk of Cu deficiency than the females [13]. A study in Lagos showed that 32.1% (n = 200) of all the children were Cu deficient and that the males 5-8 years were mostly deficient. In another study on school aged children at North-West Nigeria involving five states showed that all the children were deficient in Cu [41]. The low serum concentration of Cu in this study is an indication that copper was present at low level in the children's diet probably due to the level of the element in the soil or that copper was poorly available for absorption.

Prolonged deficiency of Cu may lead to bone lesions, which may be accompanied by osteoporosis and ocephal horn formation after adolescence in these children. Therefore Cu intake should be encouraged and confectionary foods fortified with Cu to alleviate the Cu deficiency of these children in this region.

Generally interactions between trace elements have long been recognized [42]. An intriguing interaction appears to exist between copper, zinc and iron in absorption and utilization [42]. Supplementation of Fe has been reported to affect bioavailability of Zn and Cu in Fe deficiency anemia by inter-element competition in the bowel, while on the bioavailability of Cu and Fe are affected by Zn supplementation [42]. It has been established that Fe deficiency results in increased Cu levels in the liver [43] while severe Cu deficiency causes changes in Fe metabolism, leading to anemia because Cu is an essential component in the formation of ferroxidase 1. Deficiency of Cu induces a dramatic decrease in ferroxidase activity which in turn prevents the mobilization of Fe from stores by being oxidized from +2 to +3 and its incorporation into hemoglobin therefore causing an accumulation of Fe in the liver [44]. The micronutrients deficient in this study might be an indication that they were present at low supply in the diet of the subjects or were poorly bioavailable.

Fig. 2 showed that the prevalence of Fe deficiency in the children is 32.4% and is higher than 19.8% prevalence rate among the school children in Lagos [13], and also lower than the 34.3% prevalence rate of Fe deficiency among anaemic under-5 children in Enugu south, Nigeria [35].

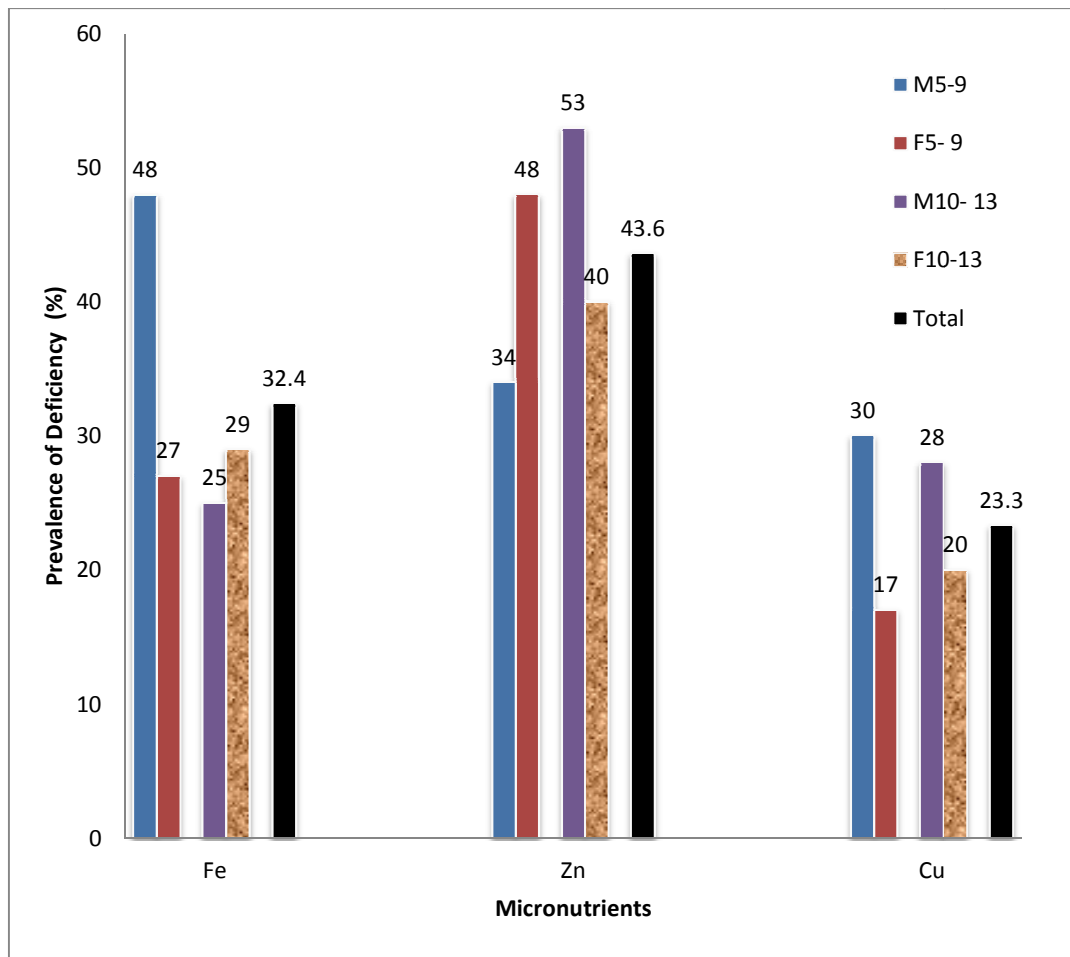


Fig. 2. Prevalence of Micronutrients Deficiency among Enugu-South school children

The prevalence of Zn deficiency among the school children was 43.6% (Fig 2), using the cut-off value for serum Zn concentration below 60µg/dl [45]. This value is higher than the 20% prevalence rate set by the International Zinc nutrition consultative group (IZiNCG), as an indicator of maximum Zn prevalence rate of public health concern [46]. It is also higher than 21% found among school children in Lagos, Nigeria [13] and of 46% and 47% prevalence rate found among school children in South Africa and Northwest Ethiopia respectively [31,34]. A study in North Central Nigeria reported a prevalence rate of 99.2% [33]. There is therefore a high prevalence of Zn deficiency among school aged children in Nigeria, more especially in Northern Nigeria.

The prevalence of Cu deficiency among the groups indicates that 23.3% (77) of all the children were Cu deficient.

4. CONCLUSION

The food intakes of school children did not supply adequate amount of micronutrients needed for a healthy body. Based on the dietary intake and serum micronutrient concentration the result shows that micronutrient deficiency exists among the school children. This can lead to adverse effect on their maturation and performance at school. Therefore, there is urgent need to educate the public on good eating life style and the importance of diversification of diets. Also a nutrition education program should be put in place in other to combat the micronutrient deficiency in this Enugu-South L.G.A and beyond.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. FAO/WHO. Human vitamin and mineral requirements. Report of a joint FAO/WHO expert consultation. Rome; 2002.
2. Allen L, de Benoist B, Dany O, Hurrell R. Guidelines on food fortification with micronutrients. Geneva, WHO; 2006.
3. Bowley A. Alliance against hunger. Editorial Nutriview. 2008;4:2. Available:http://www.dsm.com/en_us/downloads/dnp/Nutriview_2008_4.pdf (Accessed 10th September 2015)
4. Dairo MD, Ige OK. Supplementation of micronutrient in community micronutrient deficiency prevention program. Ann Ib postgrad Med. 2009;7(1):6-9.
5. Ayogu RN, Afiaenyi IC, Madukwe EU, Udentia EA. Prevalence and predictors of under-nutrition among school children in a rural South-eastern Nigerian community: A cross sectional study. BMC Public Health. 2018;18(1):587.
6. Kennedy G, Nantel G, Shetty P. The scourge of "Hidden hunger" global dimensions of micronutrient deficiencies; 2002.
7. Onyezili FN, Alo IS, Tinorgah A. Micronutrient deficiency control and child survival in Nigeria. In: Akinyele IO, Onimawo IA, Uwaegbute AC. Child Survival and the Right to Adequate Nutrition. Proceedings of the 34th Conference and Scientific Meeting of Nutrition Society of Nigeria. Held at Michael Okpara University of Agriculture, Umudike, Abia State November 26th – 29th; 2003.
8. Dyness K, Pammala MP, Haikel M, Martin EK, Theobald CEM. Prevalence and Predictors of anemia among children under 5 years of age in Arusha District, Tanzania. Pediatric Health Med Ther. 2018;9:9-15.
9. Vieira AC, Diniz AS, Cabral PC, Oliveira RS, Lola MM, Sila SM. Nutritional assessment of iron status and anemia in children under 5 years old at public day care centres. J Pediatr. 2008;83:370-6.
10. Maziya-Dixon B, Akinyele IO, Ogbuntona EB, Nokoe S, Sanusi RA, Harris E. Nigeria food consumption and Nutrition Survey 2001- 2003 Summary. International Institute of Tropical Agriculture, Ibadan; 2004.
11. Hambridge KM. Human Zinc deficiency. Journal of Nutrition. 2000;130:S1344-1349.
12. FAO/WHO. Human vitamin and mineral requirements, Report of a joint FAO/ WHO expert consultation Bangkok, Thailand. 2004; 195-221.
13. Akeredolu IA, Oguntona BE, Okafor C, Osisanya OJ. Iron, Zinc and copper malnutrition among primary school children in Lagos, Nigeria. Food and Nutrition Sciences. 2011;2:1063-1070.
14. Harris ED. Copper. In: O' Dell B L, Sunde RA, eds. Handbook of nutritionally essential minerals. New York: Marcel Dekker, Inc. 1997;231-273.
15. Ugwuja EI, Ugwu NC, Muoneke VU, Aloke C, Idenyi JN, Urochukwu H. Plasma level of copper, iron and zinc in healthy primary school children from rural communities of Ebonyi State, South Eastern Nigeria. IJFSNPH. 2011;5(2):162-72.
16. Uauy R, Olivares M, Gonzalez M. Essentiality of copper in humans. Am J Clin Nutr. 1998;67(5 Suppl):952S- 959S.
17. Nwaboikei PO. Fundamentals of Statistics. Nigeria: Koruna Books, Enugu; 2001.
18. Memon AR, Tasneem GK, Hassan IA. Evaluation of Zinc status in whole blood and scalp hair of female cancer patients, Clinica Chimica. Acta. 2007;10564.
19. Lucas BL, Feucht SA. Nutrition in childhood. In: Mahan LK, Escott-Stump S, eds. Krause's food & nutrition therapy. 12th Ed. St. Louis: Saunders Elsevier. 2008; 222-45.
20. Okeke EC, Eneobong HN, Uzuegbunam AO, Ozioko AO, Umeh SI, Kuhnlein H. Nutrient Composition of Traditional Foods and Their Contribution to Energy and Nutrient Intakes of Children and Women in Rural Households in Igbo Culture Area. Pakistan Journal of Nutrition. 2009;8(4): 304-312.
21. Madukwe EU, EneObong HH. Adequacy of micronutrient content of south eastern nigerian meals in meeting the nutritional needs of vulnerable groups. Journal of agriculture, Food Environment and Extension. 2012;3:2.
22. Food and Nutrition Board, Institute of Medicine (FNB). Overview and methods. In :Dietary Reference intakes for vitamins and mineral. Washington, D.C. National Academy Press. 2001;44-59.

23. Gundersen C, Kreider B, Pepper J. The economics of food insecurity in the United States. *Applied Economic Perspectives and Policy*. 2011;33(3):281-303.
24. Nord. Food insecurity in household children characteristics. *Economics information Bulletin*, 56 USDA, ERS; 2009.
25. Cook JT, Frank DA, Berkowitz C, Black MM, Casey PH, Cutts DB, Nord M. Food insecurity is associated with adverse health outcomes among human infants and toddlers. *The Journal of Nutrition*. 2004;134.
26. Alaimo K, Olson C, Frongillo E, Briefel R. Food insufficiency, family income and health in US preschool and school aged children. *American Journal of Public Health*. 2001;91:781-786.
27. Knudsen EI, Heckman JJ, Cameron JI, Shonkoff JP. Economic, neurologic and behavioral perspectives on building America's future workforce. *Proceedings of National Academy of Sciences of United States of America*. 2006;103(27):10155-10162.
28. Lozoff B, Jimenez E, Hagen J, Mollen E, Wolf AW. Poorer behavioral and developmental outcome more than 10 years after treatment for iron deficiency in infancy pediatrics. 2000;105(4)E51.
29. Ashiabi G. Household food insecurity and children's school engagement. *Journal of Children Poverty*. 2005;11(1):3-17.
30. Samuel FO, Egal AA, Oldewage-Theron WH, Napier CE, Venter CS. Prevalence of Zinc deficiency among primary school children in a poor pri- Urban informal settlement in South Africa, *Health SA Gesondheid*. 2010;15(1). [Art #433, 6]
31. Schlemmer U, Frolich W, Prieto RM, Grases F. Phyate in foods and significance for humans; food sources, intake, processing, bioavailability, protective role and analysis. *Mol Nutr Food Res*. 2009; 53:S330-75.
32. Amare B, Moges B, Fantahun B, Tafess K, Woldeyohannes D, Yismaw G, Ayane T, Yabutani T, Mulu A, Ota F, Kassu A. Micronutrient levels and nutritional status of school children living in Northwest Ethiopia. *National Journal*. 2012;11:108.
33. Abah RO, Okolo SN, John C, Ochoga MO. Prevalence of zinc deficiency among school children in a Rural Setting in North-Central Nigeria. *International Journal of Public Health Research*. 2015;3(5):214-217.
34. Ugwuja EI, Nwosu KO, Ugwu NC, Okonji M. Serum Zinc and Copper levels in malnourished Pre- School Age children in Jos, North central Nigeria. *Pak. J. Nutr*. 2007;6(4):349- 354.
35. Ekwochi U, Osuorah DIC, Odetunde OI, Egbonu I, Ezechukwu CC. Prevalence of iron deficiency anaemia in anemic under- 5 children in Enugu, South East Nigeria. 2014;41(2):129-132.
36. UNICEF. The state of world children; 2008. [Viewed 20th March 2015] Available:<http://www.unicef.org/sowc09/ind ex.php>
37. Cavan KR, Gibson RS, Grazioso CF, Isalgue AM, Ruz M, Solomons N. Growth and body composition of periurban Guatemalan children in relation to zinc status: a longitudinal zinc intervention trial. *Am J Clin Nutr*. 1993;57:344-52.
38. Sherif F, Hedayati M, Mirmiran P. The serum level of Zinc, Cu, Iron in elementary students of 23 province of Iran. *Irn J Endocr Metab*. 1999;1(4):275-85.
39. Hettiarachchi M, Liyanage C, Wickremasinghe R. A cross sectional study among adolescents in Sri Lanka. *Asia pac J Clin Nutr*. 2006;15(1):56-63.
40. Maureen MB. Zinc deficiency and child development. *Am J Clin Nutr*. 1998;68 (suppl):464S-9S.
41. Ebiloma IP, Afewodi SE, Agbaji AS. Assessment of mineral status and body mass index of women attending health centers in Northern states in Nigeria. *American Journal of Research Communication*. 2013;1(9):24-33.
42. Ajayi OB. Micronutrient changes in some tissues of copper deficient rates. *Pak. J. Nutr*. 2005;4: 123-125.
43. Turnlund JR. Copper: in Shils, M. E., Shike, M., Ross, A. C., Caballero, B., Cousins, R. J., eds. *Modern Nutrition in health and disease*. 10th ed. Philadelphia: Lippincott Williams and Wilkins. 2006;286-299.
44. Smith TA, Overmoyer BA, Miller ML. Sideroblastic anemia due to Zinc- Induced copper deficiency. *Clinical Hematology check sample CH 98-6*. Chicago. IL: ASCP press. 1998;4:81- 95.

45. Hotz C, Peerson JM, Brown KH. Suggested lower cut-offs of serum zinc concentration for assessing zinc status: reanalysis of the 2nd National Health and Nutrition Examination Survey data (1976-1980). *Am J Clin Nutr.* 2003;78:756-764.
46. International Zinc Nutrition Consultative Group (IZiNCG). Technical Document #1. Assessment of Risk of Zinc Deficiency in Populations and Options for its Control. Hotz C, Brown K, eds. *Food and Nutrition Bulletin.* 2007;25 supplement(2):S96-S129.

© 2020 Ugwu et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:
The peer review history for this paper can be accessed here:
<http://www.sdiarticle4.com/review-history/55261>