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Assessment Of Serum Zinc Status Of Children Aged 12-59 Months In Urban And Rural Communities Of Northwestern Nigeria.

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Abstract
Background: *Zinc deficiency remains an important public health concern in Nigeria, particularly among children aged 12-59 months, where it contributes to impaired growth, weakened immunity, and increased susceptibility to infections such as malaria and diarrhea that are prevalent in Northern Nigeria. However, limited data exist comparing urban-rural disparities in this region. The study aimed to determine the serum zinc status of children aged 12-59 months in urban and rural communities of Northwestern Nigeria.*
Methods: *A community-based cross-sectional study enrolled 260 children (130 urban, 130 rural) using multistage sampling. Serum Zn was determined by Atomic Absorption Spectrophotometry using a Buck Model 205 Atomic Absorption Spectrophotometer (Buck Norwalk, CL) by the direct method as described by Kaneko et al. Dietary intake and sociodemographic factors were assessed. SPSS version 25 was used to analyze the data.*
Results: *Overall zinc deficiency prevalence was 51.5%, higher in rural (70.8%) than urban (32.3%) (OR=4.3, 95% CI: 1.359-13.822, p=0.01) children. In the urban area, a higher proportion (49.3%) of children in the lower social class had zinc deficiency compared to (12.2%) and (6.7%) of those in the middle and upper social class, respectively (p= 0.259). Also, 70.8% of children in the lower social class were zinc deficient compared to none of those in the middle and upper social class, p=0.824*
Conclusion: *Zinc deficiency was prevalent in both urban and rural areas, but a significantly higher proportion of children in the rural areas had zinc deficiency as compared to those in the urban areas. Targeted supplementation, dietary diversification, and sanitation improvements are essential for mitigation, aligning with national nutrition strategies.*
Keywords: *Children, Northwestern Nigeria, urban-rural, Zinc deficiency*

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I. Introduction

Hidden hunger is a term used to describe human deficiencies in essential vitamins and minerals, also known as micronutrients. Micronutrients are vitamins and minerals required in small amounts that are essential to human health, development, and growth.[1] As tiny as the amounts are, however, the consequences of their absence are severe.[1] Zinc is an important micronutrient necessary for protein synthesis, cell growth and differentiation, immune function and intestinal transport of water and electrolytes.[2, 3] At the subcellular level, it is vital for the functionality of more than 300 enzymes, and for the stabilization of DNA and gene expression.[4] Zinc is unique in that the body has no specific storage reserves and is therefore classified as a Type II nutrient, meaning that deficiency causes growth retardation as the body attempts to conserve the nutrient.[5] Although zinc is relatively abundant in nature, available evidence suggests that its deficiency is one of the most prevalent mineral micronutrient deficiencies worldwide, since its first discovery in a young Iranian man in 1961.[6] Because there is no functional reserve or store of available zinc in the human body, except probably in infants[7], a regular, adequate dietary supply is required.

Zinc deficiencies is one of the micronutrient deficiencies of greatest public health concern globally, due to their high prevalence and associated health and developmental consequences.[8] Globally, zinc deficiency is very common, particularly in lower-income countries where diets are cereal-dominant and typically lower in protein.[9] Zinc deficiency can be prevalent in children. Zinc deficiency can have a number of negative health consequences, affecting the central nervous, gastrointestinal, immune, epidermal, reproductive, and skeletal systems.[10] Zinc is an essential nutrient for growth, development, proper immune function and recovery. Deficiencies can therefore stunt growth, increase susceptibility to disease and infection, increase recovery time, or, in some cases, impair recovery, reduce mental capacity, and increase the prevalence of maternal, neonatal and child complications.[3] Globally, it is estimated that 17.3% of the population has inadequate zinc intakes, with the highest estimates in South Asia and Sub-Saharan Africa.[11] Zinc deficiency contributes substantially to the morbidity and mortality of young children worldwide, as evidenced by high estimated prevalence and association with diarrhoea, pneumonia and malaria.[11] Zinc is now recognized as a major cause of stunting among children less than 5 years of age.[12] Zinc reduces both the incidence and the severity of diarrhea.[12] Addressing zinc deficiencies can reduce the incidence of diarrhea by 27%, respiratory infections by 15% and overall mortality by 6%.[13] Several measures have been taken to counter zinc deficiency and to prevent its occurrence, including recommendations by the WHO and UNICEF to administer 20 mg oral zinc supplements for 10 to 14 days in children suffering from diarrhea to recover micronutrient losses, as zinc supplements reduce deaths by diarrhea as well as from pneumonia in children by 13% and 15%, respectively.[14, 15] Existing Nigerian studies have focused on single regions or predominantly southern areas, leaving Northwestern urban-rural dynamics underexplored despite the region's high population density and status as a malnutrition hotspot. Establishing baseline serum zinc data will guide evidence-based policy interventions, aligning with global calls for systematic micronutrient monitoring in low-resource settings.

II. Methodology

Study Design
This study employed a comparative cross-sectional design.

Study Population

The study population comprised mothers or caregivers with children aged 12 to 59 months in urban and rural communities of Sokoto State.

Sample Size Determination

Sample size estimation was done based on the formula for the study design to compare proportions in 2 independent groups.

The minimum sample size was determined using the formula.[16]

$$n = \frac{(Z_{1-\frac{\alpha}{2}} + Z_{\beta})^2 \ X \ (P_1 q_1 + p_2 q_2)}{(P_1 - P_2)^2}$$

n = **116** mother-child pair per group

Allowing for a 90% response rate, the minimum sample size (ns) is given as: ns = n/0.9= 116/0.9 ≈ 129per group. Therefore, 130 subjects were recruited into the study per group.

Sampling Technique

A multistage sampling technique was used to select respondents for the study. In stage 1, Sokoto North LGA (urban) and Wurno LGA (rural) were chosen using a simple random sampling technique by balloting. In stage 2, two wards were selected from each of the selected LGAs by a simple random sampling technique (balloting). In stage 3, one settlement was chosen from each of the four wards by a simple random sampling technique (balloting). Proportionate allocation (PA) of respondents to be enrolled in each of the settlements in each group (urban and rural) was done using the calculated sample size per group, which was 130. In stage 4, a sampling frame was obtained; systematic random sampling was used to enroll households to get respondents for the study.

Data Collection Methods

The socio-demographic data and other information were collected from the mothers/caregivers of all the children enrolled for the study by interview method (using interviewer administered questionnaire) and recorded on a structured questionnaire. The information included the child's biodata, delivery history and family and social history. Each child was assigned to a socioeconomic class using the method recommended by Oyedeji based on parents' occupations and level of education.[17]

Laboratory methods

The principal researcher and a research assistant (a resident doctor from the Pediatrics Department) collected the blood samples of the participants. Five milliliters of blood from the cubital vein in the ante-cubital fossa of the forearm after thorough disinfection of the site with methylated spirit and cotton wool, using a 23G sterile needle and 5ml syringe, was collected from each of the study participants in the morning between 8am to 12noon. All samples collected on the field in sample bottles were stored inside cold boxes and immediately transported at the end of the day to the Chemical Pathology Laboratory of Usmanu Danfodiyo University

Teaching Hospital, Sokoto, Nigeria, where the biochemical analyses were conducted. Serum Zn was determined by Atomic Absorption Spectrophotometry using a Buck Model 205 Atomic Absorption Spectrophotometer (Buck Norwalk, CL) by the direct method as described by Kaneko et al.[18]

Statistical Analysis

Data were analyzed using IBM SPSS version 25 computer statistical software package. Quantitative variable (Age, serum zinc) was summarized using the mean and standard deviation and categorical variables (sociodemographic and serum zinc status) were summarized using frequencies and percentages. The Chi-square test and Fisher's exact test were used to compare sociodemographic characteristics and serum zinc status in urban and rural groups. The Chi-square test and Fisher's exact test were also performed to assess the association between sociodemographic variables and serum zinc status. The independent t-test was used to compare the mean serum zinc between the two groups. The bivariate analyses were presented in tables with Odds Ratio (OR), confidence interval (CI) and their p-values. Level of significance (α) was set at 0.05, thus, any statistical test with $p < 0.05$ was considered to be statistically significant.

Ethical consideration

Ethical approval for the study was sought and obtained from the Research and Ethics Committee of the Ministry of Health, Sokoto, Nigeria. Permission for community entry was also obtained from the State Ministry of Local Government Affairs, the LGA chairmen and district heads of the communities, before proceeding to carry out this study. A consent form was given to the literate respondents to read and sign and was read out in the native Hausa language to the respondents with no formal education to thumbprint.

III. Result

Table 1: Sociodemographic characteristics of the respondents

Variables	Urban (n=130) n (%)	Rural (n=130) n (%)	Test-statistics p-value
Age group of mothers (years)			
15-19	2 (1.5)	10 (7.7)	
20 – 24	13 (10.0)	22 (16.9)	
25 – 29	63 (48.5)	44 (33.8)	
30 – 34	27 (20.8)	28 (21.6)	χ^2= 11.059
≥35	25 (19.2)	26 (20.0)	**p=0.025**
Mean ± SD (years)	32.99 ± 7.598	30.11 ± 8.348	t=2.914 **p=0.004**
Religion			
Islam	125 (96.2)	130 (100)	Fischer's exact
Christianity	5 (3.8)	0	**p=0.029**
Tribe			
Hausa	113 (86.9)	108 (83.1)	
Fulani	9 (6.9)	7 (5.4)	
Yoruba	5 (3.8)	1 (0.8)	Fischer's exact
Igbo	3 (2.3)	0	**p<0.001**
Other	0	14 (10.8)	
Number of children			
1 – 4	65 (50.0)	79 (60.8)	χ^2= 3.051
≥ 5	65 (50.0)	51 (39.2)	p= 0.105
Mothers' education level			
None	2 (1.5)	3 (2.3)	
Quranic only	58 (44.6)	109 (83.8)	
Primary	9 (6.9)	14 (10.8)	Fischer's exact
Secondary	45 (34.6)	3 (2.3)	**p<0.001**
Tertiary	16 (12.3)	1 (0.8)	
Fathers' education level			
None	0 (0.0)	0	
Quranic only	16 (12.3)	60 (46.1)	
Primary	2 (1.5)	7 (5.4)	Fischer's exact
Secondary	56 (43.1)	46 (35.4)	**P<0.001**
Tertiary	56 (43.1)	17 (13.1)	
Occupation of mother			
Unemployed	48 (36.9)	80 (61.5)	
Farming	0 (00.0)	0 (0.0)	Fischer's exact
Trade/business	77 (59.2)	48 (36.9)	**P<0.001**
Civil servant	5 (3.9)	2 (1.5)	
Occupation of father			
Unemployed	0 (0.0)	0	
Farming	6 (4.6)	39 (30.0)	χ^2 =47.070

Trade/business	66 (50.8)	74 (56.9)	**p< 0.001**
Civil servant	58 (44.6)	17 (13.1)	
Social class of parent			
SC I	2 (1.5)	0	
SC II	14 (10.8)	1 (0.8)	
SC III	41 (31.5)	7 (5.4)	Fischer's exact
SC IV	63 (48.5)	58 (44.6)	**p<0.001**
SC V	10 (7.7)	64 (49.2)	

χ^2-Pearson's Chi-square test; *t*- Independent *t*-test

Majority of the mothers in both groups were in the age group 25-29 years. The difference in the distribution of the age groups was statistically significant (p= 0.008). Mothers in the urban area had a higher mean age compared to those in rural area, the difference was statistically significant (p= 0.004). The difference in tribe distribution was statistically significant (p<0.001) with Hausas being the majority in both groups (86.9% urban vs 83.1% rural). About one third of mothers in the urban group 45 (34.6%) compared to 3 (2.3%) in the rural group had completed their secondary education, while 109 (83.8%) had only Quranic education in the rural group compared to 58 (44.6%) in the urban group. The rural group had a higher proportion of unemployed mothers 80 (61.5%) compared to the urban group 48 (36.9%). There was a statistically significant difference in terms of the educational attainment and the occupation of the mothers of the children in both groups (p< 0.001).

Fathers who had completed tertiary education formed the highest proportion 56 (43.1%) in the urban group compared to the rural group where those with Quarnic only education 60 (46.2%) formed the highest proportion. Nearly half of the fathers 58 (44.6%) were civil servants in the urban area compared to only 17 (13.1%) in the rural area. There was a statistically significant difference in terms of the educational attainment and the occupation of the fathers of the children in both groups (p< 0.001).

There was a statistically significant difference (p<0.001) in the distribution of the respondents by social class with the majority of the respondents being in social class IV and V in Urban (48.5%) and rural group (49.2%) respectively [Table 1].

Table 2: Demographic characteristics, place of delivery, and birth order of children,

Variables	Urban (n=130) n (%)	Rural (n=130) n (%)	Test-statistics p-value
Child's age group (months)			
12-23	32 (24.6)	28 (21.5)	
24-35	30 (23.1)	30 (23.1)	χ^2= 0.927
36-47	30 (23.1)	30 (23.1)	p=0.467
48-59	38 (29.2)	42 (32.3)	
Mean ± SD (months)	34.70 ± 14.4	35.12 ± 14.8	t= 0.233 p=0.816
Sex			
Male	57 (43.8)	65 (50.0)	χ^2= 0.988
Female	73 (56.2)	65 (50.0)	p=0.384
Place of delivery			
Home	69 (53.1)	106 (81.5)	
Hospital	56 (43.1)	24 (18.5)	Fischer's exact
Clinic/dispensary	4 (3.1)	0 (0.0)	**p<0.001**
TBAs house	1 (0.8)	0 (0.0)	
Birth order			
1- 2	30 (23.0)	50 (38.5)	χ^2= 8.388
3 – 4	37 (28.5)	36 (27.7)	**p=0.016**
≥5	63 (48.5)	44 (33.8)	

χ^2-Pearson's Chi-square test, *t*- Independent *t*-test

The highest proportion of children in both the urban 38 (29.2%) and rural 42 (32.3%) groups were in the age group 48-59months. There was no statistically significant difference in age (χ^2 = 0.927, p = 0.467). The mean ages in the urban and rural areas were 34.70 ± 14.4 and 35.12 ± 14.8months r,espectively (t=0.233, p= 0.816).

A higher proportion of female children 73 (56.2%), compared to male children 57 (43.8%) was observed in the urban group; while the sex distribution was equal in rural group (50% male vs 50% female). There was no statistically significant difference in the gender distribution in the groups (χ^2 = 0.988 p =0.384). A higher proportion of children in the rural group 106 (81.5%) were delivered at home compared to 69 (53.1%) in the urban group; and this was statistically significant (Fisher's exact, p<0.001) [Table 2].

Table 3: Prevalence of micronutrient deficiency among the children

Variables	Urban n (%)	Rural n (%)	Test statistics	p- value	OR	95 CI
Serum zinc	**n= 130**	**n= 130**				
Normal	88 (67.7)	38 (29.2)	χ^2=38.498	**p<0.001**	4.3	1.359-13.822
Deficient	42 (32.3)	92 (70.8)				
Mean ±SD	118.6±42.8	86.83±26.5	t=7.196	**p<0.001**		

χ^2= Pearson's chi-square; t-independent t-test, CI=Confidence interval

About one-third (32.3%) of the children in the urban areas, compared to 92 (70.8%) of the children in the rural areas, have zinc deficiency, and this difference was statistically significant (p<0.001). Children in the urban area had a higher mean serum zinc (118.6±42.8) compared to those (86.83±26.5) in the rural area (p<0.001) [Table 3].

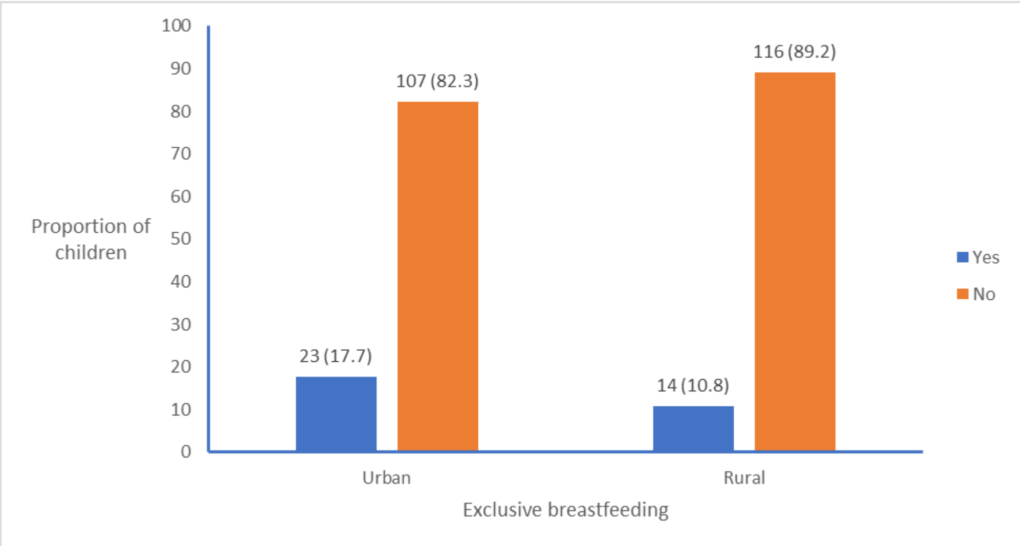

Figure 1: Exclusive breastfeeding status of children

In the urban areas, 23 (17.7%) of the children were exclusively breastfed compared to 14 (10.8%) of their counterparts in the rural areas. The difference was not statistically significant (p=0.155) [Figure 1].

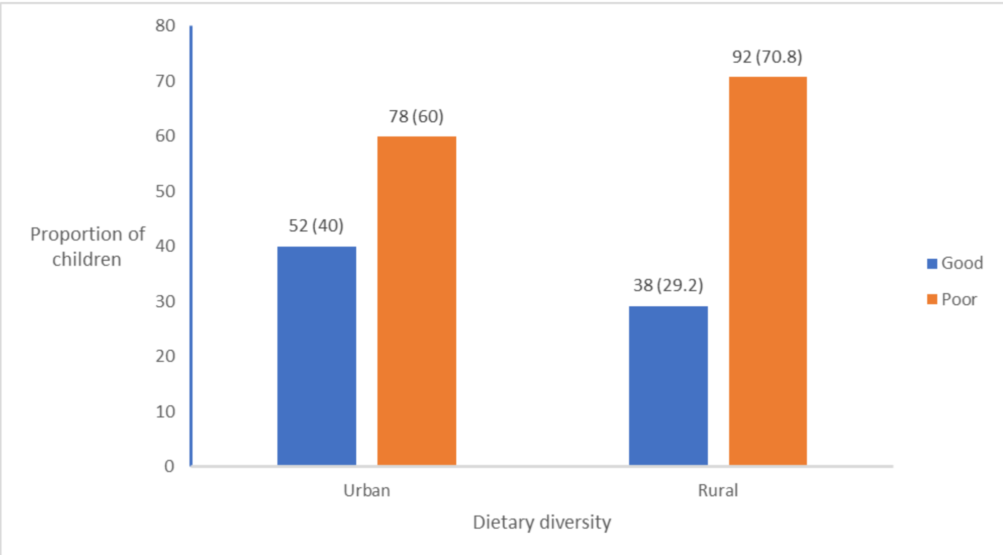

Figure 2: Dietary diversity score of the family

The majority of the children 92 (70.8%) in the rural areas, compared to 78 (60.0%) in the urban areas, had a poor dietary diversity score. The difference in proportions was not statistically significant (p=0.090) [Figure 2].

Table 4: Relationship between occupation, educational level, social class of the respondents and serum zinc of the children

		Urban			Rural		
		Serum zinc n (%)		Test statistics and p-value	Serum zinc n (%)		Test statistics and p- value
Variables		Normal	Deficient		Normal	Deficient	
Education of the mother							
	Nonformal	39 (65.0)	21 (35.0)	χ^2= 0.369 p=0.577	32 (28.6)	80 (71.4)	χ^2= 0.170 p= 0.781
	Formal	49 (70.0)	21 (30.0)		6 (33.3)	12 (66.7)	
Occupation of the mother							
	Employed	27 (56.2)	21 (43.8)	χ^2= 1.408 p= 0.162	28 (35.4)	51 (64.6)	χ^2=3.018 p=0.088
	Unemployed	61 (74.4)	21 (25.6)		10 (19.6)	41 (80.4)	
Education of the father							
	Nonformal	11 (68.8)	5 (31.3)	χ^2= 0.009 p= 1.000	17 (28.3)	43 (71.7)	χ^2= 0.043 p= 0.849
	Formal	77 (67.5)	37 (32.5)		21 (30.0)	49 (70.0)	
Occupation of father							
	Farming	4 (66.7)	2 (33.3)	χ^2=2.729 p= 0.305	11 (28.2)	28 (71.8)	χ^2=0.409 P=0.827
	Civil servant	35 (60.3)	23 (39.7)		13 (76.5)	4 (23.5)	
	Trade/business	49 (74.2)	17 (25.8)		51 (68.9)	23 (31.1)	
Social class of parents							
	Upper (SCI & II)	14 (93.3)	1 (6.7)	χ^2= 2.874 p=0.259	1 (100)	0	Fisher's exact p= 0.130
	Middle (SCIII)	36 (87.8)	5 (12.2)		7 (100.0)	0	
	Lower (SCIV & V)	13 (50.7)	36 (49.3)		30 (29.2)	92 (70.8)	

χ^2= Pearson's Chi-square

In the urban areas, 21 (35.0%) of children whose mothers had nonformal education had zinc deficiency compared to those who had formal education 21 (30.0%), p= 0.250. A higher proportion 36 (49.3%) of children in the lower social class had zinc deficiency compared to 5 (12.2%) and 1 (6.7%) of those in the middle and upper social class, respectively (p= 0.259). In the rural areas, 80 (71.4%) of the children whose mothers had nonformal education were zinc deficient as compared with 12 (66.7%) of those with formal education (p= 0.099). Also, 92 (70.8%) of children in the lower social class were zinc deficient compared to none of those in the middle and upper social class, p=0.824 [Table 4].

Table 5: Relationship between exclusive breastfeeding, dietary diversity score, birth order, number of children and serum zinc of the children

		Urban			Rural		
		Serum zinc n (%)		Test statistics and p-value	Serum zinc n (%)		Test statistics and p- value
Variable		Normal	Deficient		Normal	Deficient	
Exclusively breastfed							
	Yes	18 (78.2)	5 (21.8)	χ^2=1.594	5 (35.7)	9 (64.3)	Fisher's exact
	No	70 (65.4)	32 (34.6)	p=0.226	33 (28.4)	83 (71.6)	p=0.549
Dietary diversity							
	Good	35 (67.3)	17 (32.7)	χ^2=0.006	14 (36.8)	24 (63.2)	χ^2=1.504
	Poor	53 (67.9)	25 (32.1)	p=1.000	24 (26.1)	68 (73.9)	p=0.289
Birth order							
	1-4	48 (71.6)	19 (28.4)	χ^2= 0.986	25 (29.1)	61 (70.9)	χ^2= 0.003
	≥5	40 (63.5)	23 (36.5)	p= 0.352	13 (29.5)	31 (70.5)	p= 1.000
Number of children							
	1 – 4	47 (72.3)	18 (27.7)	χ^2=1.266	22 (27.8)	57 (72.2)	χ^2=0.186
	≥5	41 (63.1)	24 (36.9)	p=0.348	16 (31.4)	35 (68.6)	p=0.696

χ^2= Pearson's Chi-square

In the urban areas, 5 (21.8%) of children who were exclusively breastfed were zinc deficient compared to 32 (34.6%) of those who were not, p= 0.226. Additionally, 18 (27.7%) of children whose parents have fewer than five children were zinc deficient compared with 24 (36.9%) of those whose parents have five or more children, p = 0.348 [Table 5].

IV. Discussion

Zinc serves as an essential micronutrient in the human body, supporting key functions like normal gene expression, cell growth, reproduction, and immune system maintenance.[19] Low serum zinc levels can lead to impaired growth, neurological deficits, delayed wound healing, and reduced sensation of taste.[20-22] Around 50% of the world's population likely consumes zinc-deficient diets, and low zinc levels contribute to over 800,000 deaths in children under 5 from diarrhea, pneumonia, and malaria.[23, 24] Even with sufficient dietary zinc intake, high levels of phytate a zinc absorption inhibitor found in plant-based foods like cereals, legumes, and whole grains can still cause zinc deficiency. The bioavailability of zinc, along with phytate's inhibitory impact on its absorption, can be evaluated through the phytate-to-zinc molar ratio.

Zinc deficiency is one of the most common micronutrient deficiencies in children under the age of 5 years in Nigeria and other developing countries.[25] Results from this study showed that about one-third of the children in the urban areas, compared to about two-thirds of the children in the rural areas, had zinc deficiency. Similar findings were obtained from a study done in Enugu State, Nigeria, in which children in urban areas recorded higher serum zinc levels compared to those in rural areas.[26] The rural setting in Nigeria is generally characterized by low economic status, undernutrition, unsafe drinking water and poor personal and environmental hygiene, which can be the reason for the higher deficiency observed in this study. The findings in rural areas are similar to those from a study assessing the micronutrient status and its relationship with nutritional status in preschool children in Sri Lanka, where approximately 67% of the children were zinc deficient.[27] However, the findings of studies done in Abuja, Edo, Imo and Bangladesh contrast these findings.[28-30] The prevalence of zinc deficiency is higher among those in the low socio-economic classes in urban and rural areas. Similarly, Abah et al [31] reported a higher prevalence of zinc deficiency among a rural community in North Central Nigeria, with children from the lower socioeconomic class having lower serum zinc levels compared with those from middle and upper socioeconomic classes. No significant gender-based differences were observed in the zinc status of children in urban and rural areas. These findings are similar to the findings reported in studies done in Enugu, Nasarawa and Anambra States, Nigeria.[26, 32, 33] Globally, zinc deficiency is very common, particularly in developing countries where diets are cereal-dominant and typically lower in protein.[9] Zinc deficiency was found in both urban and rural children in this study, but it was more prevalent in rural children than in urban children. Zinc is an essential nutrient for growth, development, proper immune function, and recovery. Deficiencies of zinc can therefore stunt growth, increase susceptibility to disease and infection, increase recovery time, or in some cases, impair recovery, reduce mental capacity, and increase the prevalence of child complications.[21] Unlike vitamin A and iodine, there are no programs or policy initiatives in place to specifically improve the zinc intake amongst community members.[32] This is true with respect to improving the zinc supply in foods. A daily intake of zinc is required to maintain a steady state because the body has no specialized zinc storage system.[34]

V. Conclusion

Zinc deficiency was prevalent in both urban and rural areas, but a significantly higher proportion of children in the rural areas had zinc deficiency as compared to those in the urban areas. Targeted supplementation, improved economic status, dietary diversification, and sanitation improvements are essential for mitigation, aligning with national nutrition strategies.

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Conflicts of interest
There are no conflicts of interest

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