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Research Article

Assessment of Micronutrient Deficiencies among Women of Reproductive Age in Some Selected Urban and Rural Areas of Birnin Kebbi LGA, Kebbi State, Nigeria

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ABSTRACT
Micronutrient deficiencies pose significant risks to maternal and child health in resource-limited settings. This cross-sectional study utilizes anthropometric, biochemical assays, and dietary recall to assess the prevalence and determinants of iron, zinc, calcium, vitamin A, and serum total protein deficiencies among 120 pregnant women (aged 15–49 years) in three urban and three rural communities of Birnin Kebbi Local Government Area, Nigeria. The results reveal Iron deficiency was prevalent in both (urban: 4.59 ± 0.91 µmol/L; rural: 3.43 ± 0.51 µmol/L compared to normal: 10.7–28.6 µmol/L), as was zinc deficiency (urban: 4.18 ± 0.39 µmol/L; rural: 4.08 ± 0.43 µmol/L compared to normal: 10–18 µmol/L). Calcium levels were low (urban: 1.04 ± 0.21 mmol/L; rural: 1.11 ± 0.24 mmol/L compared to normal: 2.1–2.6 mmol/L), with higher deficiency in urban areas. Vitamin A was adequate (urban: 1.49 ± 0.15 µmol/L; rural: 1.43 ± 0.17 µmol/L compared to normal: >1.05 µmol/L), while total protein was elevated in (urban: 9.81 ± 1.4 g/dL; rural: 9.56 ± 1.1 g/dL compared to normal: 6.0–8.0 g/dL). Urban women had higher dietary diversity (56.6% consumed 3–5 food groups vs. 61.6% rural, consuming <3, p=0.015) and better food security (p=0.0001). Iron deficiency was associated with low education (p=0.002) and subsistence farming as an occupation (p=0.001). Targeted interventions, including supplementation and dietary diversification, are needed to address these deficiencies.

Keywords: Calcium; Iron; Micronutrient deficiency; Vitamin A; Women of reproductive age; Zinc

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INTRODUCTION

Micronutrient deficiencies, encompassing iron, zinc, calcium, and vitamin A, represent a critical global health challenge, affecting over 2 billion individuals, particularly in low-and middle-income countries (Stevens *et al.,* 2022). These deficiencies have profound implications for maternal health, increasing risks of adverse pregnancy outcomes such as preterm delivery, low birth weight, and maternal mortality (Victora *et al.,* 2023). Iron deficiency, the primary cause of anaemia, affects approximately 38% of pregnant women worldwide, impairing oxygen transport, cognitive function, and immune response (WHO, 2001). Zinc deficiency compromises immune function and fetal growth, with prevalence rates as high as 25% in sub-Saharan Africa (Wessells *et al.,* 2023). Calcium insufficiency is linked to hypertensive disorders like preeclampsia, posing risks to both maternal and fetal health, while vitamin A deficiency, though mitigated by supplementation, threatens immune and ocular health (WHO, 2011).

In Nigeria particularly rural communities, micronutrient deficiencies are exacerbated by widespread poverty, low dietary diversity, and limited healthcare access (Olatona *et al*., 2024). The National Demographic and Health Survey indicates that 18–51% of women of reproductive age (WRA) are anaemic, driven by reliance on starchy staples and inadequate consumption of micronutrient-rich foods like animal-source products (Janmohamed *et al.,* 2024). Socio-economic barriers, including low education and income, further restrict access to diverse diets, with only 50.7% of WRA achieving minimum dietary diversity in northern Nigeria (Janmohamed *et al.,* 2024). Kebbi State, in north-western Nigeria, faces unique challenges, with 75% of its population living below the poverty line and only 12 healthcare facilities per 100,000 people (NBS, 2020). Subsistence agriculture dominates the region, and cultural food practices often prioritize energy-dense crops over nutrient-rich foods, contributing to deficiencies (Ogunmodede *et al.,* 2024). Despite national efforts to address malnutrition, local data on micronutrient status in Kebbi State remain scarce, limiting the design of effective interventions.

This study aimed to assess the prevalence and determinants of iron, zinc, calcium, vitamin A, and total protein deficiencies among WRA in urban and rural areas of Birnin Kebbi. By examining socio-economic, dietary diversity, food security and anthropometric factors, the study seeks to provide evidence for targeted nutritional strategies to improve maternal and child health, aligning with Sustainable Development Goals.

MATERIALS AND METHODS

All the chemicals and reagents used in this study were of analytical grade. All from Randox Laboratories, Northern Ireland, Sigma-Aldrich Chemie GmbH, Germany, and Cyman chemicals, USA.

Study Area

The study was conducted in three rural (Zauro, Ambursa and Maurida) and three urban (Gwadangaji, Takalau and Badariya) areas of Birnin Kebbi, LGA. Kebbi state located in the North-Western Nigeria between latitudes 10° 8’N - 13°5’N and longitude 3°30E - 6°02E with a population of 3,238,628 people according to 2006 National census. It has a land area of 36800 square kilometres and 21 local government areas. The state is also characterized with tropical weather conditions of harmattan, dry season and rainy season like other Nigerian states. It is predominantly rural, with many households relying on subsistence agricultural activities for their livelihood. The state was chosen as the study area because it is one of the states in Nigeria with reported high levels of malnourishment in women of reproductive age (Olatona *et al.,* 2024. But when it comes to micronutrient deficiencies, we are working with a blank slate and there is little to no specific data about women here. Like other parts of Nigeria, people in Birnin Kebbi often rely on staple crops, and access to diverse, nutrient-packed foods can be limited (Katenga-Kaunda *et al.,* 2020).

Study Population

The study population consisted of pregnant women residing in some selected urban and rural areas of Birnin Kebbi. Which ensure a comprehensive understanding of micronutrient deficiencies, participants include women across various socio-economic and demographic backgrounds and stages of pregnancy.

Study Design

A cross-sectional design, which involves collection of information using a simple random sampling method from participants, anthropometric measurements and blood samples from subjects in the selected rural and urban communities was used. The study design was chosen because it allowed for the collection of data from a large sample of participants at a single point in time and examination of the relationships among various study parameters.

Inclusion and Exclusion Criteria

All pregnant women of the study area were enrolled utilizing the following inclusion and exclusion criteria: The participants were between the ages of 15-49 years and were not menopausal, the women were not suffering from any chronic diseases affecting the dietary intake pattern. The women were not suffering from any acute morbidity condition on the day of survey.

Sampling technique and Data collection

The Yamane (Yamane, 1967) formula often referred to as the sample size calculation formula, was used to determine the required sample size for a study based on certain parameters. The formula is expressed as:

$n=N/1+N(e)^2$

Where:

n = sample size

N = population size

e = margin of error or precision

Margin of error = 5%

= 5/100 = 0.05

Sampling Technique

The study employed a simple random technique without replacement to ensure representation across different demographic group within the population. A total number of 120 women were recruited for the study and each was given a structured questionnaire and a blood sample was collected from each participant.

Ethical Considerations

The study was approved by the Kebbi State Ministry of Health. Informed consent was obtained from all participants and they were assured of confidentiality. With ethical approval reference number: **MOH/KSREC/VOL.I/56**

Chemicals and Reagents

All the chemicals and reagents used in this study were of analytical grade. All from Randox Laboratories, Northern Ireland, Sigma-Aldrich Chemie GmbH, Germany, and Cyman chemicals, USA.

Data Collection Instruments

Quantitative data collection was done with the aid of semi-structured questionnaire containing both open and close ended questions administered to the participants to obtain their Socio-demographic information, food security, dietary diversity score, micronutrients awareness and preventions, a 24-hours dietary recall.

Anthropometric measurements

The body mass index was determined by dividing the individual's weight in kilograms (kg) by square of their height in meters (m) (Onyema *et al.,* 2024). Blood samples were collected from the study participants to assess micronutrient deficiency (iron, zinc, calcium, vitamin A) and total protein. The biochemical analysis of (iron, zinc and calcium) were assayed by using Atomic Absorption Spectrophotometer and Flame photometry (Buck Scientific Atomic Absorption Emission Spectrophotometer model 205, manufactured by Norwalk, Connecticut, USA), the serum total protein was analysed using Lowry's method as described by Adeyeye (2025) and Vitamin A (serum retinol) levels were determined through a spectrophotometric method as described by Tanumihardjo *et al*. (2024).

Data Analysis

Data were analyzed using Excel software (version 2002). Descriptive statistics (means, standard deviations, percentages) summarized prevalence and nutrient levels. Chi-square tests assessed associations between socio-demographic factors and deficiency status between urban and rural groups. At *p-value* < 0.05 was considered statistically significant.

RESULTS

Association between socio-economic and demographic Characteristics of micronutrients Deficiency

The results for iron, zinc, vitamin A and calcium are presented in table 1 and 2 respectively, the results show significant associations between demographic characteristics of iron and calcium deficiencies among women of reproductive age in Birnin Kebbi LGA. Iron deficiency was notably linked to low educational status (p=0.002) and subsistence farming as an occupation (p=0.001). Calcium deficiency showed higher prevalence in urban areas compared to rural areas, with significant differences across demographic groups (p<0.05). Vitamin A and zinc deficiencies were assessed across demographic and socioeconomic groups. Zinc deficiency was prevalent in both urban and rural areas, with no significant urban-rural differences (p>0.05). Vitamin A levels were adequate in both groups, with minimal variation. Socioeconomic factors, such as education and occupation, showed significant associations with zinc deficiency (p<0.05).

Food Security Assessment

Food security was significantly better among urban women compared to rural women. Urban women reported less worry about food shortages (65% vs. 39%, p=0.0001) and skipped meals less frequently (29% vs. 67%, p=0.0001). They also had greater access to nutrient-rich foods like vegetables, fruits, and dairy (54.6% vs. 28.7%, p=0.003). Rural women faced higher barriers due to cost and limited availability of fresh foods (p=0.049).

Anthropometric Characteristics of Women of Reproductive Age in Urban and Rural Areas

Anthropometric measurements showed significant urban-rural disparities in body mass index (BMI). Urban women had a higher mean BMI (22.5 ± 3.1 kg/m² in Urban 1) and overweight rates (up to 26.7% in Urban 2) compared to rural women (18.8 ± 4.0 kg/m² in Rural 1, underweight rates up to 50% in Rural 3) (p<0.05). These findings reflect nutritional transitions in urban areas and undernutrition in rural settings.

Micronutrients of the Participants in Selected Urban and Rural Area

Mean serum levels of micronutrients showed deficiencies in iron (urban: 4.59 ± 0.91 µmol/L; rural: 3.43 ± 0.51 µmol/L vs. normal: 10.7–28.6 µmol/L), zinc (urban: 4.18 ± 0.39 µmol/L; rural: 4.08 ± 0.43 µmol/L vs. normal: 10–18 µmol/L), and calcium (urban: 1.04 ± 0.21 mmol/L; rural: 1.11 ± 0.24 mmol/L vs. normal: 2.1–2.6 mmol/L). Vitamin A levels were adequate (urban: 1.49 ± 0.15 µmol/L; rural: 1.43 ± 0.17 µmol/L vs. normal: >1.05 µmol/L). Urban women had slightly higher levels for most micronutrients (p<0.05).

Mean Serum Total Protein

Serum total protein levels were elevated in both groups, with urban women at 9.81 ± 1.4 g/dL and rural women at 9.56 ± 1.1 g/dL, exceeding the normal range (6.0–8.0 g/dL). The difference between urban and rural groups was statistically significant (p<0.05). Values are presented as mean ± standard deviation, with chi-square tests confirming significance.

Table 1: Association between demographic characteristics of Iron and Calcium deficiency

Variables	Category	Prevalence n (%) Iron deficiency	Total	*p-value*	Prevalence n (%) Calcium deficiency	Total	*p-value*
Location	Urban	21 (35)	60	0.00001	17 (28)	60	0.0003
	Rural	30 (50)	60		12 (20)	60	
Age Group	15-20	9 (64)	14	0.7	9 (64)	14	0.0001
	21-25	14 (52)	27		6 (22)	27	
	26-30	10 (42)	24		3 (13)	24	
	31-35	7 (35)	20		2 (10)	20	
	36-40	5 (26)	19		1 (5)	19	
	41-45	4 (36)	11		5 (45)	11	
	46-48	2 (40)	5		4 (80)	5	
Educational Status	Primary	23 (70)	33	0.002	8 (24)	33	0.013
	Secondary	10 (24)	42		4 (10)	42	
	Tertiary	12 (67)	18		6 (33)	18	
	No formal education	6 (22)	27		13 (48)	27	
Occupational Status	Employed	15	16	0.001	7 (44)	16	0.41
	Farmers	26	49		13 (27)	49	
	Business	10	55		9 (16)	55	

Values are presented in frequency and % in each group, chi-square was used to determine the *p-value* at 0.05. *P-value*s with superscript are statistically significant

Table 2: Demographic and socioeconomic characteristics of Vitamin A and Zinc deficiency

Variables	category	Prevalence n (%) Vitamin A deficiency	Total	*p-value*	Prevalence n (%) Zinc deficiency	Total	*p-value*
Location	Urban	1 (2)	60	0.307	40 (66)	60	0.449
	Rural	3 (5)	60		36 (60)	60	
Age Group	15-20	0 (0)	14	0.005	8 (57)	14	0.323
	21-25	0 (0)	27		10 (37)	27	
	26-30	1 (4)	24		14 (58)	24	
	31-35	0 (0)	20		19 (95)	20	
	36-40	1 (5)	19		13 (68)	19	
	41-45	0 (0)	11		9 (82)	11	
	41-49	2 (40)	5		3 (60)	5	
Educational Status	Primary	0 (0)	33	0.483	13 (39)	33	0.1
	Secondary	1 (2)	42		26 (62)	42	
	Tertiary	1 (6)	18		17 (94)	18	
	No formal education	2 (7)	27		20 (74)	27	
Occupational Status	Employed	3 (19)	16	0.004	12 (75)	16	0.523
	Farmers	1 (2)	49		34 (69)	49	
	Business	0 (0)	55		30 (55)	55	

Values are presented in frequency and % in each group, chi-square was used to determine the *p-v P-value*s with superscript are statistically significant

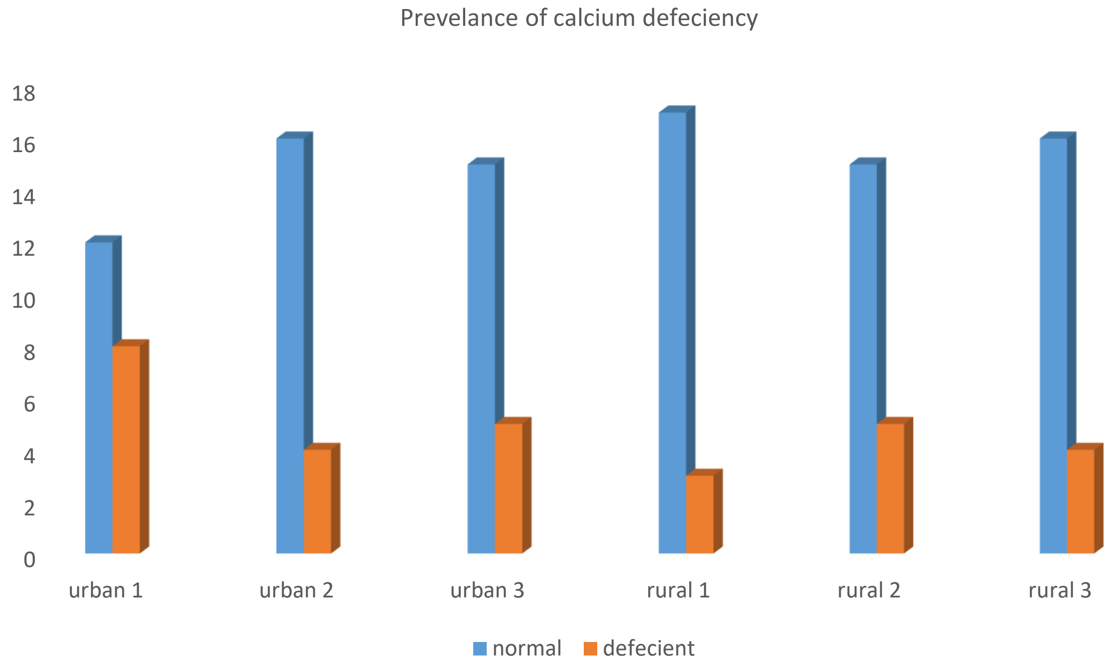

Figure 1: The Prevalence of calcium deficiency in 3 urban and 3 rural areas of the study

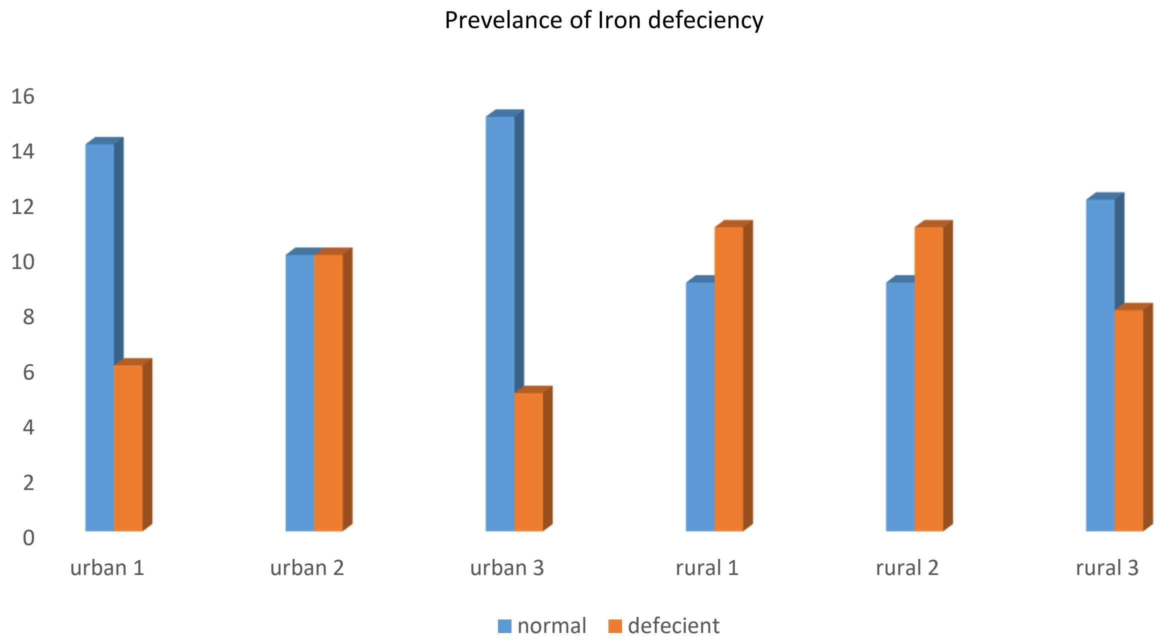

Figure 2: The figure above shows prevalence of iron deficiency in the study areas

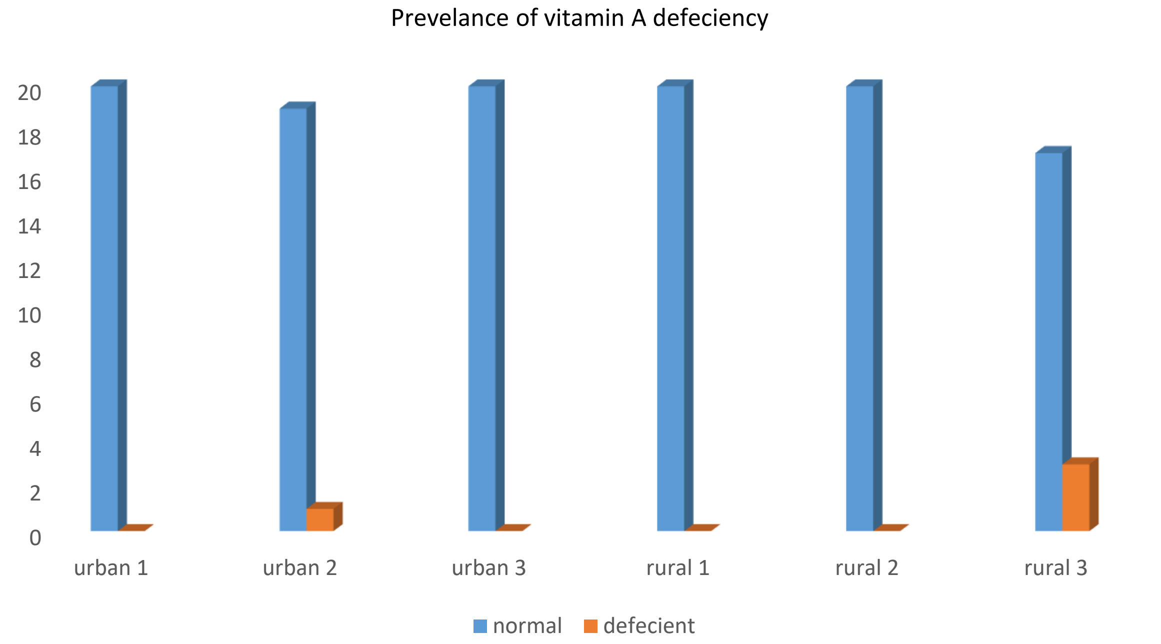

Figure 3: The prevalence of vitamin A deficiency across all groups is low showing adequacy in both urban and rural areas
This can be attributed to impact of vitamin A supplementation among women of reproductive age.

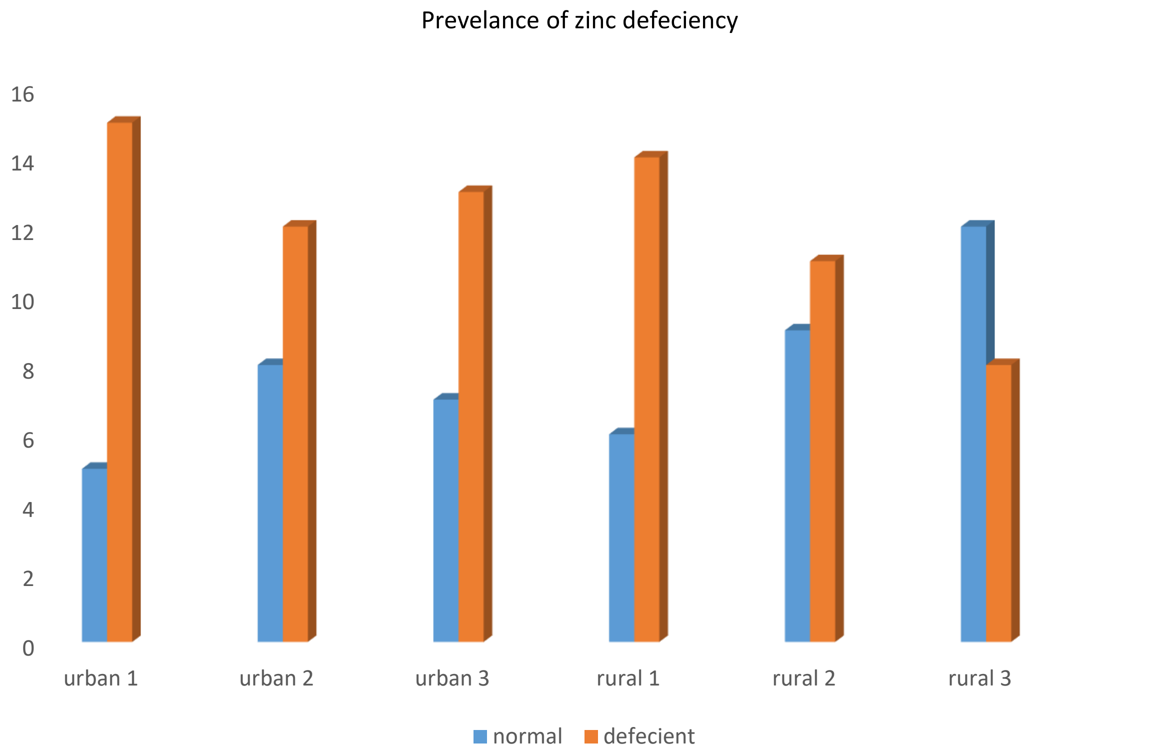

Figure 4: Zinc deficiency was found to be prevalence in both urban and rural areas
The higher deficiency across the groups suggests potential risks for prolong and impaired neonatal immunity

Table 3: **24-Hours Dietary Recall**

Food Groups	Urban (%)	Rural (%)	*p-value*
Grains and Tubers	62.5	83.2	0.013
Legumes and Nuts	49.1	72.9	0.01
Dairy Products	65	41.5	0.012
Vegetables	70.8	67	0.04
Fruits	37.5	54.6	0.028
Oils and Fats	74.1	76	0.05

The frequency values are presented as % in both urban and rural areas, chi-square was used to determine the *p-value*.

Table 4: Food Security Assessment

Questions	Response	Urban	Rural	*P-value*
Worried about food shortage?	Never	65	39	0.0001
	Rarely	15	8	
	Sometimes	11	47	
	Others	9	6	
Have you skipped meals?	No	69	33	0.0001
	Yes	29	67	
Do you consume vegetables, fruits,	Yes	54.6	28.7	0.003
dairy or milk?	No	45.3	71.3	
Do you receive food assistance	Yes	100	100	1
from NGO's?	No			

The frequency values are presented in % in each group, chi-square was used to determine the *p-value* at 0.05. *P-value*s with superscript are statistically significant

Table 5: Anthropometric Characteristics of Women of Reproductive Age in Urban and Rural Areas

Group	BMI (kg/m²)	Underweight (%)	Normal weight	Overweight (%)
Urban 1	22.5 ± 3.1	30	56.7	13.3
Urban 2	23.1 ± 2.8	28.4	45	26.7
Urban 3	21.9 ± 3.5	31.7	45.9	22.4
Rural 1	18.8 ± 4.0	41.6	55	3.4
Rural 2	20.2 ± 3.7	35	58.3	6.7
Rural 3	18.2.0 ± 3.2	50	46.6	3.3

BMI values for the groups are presented as mean ± standard deviation

Table 6: Micronutrient Awareness and Prevention Practices among Women of reproductive

Question	Response	Urban n (%)	Rural n (%)	*p-value*
Are you aware of micronutrients and their	Yes	41 (68.3)	27 (45)	0.01
importance	No	19 (31.6)	33 (55)	
Do you know foods that are rich in	Yes	35(58.3)	19 (31.6)	0.003
micronutrients	No	25 (41.6)	41 (68.3)	
Have you heard of micronutrient deficiency	Yes	30 (50)	12 (20)	0.0006
	No	30 (50)	48 (80)	
Do you take measures to prevent	Yes	39 (65) 21	19 (31.6)	0.0003
micronutrient deficiency	No	(35)	41 (68.3)	

Frequency data are presented as the number and percentage in each group for Town and village. *p-value* <0.05 between Town and Village are statistically significant

Table 7: Micronutrient levels of the participants in selected urban and rural Areas

Group	Iron (µmol/L)	Zinc (µmol/L)	Calcium (mmol/L)	Vitamin A (µmol/L)
Urban	4.59 ± 0.91	4.18 ± 0.39	1.04 ± 0.21	1.49 ± 0.15
Rural	3.43 ± 0.51	4.08 ± 0.43	1.11 ± 0.24	1.43 ± 0.17

Values are mean ± standard deviation across all groups for micronutrients

Table 8: Mean Serum Total Protein

Group	Total protein (g/dL)
Urban	9.81 ± 1.4
Rural	9.56 ± 1.1

Values are mean ± standard deviation

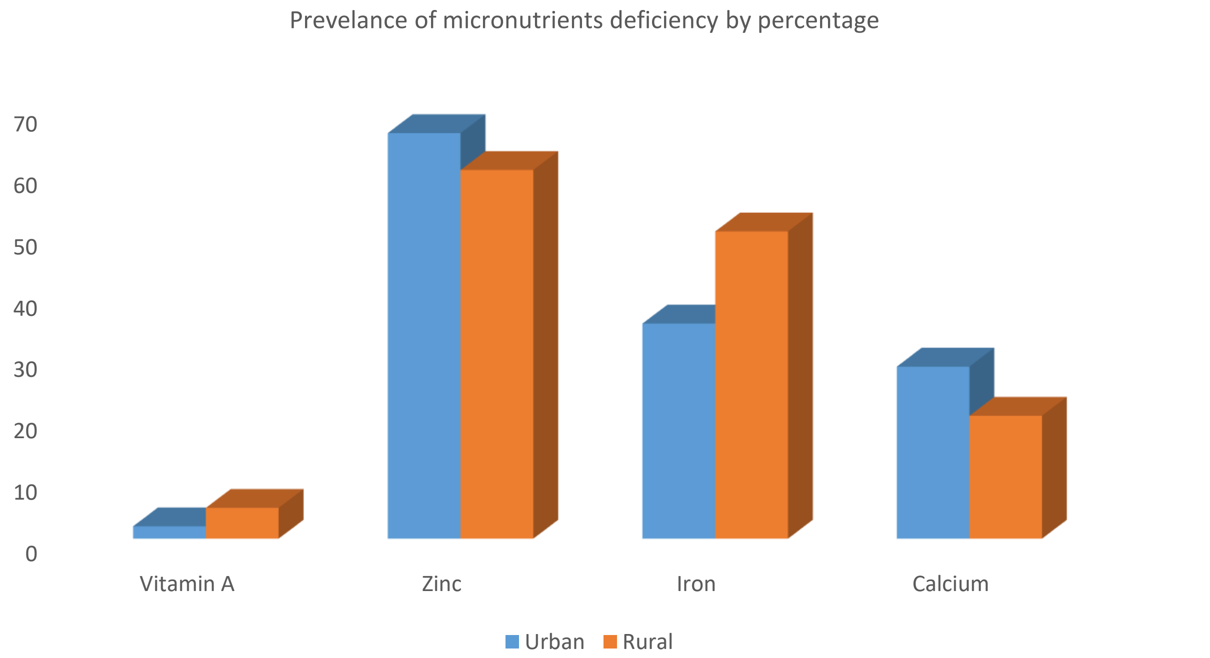

Figure 5: Prevalence of micronutrients deficiency by percentage in the urban and rural areas of the study

DISCUSSION

The results biochemical assessment of micronutrient status among the participants (WRA) in selected urban and rural areas of Birnin Kebbi LGA provides an important detail on their nutritional health. The mean serum levels of iron, zinc, calcium, vitamin A, and total protein were generally higher among urban participants compared to their rural counterparts, although the differences were relatively modest. Specifically, mean serum iron was 4.59 ± 0.91 µmol/L in urban women and 3.43 ± 0.51 µmol/L in rural women; zinc was 4.18 ± 0.39 µmol/L in urban compared to 4.08 ± 0.43 µmol/L in rural; calcium was 1.04 ± 0.21 mmol/L (urban) and 1.11 ± 0.24 mmol/L (rural); vitamin A was 1.49 ± 0.15 µmol/L (urban) and 1.43 ± 0.17 µmol/L (rural). Total protein levels were also higher in urban participants (9.81 ± 1.4 g/dL) than in rural participants (9.56 ± 1.1 g/dL).

When these findings were compared with established reference values, several important patterns emerge. Normal reference ranges are reported as follows: serum iron 10.7–28.6 µmol/L (WHO, 2001), serum zinc 10–18 µmol/L (Wessells *et al*., 2023), serum calcium 2.1–2.6 mmol/L (Ogunmodede *et al.,* 2024), serum retinol (vitamin A) 1.05–3.0 µmol/L (WHO, 2011), and serum total protein 6.0–8.0 g/dL (Kliegman *et al.,* 2015).

Both urban and rural participants showed critical iron deficiency, with mean iron levels far below the lower normal threshold of 10.7 µmol/L. This suggests a widespread prevalence of iron deficiency anaemia among pregnant women in the study area. Iron deficiency during pregnancy is a leading cause of maternal anaemia globally, contributing to adverse outcomes such as low birth weight and preterm delivery (Black *et al.,* 2013). Similar low iron status has been reported in pregnant women in other parts of Nigeria (Onyema *et al.,* 2024). Highlighting a persistent public health issue.

The mean zinc levels in both groups (urban: 4.18 µmol/L; rural: 4.08 µmol/L) were also well below the recommended minimum of 10 µmol/L, indicating severe zinc deficiency. Zinc deficiency in pregnancy is associated with increased risks of prolonged labour, low birth weight, and poor immune function in neonates (Wessells *et al.,* 2023). The minimal difference between urban and rural women suggests that zinc deficiency is a generalized problem, irrespective of location, possibly reflecting low intake of animal-source foods and high consumption of phytate-rich cereals that inhibit zinc absorption (Janmohamed *et al.,* 2024).

In contrast, calcium levels, though slightly higher in rural women (1.11 mmol/L) than urban women (1.04 mmol/L), were well below the normal range (2.1–2.6 mmol/L), indicating hypocalcemia. Adequate calcium intake during pregnancy is essential for fetal skeletal development and the prevention of hypertensive disorders such as preeclampsia (Tanumihaedjo *et al.,* 2024). The low calcium levels observed in this study are consistent with reports from other Nigerian settings where low dairy consumption is common (Ogunba and Adeyemi, 2015).

Vitamin A levels were within the normal range (>1.05 µmol/L) for both urban (1.49 µmol/L) and rural (1.43 µmol/L) participants, suggesting an adequate vitamin A status in this population. This may reflect the impact of periodic vitamin A supplementation programs targeting women of reproductive age in Nigeria. However, the small difference between groups points to the need for continued monitoring, particularly since marginal vitamin A status can still predispose individuals to subclinical deficiency and increased susceptibility to infections (Tanumihardjo *et al*., 2024).

The mean total protein levels (urban: 9.81 g/dL; rural: 9.56 g/dL) were above the upper normal limit of 8.0 g/dL, which could reflect haemoconcentration or dehydration rather than nutritional excess, since elevated total protein in pregnancy is less commonly attributed to dietary protein intake (Kliegman *et al.,* 2015). Alternatively, it may suggest a physiological adaptation or analytical variance; further investigation would be needed to clarify this finding.

The consistently better micronutrient profiles in urban women, particularly for iron and vitamin A, may be attributed to better access to fortified foods, health services, and dietary diversity in urban settings (Smith and Haddad, 2015). Conversely, rural women may face barriers such as food insecurity, lower income, and limited antenatal care access, contributing to poorer nutritional status (Fotso, 2007).

Rural women in Birnin Kebbi eat more grains, tubers (83.2% vs. 62.5%, p=0.013), and legumes (72.9% vs. 49.1%, p=0.01) than urban women, relying on staple crops typical in northern Nigeria (Olatona, 2024). Urban women consume more dairy (65% vs. 41.5%, p=0.012) and vegetables (70.8% vs. 67%, p=0.04), showing better access to nutrient-rich foods. Urban women also have higher dietary diversity, with 56.6% eating 3–5 food groups vs. 61.6% of rural women eating fewer than 3 (p=0.015). While this should lower micronutrient deficiencies (Onyeji, 2022), higher urban calcium deficiency suggests other factors at play.

Urban women in Birnin Kebbi have higher calcium deficiency than rural women, despite eating more dairy, likely due to low vitamin D, which helps absorb calcium. Vitamin D deficiency is common in African urban areas, with 47.6% of adults in North Central Nigeria affected, often from less sun exposure due to indoor lifestyles or cultural practices (Lawal, 2020; Cashman *et al*., 2019). Rural women, with more outdoor time from farming, may get enough sun to avoid this issue.

Food security affects micronutrient status in Birnin Kebbi LGA. Urban women had better food security (65% vs. 39% unworried about shortages, p=0.0001; 29% vs. 67% skipped meals, p=0.0001) and ate more nutrient-rich foods (54.6% vs. 28.7%, p=0.003). Rural women faced higher costs (63% vs. 42%) and less food access (32% vs. 44%, p=0.049), increasing iron deficiency (Janmohamed, 2024). Iron deficiency was tied to low education (70% vs. 22%, p=0.002) and farming (26% vs. 15% employed, 10% businesswomen, p=0.001), worsened by rural poverty (>75%) (Kebbi, 2020).

Anthropometric measurements highlight nutritional disparities. Rural women had lower mean BMI (18.8 ± 4.0 for Rural 1) and higher underweight rates (up to 50% in Rural 3) compared to urban women (mean BMI around 22.5 ± 3.1 for Urban 1, underweight rates around 30%). Conversely, urban women had higher overweight rates (up to 26.7% in Urban 2) compared to rural women (up to 6.7% in Rural 2) ($p < 0.05$). This pattern reflects the nutrition transition in developing countries, where urbanization leads to increased consumption of energy-dense foods and sedentary lifestyles, resulting in higher rates of overweight and obesity (Janmohamed *et al.,* 2024). Rural undernutrition, driven by food insecurity and limited dietary diversity, contributes to higher iron deficiency and poorer overall nutritional status (NDHS, 2018).

Urban women in Birnin Kebbi LGA showed higher micronutrient awareness (68.3% vs. 45%), knowledge of nutrient-rich foods (58.3% vs. 31.6%), and prevention measures (65% vs. 31.6%) than rural women (p=0.01 to 0.0003). Only 20% of rural women knew of micronutrient deficiencies, compared to 50% of urban women (p=0.0006). This gap likely worsens rural dietary practices, as awareness drives nutrition behavior (Katenga-Kaunda, 2020). Urban education and media exposure explain higher awareness, highlighting the need for rural educational interventions.

Micronutrient deficiencies impact maternal and child health. Rural iron deficiency raises risks of anemia, fatigue, and adverse pregnancy outcomes like preterm delivery (UNICEF, 2025). Urban calcium deficiency may cause skeletal issues and preeclampsia (Victora, 2021). These issues perpetuate poverty and health challenges. Rural interventions should promote dietary diversity via gardening, biofortification, and iron supplements (Nutrition International, 2023). Urban efforts should address vitamin D insufficiency to improve calcium absorption (Faber, 2015). Policies integrating nutrition into antenatal care, school feeding, and poverty and education programs are vital given Kebbi's high poverty and low education (Kebbi, 2020).

Limitations include the cross-sectional design, lack of vitamin D data, and small sample size, limiting causal conclusions and generalizability. Future studies should examine vitamin D, metabolomics, and food insecurity on oxidative stress.

CONCLUSION

This study underscores the significant burden of micronutrient deficiencies among women of reproductive age in Birnin Kebbi LGA, with rural areas facing higher iron deficiency and urban areas showing higher calcium deficiency. These disparities are driven by differences in dietary patterns, food security, socio-economic factors, and nutritional awareness. Targeted interventions, including supplementation, education, and policy reforms, are essential to improve nutritional status and support maternal and child health, contributing to Nigeria's broader goals of reducing malnutrition and achieving Sustainable Development Goals 2 and 3.

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