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HIGH PREVALENCE OF ZINC DEFICIENCY IN RURAL NIGERIAN PRESCHOOL CHILDREN: A COMMUNITY-BASED CROSS-SECTIONAL STUDY

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Abstract

Background and Aims: *In Nigeria, community-based epidemiological data related to the prevalence of zinc deficiency in preschool children are scarce. We assessed the prevalence of zinc deficiency and the associated socio-demographic variables in children aged between 6 and 60 months, living in a Nigerian rural community.* ***Materials and Methods:*** *In this cross-sectional study, the serum zinc concentrations of 252 children aged between 6 and 60 months in a rural community in Nigeria were assessed, using atomic absorption spectrophotometry. The study population was selected by multistage random sampling and at least two children were selected from every household which had children in the study age group. The socio-demographic characteristics of the subjects were obtained, using an interviewer-administered questionnaire.* ***Results:*** *A total of 252 children were studied, 134 (53.2%) males and 118 (46.8%) females. The mean age was 32.7±17.0 months, similar for both sexes. Overall, 220 (87.3%) had low serum zinc concentrations (less than 7.65µmol/L). According to age, the highest mean serum zinc concentration was 5.43±3.52µmol/L in children aged between 6 and 12 months. Correlation between serum zinc concentration and family size or socio-economic status (SES) showed that the smaller the family size and the higher the SES, the higher the serum zinc concentration.* ***Conclusions:*** *The high prevalence of low serum zinc concentration indicates that zinc deficiency is a public health problem in our rural communities, requiring public health intervention.*

key words: *Zinc deficiency, preschool children, rural community, Nigeria.*

Background and Aims

Zinc is a micronutrient that is integrated with several enzyme systems. Important biological functions of zinc include gene expression, cell division, immunity, insulin secretion and reproduction [1,2]. The main sources of zinc are beef, pork, poultry, fish and shellfish. Vegetables represent a good plant source of zinc. Some substances present in foods, such as phytic acid (present in maize, millet, sorghum), dietary fibre, calcium and

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protein may impair absorption of zinc from the intestine, potentially leading to zinc deficiency [1,3]. Processing of certain foods may affect the zinc available for absorption. In this regard, heat treatment can cause food zinc to form complexes that are resistant to hydrolysis, thereby reducing zinc's bioavailability [3]. Endogeneous sources of zinc are pancreatic and biliary secretions that are released into the gastrointestinal tract [3]. Skeletal muscle and bone (calcified and bone marrow) together account for approximately 90% of total body zinc [4]. No tissue acts as a zinc store but zinc released from muscle and bone during catabolism can, to some extent, be reutilized [3]. Approximately 0.5% of the total body zinc is found in circulating blood, of which 75% is found in erythrocytes and 10-20% in plasma [4,5]. The implication is that more than 95% of body zinc content is intracellular. Normal serum zinc concentrations range from 7.65-22.5μmol/L [6] and zinc deficiency has been defined as serum zinc below 7.65μmol/L [7].

Several indices have been used in the assessment of zinc status but there is no universally accepted measure suitable to accurately assess the zinc status of an individual [8,9]. In this regard, measurements of leucocyte, erythrocyte, hair and saliva zinc have been used as assessment measures but are not viewed as good indices of zinc status [10]. The most widely used index is the measurement of concentrations of serum zinc [11]. Zinc in the plasma decreases only when the dietary intake is so low that homeostasis cannot be maintained without use of zinc from the exchangeable pool that includes plasma zinc [12]. In clinical practice, making a definitive diagnosis of zinc deficiency is difficult. However, such a diagnosis can be derived from the combination of a dietary history of chronic low zinc intake and/or excessive intestinal losses, the presence of clinical signs (such as growth retardation or skin lesions) compatible with zinc deficiency, and low plasma/serum zinc levels [12].

Zinc deficiency is an important public-health issue, particularly in resource-poor countries [13-15]. According to the report of the Joint WHO/UNICEF/IAEA/IZiNCG when the proportion of individuals in a population with a low serum zinc is greater than 20%, that population is considered to be at risk of zinc deficiency, making it a public-health issue [16]. The Nigeria Food Consumption and Nutrition Survey (NFCNS 200-2003) found that 20% of children below 5 years age had zinc deficiency [17]. In one Nigerian study, involving children between the age 4 and 60 months the prevalence of severe zinc deficiency was 37% [18]. In that study, the total percentage of their subjects with low serum zinc level was not stated. This shows that even within the same country, there could be variations in prevalence of zinc deficiency. To the best of our knowledge, there is no published report of serum zinc status in preschool children living in a rural community in Edo State, Nigeria.

Worldwide, it is estimated that in children aged between 6 months and 5 years, 450,000 deaths each year (representing, 4.4% of all mortalities) are attributable to zinc deficiency [19]. In the paediatric age group, various morbidities have been linked to zinc deficiency. These include stunting, reduced capacity for physical work, poor wound healing, dermatitis, delayed sexual maturation, hypogeusia, night blindness, alopecia and increased susceptibility to infections [19,20]. The principal causes of zinc deficiency in developing countries include inadequate food intake, poor dietary quality, poor bioavailability, and/or the presence of parasitic infections of the gastrointestinal tract [21-23].

The present study aimed at determining the prevalence of zinc deficiency and assessing the associated socio-demographic variables in children aged between 6 and 60 months, living in a rural community in Nigeria.

Materials and Methods

This descriptive, community-based cross-sectional study was conducted over a period of 3 months, from January to March, 2013. Ethical approval for the study was sought and obtained from the Ethics and Research Committee of the University of Benin Teaching Hospital. The details of the study were explained to the chief of Udo community (the Uwague) with his subordinates (heads of the political wards) in attendance and later to the various heads of households. Informed consent was also obtained from the parents of the children who participated in the study.

Study area location

The study was conducted in Udo, a rural community in Ovia South West Local Government Area (LGA) of Edo State, Nigeria. Udo community is made up of 9 political wards (quarters). Each of these wards is headed by a chief who is a subordinate to the Uwague, the overall chief of Udo community. The major occupation of the inhabitants is subsistence farming. Some of the men and women engage in hunting and petty trading, respectively. In a nearby community (Okomu), there is Palm Oil Extracting Factory which processes palm nuts into palm oil and where some of the men are employed as unskilled workers.

Sampling and recruitment of study population

The study population consisted of children aged 6 to 60 months who reside with their parents in the Udo community. With some research assistants, the houses in the community were numbered and labeled. The members of each of the households were interviewed to determine the number and ages of persons in each household. Subsequently, those aged between 6 and 60 months were counted and recorded. Thus, a total of 1,028 children aged between 6 and 60 months were obtained by direct counting in all the households within the Udo community. The minimum sample size for the study population was obtained, using the minimum sample size determination table by Bartlett et al [24]. The minimum sample size obtained was 213. To accommodate attrition due to losses of samples, haemolyzed blood samples and unforeseen laboratory problems a high attrition rate of 35% was built-in, making the final sample size to be 292. Fifty percent of the 9 wards were selected by simple balloting to represent the Udo community. This was approximated to five political wards (quarters) and they were selected using a table of random numbers. Since the population of these political wards were not even, appropriate random sampling technique was used in selecting the subjects. The number of children between the ages of 6 to 60 months in each of these political wards was known and so, the number to be selected from each of the wards was allocated proportionately, using percentages as follows: Efa 28% (82 children), Ogbe 36% (103 children), Ihogbe 18% (53 children), Ikpema 5% (16 children) and Aragua 13% (38 children). By combining the highest educational attainment of the mother and father's occupation we analyzed the socio-economic status (SES) of the parents in keeping with the criteria previously suggested in a Nigerian study [25]. Thus, the SES of the subjects was categorized into high, middle and low. Based on the number of children, the family size was classified as small size; one or two children, medium size; three or four children, and large size; five or more children.

Blood sample collection and serum zinc analysis

Before collection of blood sample, the socio-demographic data of the children and their families were obtained from the parents/guardian, using an interviewer-administered questionnaire. The children were also examined. The procedure for blood sample collection was explained to each parent and consent obtained. Using standard aseptic technique, 3 to 4 mls of blood was collected from the child via any easily accessible vein on the forearm into a labelled plain specimen bottle and kept aside for centrifuging later the same day. All the blood samples were collected in the morning, thereby minimizing effect of diurnal variation. Six to 12 hours after collection, serum was separated from the blood following centrifugation. The serum was stored at -20^{o}C until analysis. The serum zinc was analysed by atomic absorption spectrophotometer (Alpha 4-model, S/No 4200 by Chemtech Analytical, United Kingdom), utilizing flame for analysis. In this study, serum zinc concentrations below 7.65µmol/L was defined as deficiency [6].

Statistical analysis

The data were collated and entered into an Excel spread sheet. The accuracy of the data entered was double checked. Analysis of the data was performed using Microsoft Excel and SPSS (Statistical Package for Social Sciences) version 20.0 software. Measures of central tendency and dispersion involving the mean and standard deviation were computed for all quantitative data. Confidence intervals, frequency distribution, percentages and ratios were calculated. Correlation and multiple linear regression analysis were employed to evaluate the degree of relationships between variables. Test for significant differences between means of variables was carried out, using the Single Factor Analysis of Variance (ANOVA). The level of statistical significance was set at $p < 0.05$.

Results

Of the 292 eligible children, data for 40(13.5%) were excluded from further analysis because they were incomplete. Thus, 252 children, 134(53.2%) males and 118(46.8%) females, were left for further analysis of their data. The male-to-female ratio was 1.1:1. The mean age of the study population was 32.7±1.7 months. The mean age was similar for both sexes. Most of the subjects were aged 13 to 24 months (Table 1).

Table 1. Age and gender distribution of subjects.

Parameter	Frequency	Percentage(%)
Age (months)		
6-12	38	16.1
13-24	68	27.0
25-36	57	22.6
37-48	38	16.1
49-60	51	20.2
Gender		
Male	134	53.2
Female	118	46.8
Total	252	100.0

As shown in Figure 1, a great majority of the children came from families in the low social class.

The overall mean serum zinc level was 4.77±3.02µmol/L (range of 1.0 -16.52µmol/L). Figure 2 shows that a vast majority (87.3%; 95% CI = 83.2-91.4) of the subjects had low serum zinc levels (< 7.65µmol/L).

According to age group, the highest mean serum zinc concentration was 5.43±3.52µmol/L and this was found in children aged between 6 and 12 months as detailed in Table 2. The mean serum zinc progressively declined from the age of 13 months up to 48 months (Table 2).

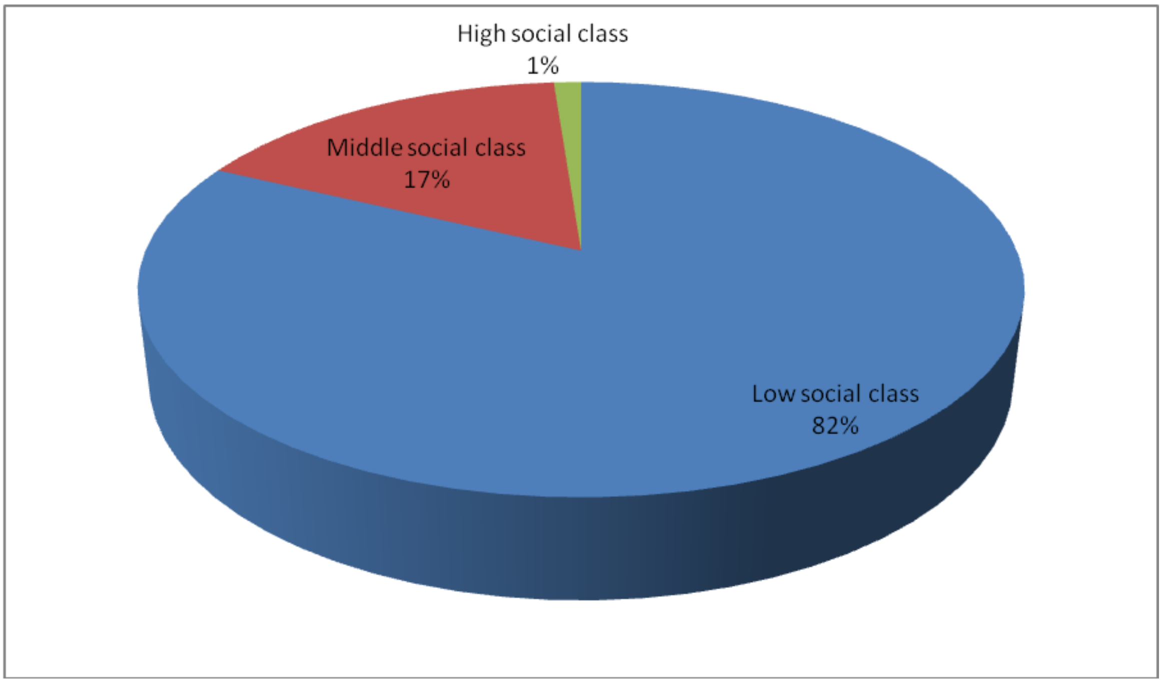

Figure 1. *Social class distribution of the subjects' families.*

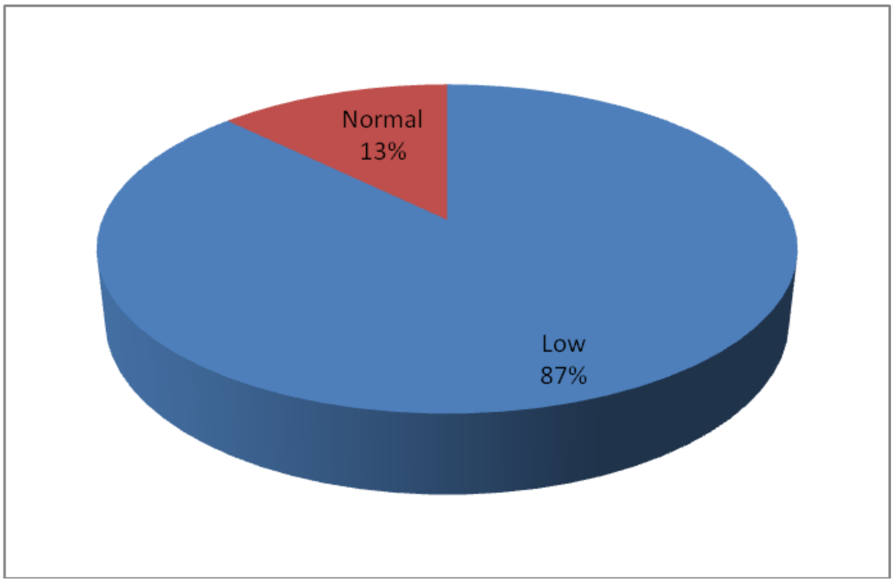

Figure 2. *Percentage distribution of serum zinc concentration.*

Table 2. Mean serum zinc concentrations according to age, gender, social class and family size.

Parameters	No of subjects (N = 252)	Serum zinc (Mean±SD µmol/L)	95% CI	F	p-value
Age (months)				0.248	0.29
6-12	38	5.43±3.52	4.30-6.56		
13-24	68	5.03±3.14	4.27-5.79		
25-36	57	4.78±2.92	4.02-5.54		
37-48	38	4.05±2.44	3.29-4.81		
49-60	51	4.48±2.95	3.68-5.28		
Gender				0.997	0.33
Male	134	4.95±3.21	4.41-5.49		

Table 2. *Continued*.

Parameters	No of subjects (N = 252)	Serum zinc (Mean±SD µmol/L)	95% CI	F	p-value
Female	118	4.57±2.80	4.06-5.08		
Social class				0.80	0.44
Low	207	4.66±2.91	4.26-5.06		
Middle	42	5.30±3.48	4.25-6.35		
High	3	5.05±3.97	0.56-9.53		
Family size				1.55	0.21
Small	79	5.27±3.45	4.51-6.03		
Medium	112	4.56±2.89	4.02-5.10		
Large	61	4.53±2.64	3.87-5.19		

CI = Confidence interval

No correlation was found between the serum zinc level and the age of the subjects. Concerning the serum zinc concentration and family size, our results showed that the smaller the family size, the higher the serum zinc concentration; r = minus 0.07; p = 0.25. Similarly, the higher the socio-economic status, the higher the mean serum zinc concentration; r = 0.08; p = 0.21. However, these correlations were not statistically significant.

Discussion

We found a high prevalence rate of zinc deficiency in our rural community. Our prevalence rate is much higher than the 20% set by the Joint WHO/UNICEF/IAEA/IZiNCG Interagency meeting for recognizing zinc deficiency risk of public health importance, needing intervention in a given population [16]. This finding is a cause for concern, considering the various morbidities associated with zinc deficiency in the pediatric age group. Such morbidities include impaired cognitive function, growth failure, delayed sexual maturation and increased risk of infections [1,3]. Despite differences in cut-off values used in defining zinc deficiency, the prevalence rate found among our subjects agrees with that reported among preschool children from Cameroon [26]. Our cut-off value of 7.65µmol/L was lower than the 9.9µmol/L (65µmg/dl) used in the study in Cameroon [26]. In a previous study by Wessells et al, 7.65µmol/L was also used as cut-off value [7], justifying its use in our study. On the other hand, our prevalence rate was much higher than the 63% reported in another Nigerian study, involving urban preschool children [27]. Together, the lower cut-off value used in our study and the rural nature of the study population may explain the observed higher prevalence rate found in the present study. Zinc deficiency has been shown to be commoner in rural compared with urban children [28,29]. Again, the prevalence rate found in our study was higher than 65% found among Beninese rural preschool children [15]. In that study, a higher cut-off value (9.9umol/L) was used in defining zinc deficiency, probably accounting for the observed differences in prevalence rates.

Poverty and illiteracy were notable findings among the families of our subjects and this is evident in their low socio-economic status (SES). We found that children from families in the low SES had the lowest mean serum zinc concentration compared with their counterparts from families in the middle or high SES, respectively. Our data revealed a slight negative trend between serum zinc concentration and family size and a slight positive trend between serum zinc concentration and SES. A similar influence of SES on serum zinc concentrations has been reported in some studies [30,31].

In developing countries, the major etiologic factors for zinc deficiency are low intake of zinc-rich foods, poor bioavailability of zinc, and the presence of parasitic infections of the gastrointestinal tract [21-23]. Together, these factors which are known to be common in Nigeria, may account for our high prevalence rate of zinc deficiency [27,28,30]. Our data indicate that the lowest and highest mean serum zinc concentrations were found among children aged 37 to 48 months and 6 to 12 months, respectively. This suggests that infants had better zinc status than toddlers. This is not surprising as toddlers are transitioning to complementary foods, making them vulnerable to micronutrient deficiencies, including zinc. In Nigeria, these complementary foods consist mainly of gruels from maize and millet which are poor not only in zinc content but also in its bioavailability. In addition, it is possible that during the period of infancy, a fairly appropriate breast feeding practices are observed in our community, leading to better zinc status among children aged 6 to 12 months. In consonance with our finding regarding the influence of age, a study in India reported a similar finding [32]. Although not statistically significant, we observed that boys had a slightly higher mean serum zinc concentration than girls. In general, this finding is in keeping with the results of a similar study among preschool children in India [32]. The reason for the better zinc status in males than females is difficult to explain. Could it be due to preferential parental nutritive care for boys over girls, as practiced in some cultures [33-35] ?

One limitation of our study was that we assessed zinc deficiency using only serum zinc concentrations without assessing the intake of dietary zinc which would have provided information regarding etiology. On the other hand, our study had some strength. First, all the blood samples were collected in the morning, thereby minimizing effect of diurnal variation. Secondly, at least two children aged between 6 and 60 months in every household within the study community were included in the study population, making our study sample more representative of the whole community compared with similar previous Nigerian studies [18,27,28,30].

Conclusions

In conclusion, the high prevalence of severe zinc deficiency in our rural communities is a public-health problem, requiring public health intervention strategies to improve the zinc nutritional status of these preschool children. Zinc nutritional intervention strategies such as nutrition education of the parents (e.g., dietary diversification by adding animal proteins, improvement in food processing techniques to ensure bioavailability of zinc), routine treatment for intestinal parasites, using broad-spectrum anti-helminthics (to reduce faecal zinc losses), rotavirus vaccine immunization (to reduce zinc loss from diarrheal diseases), targeted supplementation, and fortification of staple foods with zinc are suggested.

Duality of interest: We have no competing interest with regard to the scope of this study.

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