# *Original Research Article*

# assessment of NUTRITIONAL and antioxidant status of under-FIVE Years children in Funakaye L.G.A Gombe state, Nigeria

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# ABSTRACT

Malnutrition, particularly in early childhood, compromises immunity, exacerbates illnesses, and increases mortality rates from diarrhea and respiratory infections despite various maternal and child nutrition policies in Nigeria. Micronutrients, including vitamins and minerals, and antioxidants, essential for health, were the primary focus of this research. The study involved 100 under-five children from 10 wards, evaluating; anthropometric indices (weight-for-age, height-for-age, BMI-for-age), antioxidant vitamins (A, C, D, E), and minerals (Zn, Mn, Se, Fe, Cu), along with antioxidant enzymes (SOD, CAT, GPX). Results revealed significant variations in micronutrient levels across the wards. For instance, vitamin A levels ranged from 933.4±219.0 µg in Tilde Bodor to 1618.7±665.4 µg in Ribadu. Similarly, vitamin C was highest in Jillahi (322.4±99.3 µg) and lowest in Ribadu (191.5±28.9 µg). Variations in other vitamins, including D and E, and minerals like selenium, copper, and zinc, were also statistically significant (P < 0.05). Anthropometric findings showed mean values for mid-upper-arm circumference (MUAC), weight-for-age (WAZ), height-for-age (HAZ), and BMI-for-age (BAZ) at 11.44±2.54 cm, 0.21±0.62, 0.73±0.19, and 0.37±0.79, respectively. The prevalence of severe acute malnutrition (2%), moderate acute malnutrition (9%), overweight (7%), and obesity (1%) highlighted varying degrees of nutritional challenges. Additionally, rates of underweight, stunting, overweight, and obesity were recorded at 6%, 3%, 7%, and 3%, respectively.

**Keyword: under-five children, Micronutrients, antioxidant enzymes and anthropometric indices**

## **Introduction**

Malnutrition represents insufficient, excessive, or imbalanced consumption of nutrients. The World Health Organization (WHO) cites malnutrition as the greatest single threat to the world's public health (WHO). In developing countries such as Nigeria, this imbalance is most frequently associated with under-nutrition, which presents mainly as protein-energy malnutrition (PEM) and micronutrient deficiencies [1]. PEM and micronutrient deficiency are very common diseases affecting children in the developing world [2]. Malnutrition is used to refer to the deficiencies of vitamins and/or minerals of public health importance. These include, but not limited to, iron deficiency anemia, iodine deficiency disorder (IDD), Vitamin A deficiency, Vitamin D deficiency, and zinc deficiency [3]. PEM, on the other hand, represents a range of pathological conditions arising from the deficiency/imbalance of protein and energy, and is commonly associated with infections [4]. It occurs more frequently in infants and young children, but it is also observed in adolescents and adults, mostly lactating women, especially during periods of famine or other emergencies. Globally, all children under 5 years of age are at a risk of one form of nutrient deficiency or the other, with cases of rickets rising, especially among dark-skinned population [2], Micronutrient deficiency has been considered as a major risk factor for child survival in Nigeria, increasing the risk of death from common diseases such as acute gastroenteritis, pneumonia, and measles [5]. The prevalence of micronutrient deficiencies in Nigerian children under 5 years was reported 12 years ago by the Nigerian Food Consumption Survey as, 23.3%, 34.0%, 13.0%, and 20.0% for Vitamin A deficiency, iron deficiency anemia, IDDs, and zinc deficiency disorders, respectively [6].

The 2013 Nigeria Demographic and Health Survey [7], revealed that 37% of children under the age of five are stunted, while 21% are severely stunted, eighteen percent of under-five children in Nigeria are considered wasted and 9% are severely wasted while 29% are underweight, with 12% being severely underweight [7]. The under-five mortality rate in Nigeria is 128/1000 live birth which is among the world’s highest [7]. Children whose mothers have no education (54%) and those from the poorest households (55%) are more likely to be stunted. In Nigeria, 7% of children under five are wasted, a sign for acute malnutrition in addition, 22% of children under five are under weight. Rural children have higher levels of stunting, wasting and underweight compared to urban children [7]. There have been many studies on nutritional status of under-five children and factors responsible but very few looks at the influence of micronutrients on the antioxidant and nutritional status of their under-fives [8]. The aim of this research is to assess of nutritional and antioxidant status of under-five years children in Funakaye L.G.A Gombe state, Nigeria.

# 2.0 MATERIALS AND METHODS

## **2.1 Chemical and Reagents**

All the chemicals and reagents used are of analytical grade and were purchased from reputable companies.

**2.2 Eligibility Criteria**

The inclusion criteria for respondents who will participate in the study were children aged 0- 59 months.

Children aged 0 – 59 months that were sick requiring hospitalization and those that are handicapped were excluded from the study. Children above 59 months are also excluded.

## **2.3 Study Area**

The study was conducted at Funakaye local government area, Gombe State, Nigeria. The samples were collected from 10 wards of Funakaye LGA, which has a coordinates of10°51’N and 11°26’E and analyzed at the Department of Biochemistry Laboratory, Gombe State University, Nigeria. The local government is bounded in the east by Gongola River and Lake DadinKowa, beyond which lies Yobe State and Borno state. It has a total area of 546 m2. The study population; Funakaye local government has a total population 346,866 and under-five age proportion of 4,494 [9].

**2.4 Sample Size**

The sample size for the study was determined using Cochrane’s sample size formula below:

N= Z2pq

 d2

Where:

N= minimum sample size

Z= standard normal deviate corresponding to 95% confidence level, the value obtained from normal distribution table is 1.96

P= prevalence, estimated from a reference previous study, in this case 13.6%

q= complementary probability of p, i.e (1-p).

d= desired precision. In this case 5% = 0.05

Imputing:

(1.96)2 × 0.136 (1- 0.545)

 (0.05)2

= 3.8416 ×0.136 ×0.455

 0.0025

 = 0.953

 0.0025

= 95.09

A total number of 100 under five children were consented across the ten political wards, hence 10 individuals per ward grouping, with attrition of almost 5%.

## **2.6 Biochemical Analysis**

## Serme Superoxide Dismutase (SOD) and Glutathione Peroxidase (GSH), were determination according to [11], catalase activity by Sinha [12] method.

## Serum vitamin A and C by Oser [13]. Serum vitamin E by Backer *et al*. [14] vitamin D by Lindmark *et al* [15].

## Serum micro minerals (Zn, Mn, Se, Ca, Cu and Fe) were determined using AAS according to FAO [16].

## **2.7 Determination Macro nutrient and Energy intake**

Macronutrient and energy intake derived from the food frequency questionnaire were analyzed using Nutri-survey software version and the result were compared with RDA (WHO) of under-five children.

**2.8 Determination of Demographic Characteristics**

A questionnaire was used to collect demographic data from the parent of the study population. Such as household income, educational background and the type of food eaten.

## **2.9 Data analysis**

Data analysis was done with Statistical Package for social sciences (SPSS) version 20.0 (Chicago II). Frequency and percentage were used to summarize categorical variables such as the nutritional status, age category and socio-economic status while means and standard deviations were used to summarize continuous variables such as weight for height and height for age z-scores and also chi square test was used to measure the nutritional status. All reported p-values <0.05 were taken as statistically significant. Results are presented in tables and charts.

**3.0 RESULTS and Discussion**

## ***Demographic Characteristics of Study Respondents***

A total of 100 under 5 years children were screened, of these, (14%) aged between 0 and 11 months, (21%) children were within the age of 12 – 23 months while (17%) of the children aged between 24 and 35 months. Children that aged between 36 and 47 months, and between 48 and 59 months had frequencies of (26%) and (22%) respectively (Figure 1).

The result showed that 49% of the study respondents are of the Fulani ethnic group while 23% and 20% are of Kanuri and Bolewa ethnic groups respectively. In addition, 8% of the study respondents are from other ethnic groups (Figure 2).

Figure 3 showed the distribution of household and number of children in the family. The result showed that (22%) of the respondents were from household of 2 to 3 persons, while 34 (34%) are from household of 4 to 5 persons. In addition, 44% respondents are of the household of more than 6 persons. Similarly, (41%) of the respondents are from family having more than 6 children in the family while (36%) are of family with 4 -5 children.

The study showed the respondents’ parental occupation (Figure 4). in which 41% of the respondents’ parents are traders, 11% are farmers, 10% are house wives 31% are civil servants while 7% of the respondents’ parents did not disclose their occupation. Figure 5 showed that majority (30%) of the respondents’ household earn above ₦45,000 while the least income household (12%) earn less than ₦5,000. Figure 6 shows the educational levels of the respondents’ parents, those that attended primary (12%), junior secondary (13%), senior secondary (29%), post-secondary (19%) and 13% are graduates. However, the result showed that 14% of the respondents’ parents had no formal education.

Figure 1: Age of under-five children (*n* = 100)

Figure 2: Ethnic groups of the study respondents in Funakaye LGA (*n* = 100)

Figure 3: Number of household and children in the family of the study respondents (*n* = 100)

Figure 4: Parental occupation to the study respondents (*n* = 100)

Figure 5: Estimated household income of study participants

Figure 6: Educational Level of study participants’ parents

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## ***Energy and macronutrients intakes***

Table 1 shows the mean nutrient intake as percentage of RDA for the under-five children derived from the food frequency questionnaire (FFQ). The mean energy, protein, vitamin A, iron and calcium intake in the under-five children were 1364.4kcal, 39.1 g, 311.1µg, 538mg and 370.5mg respectively. These values were below the recommended dietary allowance (RDA) in the children. The children were found to consume high amount of carbohydrate foods resulting to the 113% fulfillment of the carbohydrate intake in the study population.

**Table 1: Mean Nutrient Intake as Percentage of RDA for the Under-Five Children (Nutri-Survey App 2020 Version)**

|  |  |  |  |
| --- | --- | --- | --- |
| Variable | Intake | RDA(WHO) | Percentage fulfillment (%) |
| Energy (kcal) | 1364.4 | 2036.3 | 67 |
| Water (g) | 402.9 | 1300 | 31 |
| Protein (g) | 39.1 | 60.1 | 65 |
| Fat (g) | 32.3 | 69.1 | 47 |
| Carbohydrate (g)  | 327.8 | 290.7 | 113 |
| Dietary fiber (g) | 40.6 | - | - |
| Alcohol (g) | 0 | - | - |
| Cholesterol (mg) | 25.3 | - | - |
| Vit. A (µg) | 311.1 | 600 | 52 |
| Carotene (mg) | - | - | -  |
| Vit. E (eq.) (mg) | 2 | 5.5 | 36 |
| Vit. B1 (mg) | 0.2 | 0.6 | 33 |
| Vit. B2 (mg) | 0.3 | 0.7 | 43 |
| Vit. B6 (mg) | 0.1 | 0.4 | 25 |
| Tot. folic acid (µg) | 129.7 | 200 | 65 |
| Vit. C (mg) | 37.7 | 60 | 63 |
| Sodium (mg) | 188.9 | - | -  |
| Potassium (mg) | 1299.6 | 1500 | 87 |
| Calcium (mg) | 370.5 | 600 | 62 |
| Magnesium (mg) | 37.3 | 80 | 47 |
| Phosphorus (mg) | 436.2 | 500 | 87 |
| Iron (mg) | 5.8 | 8 | 73 |
| Zinc (mg) | 1.5 | 3 | 50 |

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## **Anthropometric profile of the study respondents**

The result of the anthropometric profile of the study respondents showed a mean weight of 13.98±2.49kg. The mean heights (0.87±0.10 m) of the respondents in the current study ranged between 0.65 and 1.02m. The study respondents had a mean BMI of 19.02±4.37 kg/m2 that ranged between 11.73 and 33.88kg/m2. The result further showed a mid-upper-arm circumference (MUAC) of 11.44±2.54 cm (Figure 7).

**Figure 7: Anthropometric Status of the study respondents across the various locations**

**Keys:** Columns represent mean ± SD of 10 observations from each sampling locations. BE – Bajoga East; BW – Bajoga West; WA – Jillahi; KT – Kupto; TW – Tongo Ward; WW – Wawa/Wakkaltu; AM – Ashaka/Magaba; TB – Tilde/Bodor; BG – Bage; RB – Ribadu.

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## **Nutritional status of Study Respondents**

Table 2 shows the nutritional status of the study respondents according to their ages, of the 100 under – five years children, 94% had normal weight-for-age (WAZ), 4% were underweight while 2% were severally underweight.

The mean Z-score of the height-for-age (HAZ) classification of the children was 0.73±0.19, with 97% of the children having the normal height-for-age (HAZ).

The result shows that of the 100 under-five years children, 2% were stunted while 1% was severally stunted. Based on the BMI-for-age (BAZ) classification, 3% of the study subjects were obese, 7% were overweight, 85% were normal while 5% were underweight. The differences between the various parameters of nutritional status were found to be statistically insignificant at (*P*> 0.05).

**Table 2: Nutritional Status Distribution of the Study Respondents According to age Range**

|  |  |
| --- | --- |
| Nutrition Indicators | Age group (months) |
| **0 – 11** | **12 – 23** | **24 - 35** | **36 - 47** | **48 – 59** |
| Weight-for-age (WAZ) | **Mean Z-score (0.21±0.62)** |
| Normal | 92.9% | 90.4% | 94.1% | 96.1% | 95.4% |
| Underweight | 7.1% | 4.8% | 0.0% | 3.9% | 4.6% |
| Severally underweight | 0.0% | 4.8% | 5.9% | 0.0% | 0.0% |
| Height-for-age (HAZ) | **Mean Z-score (0.73±0.19)** |
| Normal | 100.0% | 95.2% | 94.1% | 96.1% | 100.0% |
| Stunted | 0.0% | 4.8% | 5.9% | 0.0% | 0.0% |
| Severally stunted | 0.0% | 0.0% | 0.0% | 3.9% | 0.0 |
| BMI-for-age(BAZ) | **Mean Z-score (0.37±0.79**) |
| Obese  | 0.0% | 0.0% | 5.9% | 7.8% | 0.0% |
| Overweight  | 7.1% | 9.5% | 0.0% | 11.5% | 4.6% |
| Normal | 85.8% | 81.0% | 94.1% | 66.8% | 90.8% |
| Underweight | 7.1% | 9.5% | 0.0% | 3.9% | 4.6% |

**aNutrition Assessment and Classification User’s Guide Module 2 (2016).**

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## **Vitamins and Minerals Status of the Study Respondents**

Table 3 presents the result of the vitamins A, C, E and D status of the study respondents. The current result showed a higher serum level of Vitamin A in samples from Ribadu (RB) and Tilde/bodor (TB) has the lowest level of serum vit A at P<0.05 which means that there is a significance difference in vitamin A level. The result also showed a significant difference at P<0.05 in the level of vitamin C with Jillahi (JH) ward having the highest level and Ribadu (RB) ward having the lowest level at P<0.05. the result also showed that, there is a significant difference in the level of vitamin D with Ribadu (RB) and Jillahi (JH) wards having the highest level and Bajoga west (BW) having the lowest level of serum vitamin D at P<0.05. the result also showed that, there is a significant difference in the serum level of vitamin E, for which Bajoga west (BW), Tongo (TW) and Bage (BG) wards have the lowest level while Ashaka/magaba (AM) having the highest level of vitamin E at P<0.05.

**Table 3: Vitamin Status for the Under-Five Children**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Variables** | **Vitamin A (µg/L)** | **Vitamin C (µg/L)** | **Vitamin D (µg/L)** | **Vitamin E (µg/L)** |
| BE | 1263.72 ± 383.1 | 288.6 ±36.4 | 25.4 ± 4.9 | 11.2 ± 1.6 |
| BW | 1404.1 ±545.0 | 258.4±61.2 | 21.1 ±3.7 | 9.6 ±1.2 |
| WW | 1322.3 ±521.5 | 281.6 ±63.8 | 24.5 ±3.6 | 10.0 ±1.9 |
| KT | 1075.5 ±583.5 | 286.9 ±54.4 | 23.0 ±3.9 | 10.9 ±1.6 |
| TW | 1136.2 ± 583.1 | 268.7 ±25.2 | 23.3 ±4.4 | 9.6 ±1.1 |
| JH | 1339.8 ±321.2 | 322.4±99.3 | 27.7 ±2.9 | 10.8 ±2.3 |
| AM | 1061.4 ± 576.2 | 207.6 ±35.5 | 27. 0 ±3.1 | 13.3 ±1.7 |
| TB | 933.4 ±219.0 | 270.3 ±20.8 | 27.0 ±3.1 | 11.8 ±2.7 |
| BG | 1135.9 ±673.0 | 200.9 ±52.1 | 27.3 ±2.9 | 9.6 ±1.2 |
| RB | 1618.7 ±665.4 | 191.5 ±28.9 | 27.9 ±3.2 | 11.3 ±2.6 |

**Keys:** Columns represent mean ± SD of 10 observations from each sampling locations. Values followed by different letters across the rows are significantly different at *P*< 0.05 (Post Hoc Tukey). BE – Bajoga East; BW – Bajoga West; WW – Wawa/Wakkaltu; KT – Kupto; TW – Tongo Ward; JH – Jillahi; AM – Ashaka/Magaba; TB – Tilde/Bodor; BG – Bage; RB – Ribadu.

The result of the minerals status (Table 4) of the study group showed that there is a significant difference at P<0.05 in copper level of which Tilde/bodor (TB), Jillahi (JH) and Bajoga east (BE) has the highest level of copper while Tongo (TW) and Wawa/wakkaltu (WW) has the lowest at P<0.05. the result also showed that, there is a significant level of selenium level in Ashaka/magaba (AM) and Tilde/bodor ward. while the level of selenium was found to be lower in Jillahi (JH), Bage (BG) and Bajoga west (BW) at P<0.05.

The result also showed that there is a significant difference at P<0.05 on calcium level at AM, RB while Tilde/bodor, Bage (BG) and Ribadu (RB) wards were found to be lower.

The result also showed a significant difference at P<0.05 on zinc level, where by Jillahi (JH), AM, and Tilde/bodor (TB) while is lower in Wawa/wakkaltu (WW) ward.

The iron level were found to be statistically lower at Bage ward (BG) while higher at Tongo ward (TW) at P<0.05. the result also showed that, the level of manganese in Bajoga east (BE) was statistically lower 18.7 while that of Tongo ward (TW) was significantly higher 25.5 at P<0.05.

**Table 4: Mineral Status for the Under-Five Children**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **Variables** | **Copper (µg/dL)** | **Selenium (µg/dL)** | **Calcium (µg/dL)** | **Zinc (µg/dL)** | **Iron (µg/dL)** | **Manganese (µg/dL)** |
| BE | 0.9 ±0.4 | 1.5 ±1.3 | 2.8 ±2.1 | 2.1 ±1.2 | 16.8 ±1.9 | 18.7 ±2.9 |
| BW | 0.8 ±0.4 | 0.6 ±0.4 | 3.5 ±1.1 | 2.0 ±1.3 | 17.4 ±1.4 | 20.5 ±2.5 |
| WW | 0.6 ±0.2 | 2.8 ±1.9 | 3.0 ±1.9 | 1.9 ±1.1 | 17.0 ±2.7 | 23.0 ±3.3 |
| KT | 0.7 ±0.3 | 0.7 ±0.3 | 2.6 ±0.7 | 3.7 ±1.6 | 17.4 ±1.9 | 24.7 ±2.7 |
| TW | 0.6 ±0.4 | 0.7 ±0.4 | 2.2 ±1.0 | 3.1 ±0.6 | 18.0 ±2.3 | 25.5 ±2.8 |
| JH | 0.9 ±0.4 | 0.5 ±0.2 | 2.9 ±1.3 | 4.0 ±0.6 | 17.2 ±2.2 | 19.5 ±2.1 |
| AM | 0.7 ±0.4 | 4.0 ±1.5 | 4.0 ±2.1 | 4.3 ±1.8 | 16.3 ±2.21 | 22.7 ±2.9 |
| TB | 1.3 ± 0.7 | 3.6 ±1.4 | 1.7 ±0.5 | 4.2 ±1.4 | 17.3 ±2.2 | 20.0 ±2.4 |
| BG | 0.7 ±0.3 | 0.5 ±0.4 | 1.8 ±1.2 | 3.4 ±0.7 | 16.3 ±2.2 | 20.0 ±2.5 |
| RB | 0.6 ±0.3 | 1.7 ±0.5 | 1.5 ±0.8 | 2.8 ±1.6 | 16.8 ±2.7 | 22.7 ±2.7 |

**Keys:** Columns represent mean ± SD of 10 observations from each sampling locations. Values followed by different letters across the rows are significantly different at *P*< 0.05 (Post Hoc Tukey). BE – Bajoga East; BW – Bajoga West; WW – Wawa/Wakkaltu; KT – Kupto; TW – Tongo Ward; JH – Jillahi; AM – Ashaka/Magaba; TB – Tilde/Bodor; BG – Bage; RB – Ribadu.

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## **Antioxidant status of the study respondents**

This study showed the antioxidant status of the study group (Figure 8). Catalase activity in the study population was found to lowest (6218.26±3175.28 U/ml) in samples from Ribadu (RB) while the highest Catalase activity was observed in samples from Tilde/Bodor (TB) (11166.3±4039.50 U/ml). The glutathione peroxidase (GPx) levels in the study population were lower in Bajoga east BE (3283.8±1078.67 U/ml), and higher in kupto and tilde bodor wards KT (5027.22±814.14 U/ml), TB (6932.28±904.37 U/ml), Furthermore, the result showed that there is a significant difference in the SOD activity, jillahi and kupto wards having statistically higherwhile ribadu ward has lower at P<0.05.

Figure 8: Antioxidants status of study respondents (*n* = 100).

**Keys:** Columns represent mean ± SD of 10 observations from each sampling locations. BE – Bajoga East; BW – Bajoga West; JH – Jillahi; KT – Kupto; TW – Tongo Ward; WW – Wawa/Wakkaltu; AM – Ashaka/Magaba; TB – Tilde/Bodor; BG – Bage; RB – Ribadu.

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## ***Correlation between vitamins, minerals, antioxidant and anthropometric status of under-five Study Participants***

The present result showed the correlation between vitamins, mineral levels and anthropometric status of study participants (Table 5). The result showed weak significant negative relationship between weight and vitamin E (*P*< 0.01, *r* = -0.269) and selenium (*P* < 0.05, *r* = -0.217) levels. Weak positive relationship was also found between height and vitamin C (*P* < 0.05, *r* = 0.249) and weak negative correlation between serum height and Zinc (*P* < 0.05, *r* = -0.220) levels. BMI showed weak negative correlation between vitamin A (*P* < 0.05, *r* = -0.104), vitamin D (*P* < 0.05, *r* = -0.195), vitamin E (*P* < 0.05, *r* = -0.170) and weak positive correlation in vitamin C (*P* < 0.05, *r* = 0.150) levels. MUAC had weak association with vitamin E (*P* < 0.05, *r* = 0.112), vitamin C (*P* < 0.05, *r* = 0.103) and calcium (*P* < 0.05, *r* = 0.160).

Table 5: Correlation Between Vitamins, Mineral Levels and Anthropometric Measures of Study Participants

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Variable** | **Vit****\_A** | **Vit\_****C** | **Vit\_****D** | **Vit\_****E** | **Cu** | **Se** | **Ca** | **Zn** | **Fe** | **Mn** |
| MUAC | 0.066 | 0.103 | -0.195 | -0.112 | -0.004 | -0.084 | 0.160 | -0.089 | 0.039 | -0.064 |
| Weight | -0.023 | -0.135 | -0.114 | **-0.269\*\*** | 0.078 | **-0.217\*** | -0.12 | -0.193 | -0.011 | -0.007 |
| Height | 0.085 | 0.149 | -0.039 | -0.053 | -0.051 | -0.070 | -0.088 | **-0.220\*** | 0.026 | -0.058 |
| BMI | -0.104 | 0.150 | -0.042 | -0.170 | 0.129 | -0.103 | -0.010 | 0.075 | -0.039 | 0.050 |

**\*\***.Correlation is significant at the 0.05 level (2-tailed). **\***.Correlation is significant at the 0.05level (2-tailed). MUAC – mid-upper-arm circumference, Zn- zinc, Cu- copper, Ca – calcium, Se- selenium, Fe – iron, Mn- manganese.

Table 6 revealed the association between antioxidant status and anthropometric measures of Study Participants. From the result, there was weak positive correlation between MUAC and CAT (*P* < 0.05, *r* = 0.236) and SOD (*P* < 0.01, *r* = 0.369). The result showed weak significant negative correlation between weight and GPx (*P* < 0.05, *r* = -0.187). Weak negative correlation were also found between GPx and MUAC (*P* < 0.05, *r* = -0.179) and height (*P* < 0.05, *r* = -0.144). Furthermore, SOD showed weak correlation against height (*P* < 0.05, *r* = -0.111) and BMI (*P* < 0.05, *r* = -0.106). MUAC has a strong positive correlation with SOD, but mildly strong correlation with CAT.

**Table 6: Correlation between antioxidant status and anthropometric measures of Study Participants**

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **CAT** | **GSH** | **SOD** |
| MUAC | **0.236\*** | -0.179 | **0.369\*\*** |
| Weight | -0.049 | **-0.187\*** | -0.012 |
| Height | -0.039 | -0.144 | -0.111 |
| BMI | -0.024 | 0.001 | 0.103 |

**\*\***.Correlation is significant at the 0.05 level (2-tailed). **\***.Correlation is significant at the 0.05
level (2-tailed). MUAC – mid-upper-arm circumference, BMI – body mass index, CAT- catalase, GPx- glutathione peroxidase, SOD- superoxide dismutase.

Table 7 shows the relationship between nutritional status and educational background of under-five maternal parents. There are no statistically significant relationships between educational background of under-five maternal parents and occurrence of stunting (χ2 = 12.169, *P* = 0.274), underweight (χ2 = 13.625, *P* = 0.191) and overweight (χ2 = 20.549, *P* = 0.152) in under-five children study population. The result shows the relationship between nutritional status and estimated household income of under-five maternal parents (Table 8). There are no statistically significant relationships between estimated household income and occurrence of underweight (χ2 = 14.399, *P* = 0.155) and overweight (χ2 = 23.977, *P* = 0.065) in under-five children study population. There are statistically significant relationships between estimated household income and occurrence of stunting (χ2 = 19.743, *P* = 0.0318). The result further showed that parents whose estimated household income is low are more likely to have stunted children and more likely to have underweight children compared to those who earn high income.

**Table 7: Relationship Between Nutritional Status and Educational Background of Under-Five Maternal Parents(*n***=**100)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| EducationalStatus  | Weight-for-age (WAZ) | Total |  | χ2 | *P-value* |
| **Normal** | **Under-weight** | **Severally underweight** |
| No formal education  | 11 | 2 | 1 | 14 |  | 13.625 | 0.191 |
| Primary School  | 10 | 1 | 1 | 12 |  |  |  |
| Junior Secondary School  | 12 | 1 | 0 | 13 |  |  |  |
| Senior Secondary  | 29 | 0 | 0 | 29 |  |  |  |
| Post-Secondary School  | 19 | 0 | 0 | 19 |  |  |  |
| Graduate | 13 | 0 | 0 | 13 |  |  |  |
|  | **Height-for-age (HAZ)** | **Total** |  | **χ2** | ***P-value*** |
| Educational Status  | **Normal** | **Stunted** | **Severally****stunted** |  |
| No formal education  | 12 | 1 | 1 | 14 |  | 12.169 | 0.274 |
| Primary School  | 11 | 1 | 0 | 12 |  |  |  |
| Junior Secondary School  | 13 | 0 | 0 | 13 |  |  |  |
| Senior Secondary  | 29 | 0 | 0 | 29 |  |  |  |
| Post-Secondary School  | 19 | 0 | 0 | 19 |  |  |  |
| Graduate | 13 | 0 | 0 | 13 |  |  |  |
|  | **BMI-for-age (BAZ)** | **Total** | **χ2** | ***P-value*** |
| Educational Status  | **Obese** | **Over-weight** | **Normal** | **Under- weight** |
| No formal education  | 2 | 2 | 8 | 2 | 14.00 | 20.549 | 0.152 |
| Primary School  | 1 | 1 | 9 | 1 | 12.00 |  |  |
| Junior Secondary School  | 0 | 2 | 10 | 1 | 13.00 |  |  |
| Senior Secondary  | 0 | 1 | 28 | 0 | 29.00 |  |  |
| Post-Secondary School  | 0 | 1 | 17 | 1 | 19.00 |  |  |
| Graduate | 0 | 0 | 13 | 0 | 13.00 |  |  |

**Table 8: Relationship Between Nutritional Status and Estimated Household Income of Under-Five Maternal Parents (*n***=**100)**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| HouseholdIncome | Weight-for-age (WAZ) | Total |  | χ2 | *P-value* |
| **Normal** | **Under-weight** | **Severally underweight** |
| <N 5,000  | 6 | 1 | 0 | 7.00 |  | 14.3997 | 0.1555 |
| N 5,000- N14,999  | 11 | 2 | 1 | 14.00 |   |   |  |
| N 15,000- N 24,999  | 12 | 1 | 1 | 14.00 |   |   |  |
| N 25,000- N 34,999  | 16 | 0 | 0 | 16.00 |   |   |  |
| N 35,000- N 44,999  | 23 | 0 | 0 | 23.00 |   |   |  |
| ≥ N 45,000 | 26 | 0 | 0 | 26.00 |   |   |  |
|  | **Height-for-age (HAZ)** | **Total** |  | **χ2** | ***P-value*** |
| Household Income | **Normal** | **Stunted** | **Severally****stunted** |  |
| <N 5,000  | 6 | 0 | 1 | 7.00 |  | 19.7429 | **0.0318\*** |
| N 5,000- N14,999  | 16 | 1 | 0 | 17.00 |   |   |  |
| N 15,000- N 24,999  | 11 | 1 | 0 | 12.00 |   |   |  |
| N 25,000- N 34,999  | 14 | 0 | 0 | 14.00 |   |   |  |
| N 35,000- N 44,999  | 24 | 0 | 0 | 24.00 |   |   |  |
| ≥ N 45,000 | 26 | 0 | 0 | 26.00 |   |   |  |
|  | **BMI-for-age (BAZ)** | **Total** | **χ2** | ***P-value*** |
| HouseholdIncome  | **Obese** | **Over-weight** | **Normal** | **Under- weight** |
| <N 5,000  | 0 | 0 | 10 | 2 | 12.00 | 23.977 | 0.0655 |
| N 5,000- N14,999  | 0 | 1 | 14 | 1 | 16.00 |   |   |
| N 15,000- N 24,999  | 0 | 1 | 3 | 2 | 6.00 |   |   |
| N 25,000- N 34,999  | 1 | 2 | 8 | 0 | 11.00 |   |   |
| N 35,000- N 44,999  | 1 | 1 | 23 | 0 | 25.00 |   |   |
| ≥ N 45,000 | 1 | 2 | 27 | 0 | 30.00 |   |   |

**\****Significance*

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## **4.0 Discussion**

The study highlights malnutrition as a pressing concern, characterized by insufficient or imbalanced nutrient intake among children, particularly in Nigeria. Malnutrition, exacerbated by deficiencies in micronutrients and antioxidant activities, compromises children's immunity, heightens susceptibility to infections, and increases mortality rates, especially from diarrhea and respiratory illnesses. Family size significantly impacts children's nutritional status, as observed in this study, corroborating findings by Ajao *et al*. [17] and Chaudhury *et al*. [18], WHO noted that large family sizes decrease per capita food allocation and per capita income. Socioeconomic status also plays a critical role, with poorer households struggling to procure nutritious food or access quality healthcare. Research by Ajieroh [19]) emphasized the importance of maternal education and household income in determining child nutrition, findings supported by studies from Bloss *et al*. [20] and Islam *et al*. [4].

Dietary assessments in the study revealed that the mean intake of energy, protein, vitamin A, iron, and calcium among under-five children fell below recommended dietary allowances (RDAs), echoing findings by Fatiregun & Adejugbagbe [21] in South-Western Nigeria. Approximately 27% of Nigerian children under five meet their RDAs, leaving many vulnerable to protein-energy malnutrition and micronutrient deficiencies, which impair immune defenses and prolong illnesses. These deficiencies are a leading cause of morbidity and mortality among children in developing countries, particularly in sub-Saharan Africa, as poor nutrition weakens immune responses and exacerbates disease conditions.

The prevalence of malnutrition in the study area was 19%, including underweight (6%), stunting (3%), overweight (7%), and obesity (3%). These findings align with recent research, such as Jude *et al*. [22], which recorded an 8.5% malnutrition prevalence among under-five children in South-Eastern Nigeria. Stunting, often indicative of chronic malnutrition, was relatively low (3%) compared to higher rates in Ethiopia and other countries, which may be attributed to differences in food composition and socio-economic conditions. The low prevalence of stunting suggests a less severe issue in the study area, emphasizing the need for quality complementary foods and investment in sustainable, food-based strategies to combat micronutrient deficiencies.

Underweight prevalence was lower (5%) compared to findings in Ethiopia, where studies recorded rates of 21% and higher. Wasting, typically caused by recent illness or food shortages, was also less prevalent than stunting or underweight, indicating a higher occurrence of chronic rather than acute malnutrition in the study area. Overnutrition, reflected in a combined overweight and obesity prevalence of 10%, exceeded Nigeria's national average, indicating a growing nutritional transition in some regions. These findings underscore the dual burden of malnutrition, with both undernutrition and overnutrition posing health risks to children.

The study assessed serum levels of vitamin A, D, and E among children, finding no evidence of vitamin A deficiency, contrary to previous findings by Akinyele [23] that identified marginal and clinical deficiencies in Nigeria's Northwest zone. The observed vitamin D levels varied significantly, influenced by dietary differences and sun exposure, aligning with findings from Wei *et al*. [24] in China. Vitamin D deficiency, linked to rickets in children, remains a concern in some contexts but is mitigated by adequate sunlight in the study area. Vitamin E levels also varied, likely due to dietary supplementation, hormonal differences, and general health conditions. Excessive vitamin E intake can antagonize other fat-soluble vitamins, emphasizing the need for balanced supplementation.

Iron status among children was also evaluated, with serum ferritin levels indicating no deficiency in the study

population, contrary to prior surveys like Akinyele's [23], which found iron deficiency rates of 21.7% among under-fives in the Northwest zone. Adequate dietary iron intake in the study area, supported by iron-rich staple foods such as maize and beans, likely contributed to these findings. This aligns with Adish *et al*. [25], who reported sufficient dietary iron levels in Ethiopian children. These findings highlight the critical role of diet in addressing micronutrient deficiencies and underline the need for targeted nutritional interventions to improve child health.

##

## **5.0 Conclusion**

To conclude, the study showed prevalence rates of malnutrition 19% consisting of 11% Undernutrition and 8% over nutrition. Undernutrition in form of chronic malnutrition (stunting), acute malnutrition(wasting), and underweight is widespread across Nigeria. The severity varies according to geographical zones with the Northern zones contributing the highest percentage of stunting and underweight. This study established that he determinants of under-nutrition are interrelated and thus requires a multi-sectoral and multi-disciplinary approach in addressing. Inadequate/inappropriate feeding practices have been identified as a major cause of chronic and acute malnutrition among under-five children in Nigeria. The low rate of protein-energy malnutrition and micronutrient deficiencies among the under-five children in the area of study although not significantly related with their nutritional status should encourage sustained efforts to prevent further rise and possibly eliminate the scourge of malnutrition.

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## **6.0 Recommendations**

The following recommendations aim to address under-nutrition among under-five children in Nigeria:

1. Revisit National Policy on Food and Nutrition: There should be collaboration between the agriculture and nutrition sectors. Policies should include strategies to promote household access to nutritious food, such as food fortification and home gardening, particularly for women.
2. Encourage Female Enrollment in Schools: Female education, particularly in northern Nigeria, should be prioritized by collaborating with relevant ministries to advocate for the education of girls and women.
3. Track Malnutrition Trends: Regular surveys should be conducted by relevant bodies (e.g., FMOH, NPC, NCFN) to monitor progress in addressing malnutrition and health indicators.
4. Support Research on Household Food Security: Research on food security at the national level should be encouraged and financed by government bodies and academic institutions.
5. Train Health Workers: Health workers, especially at Primary Health Care (PHC) centers, should receive regular training in nutrition counseling, growth monitoring, child care, breastfeeding, and complementary feeding.
6. Promote Community-based Health and Nutrition Interventions: Local Government Areas (LGAs) should collaborate with the FMOH, SMOH, community, religious leaders, and NGOs to promote good nutrition practices at the community level.

**Ethical approval and consent**

Ethical approval for the study was obtained from the Gombe State Primary Health Care Development Agency. Parents of all consented subject for the study signed. Confidentiality was ensured at every stage of this study, and all procedures were carried out in accordance with the ethical standard dated 27thJune, 2019 with a number FKLG/PHC/ADM/ST/6/VOL.1

**Disclaimer (Artificial intelligence)**

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc.) and text-to-image generators have been used during the writing or editing of this manuscript.

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