

Assessment of Selected Serum Trace Minerals, Iron Status and Anemia among Pregnant Women at First Antenatal Booking in Ido-Ekiti, Ekiti State, Southwest Nigeria

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ABSTRACT

Maternal micronutrients requirements are increased during pregnancy due to an increase in body tissue reserves and metabolic demands, and the development of placenta and the foetus. The aim of this study was to determine the levels of some micronutrients and the incidence of anaemia among pregnant women at their first antenatal booking in order to identify those at risk of nutrition related complications in Federal Teaching Hospital, Ido-Ekiti, Ekiti-State, Nigeria. This case-control study consists of a total of 330 women between the ages of 21 and 40 years. The study subjects were grouped into 165 pregnant women and 165 non-pregnant controls. A self-administered questionnaire was used to collect socio-demographic data. Blood samples were drawn from each of the participants and iron, zinc, copper, and magnesium levels were determined using Atomic Absorption spectrophotometry. Ferritin was determined using Enzyme-linked immunosorbent assay (ELISA). Transferrin level, total iron-binding capacity, and full blood count were also analysed. Serum iron, total iron-binding capacity, transferrin, copper, magnesium, and zinc were significantly lower in pregnant women than non-pregnant controls ($p < 0.05$). Serum ferritin showed no significant difference between both groups ($p = 0.858$). The overall incidence of anaemia at first booking was 6.1%. Pregnant women present with significant reductions in serum trace minerals and haematological parameters at their first antenatal booking. Subclinical micronutrient depletion is widespread prior to routine care. Early booking and evaluation of maternal micronutrients is key to better pregnancy outcomes.

KEYWORDS

Iron Deficiency, Serum Ferritin, Pregnancy, Haematological Parameters, South-western Nigeria

I. INTRODUCTION

Antenatal care is a key entry point for a pregnant woman to obtain adequate services and should be commenced immediately after confirmation of pregnancy. [1] The antenatal period provides important opportunities to catch pregnant women with micronutrient deficiencies and other preventable diseases that may hurt both mother and the developing fetus. [2] Nutrition status before conception and during pregnancy may have a profound

impact on the fetus and could increase the risk of metabolic diseases in adulthood. [3] Research studies suggest that nutritional status during windows of development from conception to early childhood can significantly change both the immediate and long-term health status of the child. [4,5] Nutrition during fetal life is one of the fundamental exposures that have the capacity to impact the development and subsequent function of most organ systems of the body, including metabolism, immune development, neurodevelopment and many other physiological processes. [5]

Poor maternal and new-born care is a significant public health challenge especially in developing countries of the world. [6] Most of the adverse pregnancy outcomes may be prevented if adequate evaluations are done at first booking and ante natal care (ANC) follow-up within the early pregnancy period. [7] Maternal mortality rates (MMR) are unacceptably high in Sub-Saharan Africa. In Nigeria, MMR has been reported to be 800 deaths per 100,000 live births and accounts for 19% of deaths globally. [8] Micronutrient malnutrition, also called hidden hunger, is the main form of malnutrition observed among pregnant women in Africa. It increases the risk of intrauterine growth retardation (IUGR) and neural tube defects in the children born to these malnourished women. [9] Many factors that make women vulnerable to micronutrient deficiencies are common in our setting. These include poor quality diets, repeated pregnancies, short inter pregnancy intervals and increased physiological needs. [9] These may be exacerbated by several factors including inadequate healthcare systems, poverty and inequities, polygamy, early marriage, adolescent pregnancies and traditional dietary practices. [9]

To address the gaps in local baseline data and mitigate these risks, establishing the prevalence of maternal trace mineral depletion and associated anaemia is essential. The detection and prevention of these deficiencies represent a highly cost-effective approach to reducing maternal, fetal, and perinatal morbidity and mortality. Therefore, this study was designed to assess serum trace mineral levels, iron status, and the incidence of anaemia among pregnant women at first antenatal booking in Federal Teaching Hospital, Ido-Ekiti, Southwest Nigeria, in order to identify those at risk of nutrition-related complications.

II. METHODOLOGY

A. Study Design and Population

The study design was a case-control study of pregnant women at first booking at the antenatal clinic in the hospital. The study populations were pregnant women in the rural town of Ido-Ekiti, Ekiti State at their first booking at Federal Teaching Hospital, Ido-Ekiti (FETHI) while non-pregnant healthy women were selected as control population.

B. Ethical Approval and Informed Consent

The ethical clearance for this research was given by Federal Teaching Hospital, Ido-Ekiti (FETHI). Ethical Committee with reference number ERC/2019/12/U4/313A. The collection of the sample information regarding the study was explained to the subjects. Oral and written consent for participation in the study were also obtained.

C. Inclusion and Exclusion Criteria

1. Inclusion criteria:

Apparently healthy pregnant women within ages 21-40 who visited the hospital to book for antenatal care for the first time were recruited for the study. Also, apparently healthy non-pregnant women were recruited into the control group.

2. Exclusion criteria:

Pregnant women with pregnancy complications, haemoglobinopathies or HIV infection and those that have been attending antenatal clinics before the study were excluded from the study. Also, all non-consenting pregnant and non-pregnant women were excluded.

D. Sample Size and Study Subjects

A minimum sample size of 330 participants was required, based on a prevalence of 12.2% for anaemia in Nigerian pregnant women reported by Hassan et al. [10]. Hence, a total of 330 subjects were recruited, out of which 165 were apparently healthy non-pregnant women who were mostly volunteers from the staff of the hospital and served as control subjects and 165 were pregnant women attending the antenatal clinic in the hospital.

E. Data Collection and Laboratory Analysis

A self-administered questionnaire was used to obtain information on demography and medical history. 6mL of venous blood was collected from the antecubital fossa of each pregnant woman at first booking subject, and 3mL blood was dispensed into serum separator bottles. The samples were allowed to clot and then spun at 5,000 rpm for 5 minutes. The serum was separated and then kept frozen at -20°C until analysis. The remaining 3mL of blood was dispensed into EDTA anticoagulant bottles. It was mixed gently by inversion and then immediately taken to the laboratory for a full blood count.

Ferritin was assayed through Enzyme-linked immunosorbent (ELISA) technique using commercially prepared Elab Science reagent kit. Serum iron, zinc, magnesium and copper were determined through Atomic Absorption Spectroscopy (AAS) using Buck Scientific model 211 VGP machine and Haematological parameters were determined through a full blood count using a Mindray BC-5000 haematology analyser.

F. Statistical Analysis

The data were analysed using Statistical Package for the Social Sciences (SPSS version 21.0, IBM, Chicago, IL, USA). Analysis for categorical data was done using a Chi-square (χ^2) test, while the strength of association was determined using correlation coefficient and the level of statistical significance was set at $p < 0.05$.

III. RESULT

Table 1 shows the socio-demographic characteristics of pregnant and non-pregnant women. It indicates that participants within the age group of 26-30 years old were more than those within the age groups of 21-25, 31-35 and 36-40 years, although the differences were not statistically significant ($p = 0.138$). Also, most of the pregnant women 147(89.1%) were married while 18(10.9%) were single and the difference was statistically significant ($p < 0.001$). A greater number of the respondents 119(72.1%) had tertiary education while 46(27.9%) had secondary education and none had primary education ($p < 0.001$).

Table 1: Socio-demographic Characteristics of Pregnant Women compared with those of Non-Pregnant Controls

Variables	Pregnant women n (%) N = 165	χ^2	p-value	Non-pregnant women N (%) N = 165	χ^2	p-value
Age (in years)						
21-25	44 (26.7)	5.519	0.138	29 (17.6)	14.246	0.026
26-30	46 (27.9)			54 (32.7)		
31-35	45 (27.3)			49 (29.7)		
36-40	30 (18.2)			33 (20.0)		
Marital Status						
Married	147 (89.1)	201.709	<0.001	141 (85.5)	165.927	<0.001
Not married	18 (10.9)			24 (14.5)		
Educational Status						
Secondary	46 (27.9)	64.594	<0.001	44 (26.7)	71.867	<0.001
Tertiary	119 (72.1)			121 (73.3)		

Table 2 shows the medical characteristics of pregnant women, gestational age, and interval of pregnancy, parity and body mass index of pregnant women. Most of the study participants 109(66.1%) came for booking within gestational age of <20 weeks, while 56(33.9%) came for booking after 20weeks of pregnancy ($p < 0.001$). The parity of the study population indicated that 101(61.2%) were multiparous, 20(12.1%) primiparous and 44(26.7%) were nulliparous. The difference was statistically significant ($p < 0.001$). The interval of pregnancy indicates that 69(57.0) had 1-2 year interval while 52(43.0) had 3-4 years between pregnancy ($p = 0.029$). Most of the pregnant women 109(66.1%) were overweight, 14(8.5%) obese and 42(25.5%) had normal BMI ($p < 0.001$).

Table 2: Some Medical Characteristics of Pregnant Women

Variables	Pregnant women N (%) N = 165	χ^2	p-value
Gestational Age at first booking			
<20 weeks	109 (66.1)	34.048	<0.001
≥20 weeks	56 (33.9)		
Parity			

Nulliparous	44 (26.7)	94.418	<0.001
Primiparous	20 (12.1)		
Multiparous	101 (61.2)		
Interval of pregnancy			
1-2	69 (57.0)	4.777	0.029
3-4	52 (43.0)		
Body Mass Index			
Normal (18.5-24.9Kg/m ²)	42 (25.5)	129.982	<0.001
Overweight (25.0-29.9Kg/m ²)	109 (66.1)		
Obese (≥30.0Kg/m ²)	14 (8.5)		

Table 3 shows the level of awareness and uptake of micronutrients among pregnant women at first booking. Results indicate that 119(72.1%) had full knowledge of micronutrients, while 46(27.9%) had no knowledge of micronutrients ($p < 0.001$). Some 95(57.6%) were already on micronutrient supplements while 70(42.4%) had not been taking micronutrient supplements, the difference was statistically significant ($p = 0.006$). Among those who were on micronutrient supplements 58(61.1%) had the supplementation recommended by healthcare providers, while 37(38.9%) were not recommended by doctors ($p = 0.002$).

Table 3: Awareness and Uptake of Micronutrients among Pregnant Women

Variable	Frequency N = 165	(%)	χ^2	p-value
Ever heard of micronutrients				
Yes	119	72.1	64.594	<0.001
No	46	27.9		
Been taken micronutrients				
Yes	95	57.6	7.576	0.006
No	70	42.4		
It was recommended by a doctor (n = 95)				
Yes	58	61.1	9.284	0.002
No	37	38.9		

Table 4 shows the frequency of some basic food intake by pregnant women at first booking. The basic food taken was distributed into 4-6 weeks, 1-3 weeks, and 2 times/day. Eggs, chicken, milk/yoghurt, peanuts, vegetables, red meat, potatoes and apples were among the food items most frequently used by pregnant women at first booking, while carrot and mangoes were among the least commonly consumed by pregnant women.

Table 4: Frequency of Intake of Some Food Items among Pregnant Cases

Variables	Frequency of intake N = 165			
	Never	4-6 weeks	1-3 weeks	2 times/day
Red meat	17 (10.3)	14 (8.5)	63 (38.2)	71 (43.0)
Egg	13 (7.9)	10 (6.1)	88 (53.3)	54 (32.7)
Chicken	15 (9.1)	49 (29.7)	81 (49.1)	20 (12.1)
Milk/ Yoghurt	19 (11.5)	18 (10.9)	69 (41.8)	59 (35.8)
Peanut	50 (30.3)	24 (14.5)	65 (39.4)	26 (15.8)
Mangoes	57 (34.5)	49 (29.7)	47 (28.5)	12 (7.3)

Apple	19 (11.5)	34 (20.6)	78 (35.2)	34 (20.6)
Orange/Citrus fruits	9 (5.5)	17 (10.3)	58 (35.2)	81 (49.1)
Potatoes	44 (26.7)	48 (29.1)	63 (38.2)	10 (6.1)
Vegetables	0 (0.0)	3 (1.8)	38 (23.0)	124 (75.2)
Carrot	17 (10.3)	16 (9.7)	71 (43.0)	61 (37.0)

Table 5 shows the comparison of some hematological parameters of pregnant women with non-pregnant women. Packed cell volume (PCV), red blood cell count (RBC), lymphocyte and platelet count are significantly lower while white blood cell (WBC), neutrophil are significantly higher among pregnant women than non-pregnant control subjects ($p < 0.001$).

Table 5: Some Hematological Parameters of Pregnant Women compared with Non-pregnant Women (Controls)

Variables	Pregnant women		Non-pregnant women (Controls)		t	p-value
	Mean $\pm$ SD N = 165	S.E.M	Mean $\pm$ SD N = 165	S.E.M		
Hematological Parameters						
PCV (%)	31.5 $\pm$ 4.1	0.319	37.9 $\pm$ 2.6	0.200	-16.955	<0.001
WBC ($\times 10^3$)	6.9 $\pm$ 1.8	0.136	5.9 $\pm$ 1.1	0.090	5.797	<0.001
RBC	3.9 $\pm$ 0.5	0.038	4.6 $\pm$ 0.5	0.035	-14.816	<0.001
Neutrophil (%)	62.8 $\pm$ 8.9	0.691	48.3 $\pm$ 6.0	0.464	17.423	<0.001
Lymphocyte (%)	27.0 $\pm$ 7.4	0.578	40.4 $\pm$ 5.9	0.457	-18.116	<0.001
Mist (%)	10.2 $\pm$ 4.1	0.319	11.0 $\pm$ 3.4	0.263	-2.006	0.046
Platelet ($\times 10^3$)	210.6 $\pm$ 51.5	4.007	244.2 $\pm$ 53.5	4.200	-5.814	<0.001

Table 6 shows the comparison of measured micronutrient levels among pregnant women with non-pregnant control subjects. Serum iron (37.8 ± 18.6 vs 41.7 ± 11.1 ; $p = 0.021$), TIBC (190.4 ± 94.4 vs 210.9 ± 75.2 ; $p = 0.030$), transferrin (186.4 ± 33.0 vs 216.9 ± 22.6 ; $p < 0.001$), copper (29.4 ± 12.7 vs 50.8 ± 14.0 ; $p < 0.001$), magnesium (0.53 ± 0.32 vs 0.91 ± 0.36 ; $p < 0.001$) and zinc (50.6 ± 36.0 vs 58.3 ± 22.8 ; $p = 0.021$) were significantly lower among pregnant women than non-pregnant control subjects. The difference in the means of serum ferritin between pregnant and non-pregnant women was insignificant ($p = 0.858$).

Table 6: Comparison of Some Micronutrients Levels in Pregnant Women with Non-pregnant Control Subjects

Variable	Pregnant women		Non-pregnant women		t	p-value
	Mean $\pm$ SD N = 165	S.E.M	Mean $\pm$ SD N = 165	S.E.M		
Micronutrients						
Iron ($\mu\text{g/dL}$)	37.8 $\pm$ 18.6	1.446	41.7 $\pm$ 11.1	0.866	-2.312	0.021
TIBC ($\mu\text{g/dL}$)	190.4 $\pm$ 94.4	7.346	210.9 $\pm$ 75.2	5.857	-2.180	0.030
Transferrin (mg/dL)	186.4 $\pm$ 33.0	2.288	216.9 $\pm$ 22.6	1.759	-9.793	<0.001
Ferritin (ng/mL)	46.0 $\pm$ 29.4	2.288	46.5 $\pm$ 23.4	1.823	-0.179	0.858
Copper ($\mu\text{g/dL}$)	29.4 $\pm$ 12.7	0.987	50.8 $\pm$ 14.0	1.091	-14.516	<0.001
Magnesium ($\mu\text{g/dL}$)	0.53 $\pm$ 0.32	0.026	0.91 $\pm$ 0.36	0.027	-10.079	<0.001
Zinc ($\mu\text{g/dL}$)	50.6 $\pm$ 36.0	2.801	58.3 $\pm$ 22.8	1.774	-2.326	0.021

Table 7 shows the comparison of micronutrient levels between different ages among pregnant women. Serum iron, TIBC and zinc were significantly higher ($p < 0.001$) among pregnant women within the age group of 21-25 years than other age groups.

Table 7: Comparison of Micronutrient Levels between Age Groups of Pregnant Women

Variable	Age group (in years)				F	p-value
	21-25 Mean $\pm$ SD n = 44	26-30 Mean $\pm$ SD n = 46	31-35 Mean $\pm$ SD n = 45	36-40 Mean $\pm$ SD n = 30		
Micronutrients						
Iron ($\mu\text{g/dL}$)	50.7 $\pm$ 24.6	36.3 $\pm$ 17.4	34.6 $\pm$ 18.5	36.0 $\pm$ 17.4	6.277	<0.001
TIBC ($\mu\text{g/dL}$)	246.7 $\pm$ 91.6	176.8 $\pm$ 84.9	172.1 $\pm$ 13.6	156.0 $\pm$ 85.7	8.441	<0.001
Transferrin (mg/dL)	195.8 $\pm$ 37.4	179.7 $\pm$ 34.2	178.1 $\pm$ 39.3	177.4 $\pm$ 28.0	2.437	0.067
Ferritin (ng/mL)	54.8 $\pm$ 35.4	45.1 $\pm$ 29.9	40.5 $\pm$ 21.2	42.7 $\pm$ 28.0	2.010	0.622
Copper ($\mu\text{g/dL}$)	28.0 $\pm$ 11.1	28.5 $\pm$ 9.2	31.1 $\pm$ 14.4	30.5 $\pm$ 16.4	0.591	0.622
Magnesium ($\mu\text{g/dL}$)	0.53 $\pm$ 0.33	0.55 $\pm$ 0.32	0.54 $\pm$ 0.34	0.50 $\pm$ 0.34	0.162	0.922
Zinc ($\mu\text{g/dL}$)	63.4 $\pm$ 29.9	49.3 $\pm$ 21.0	44.0 $\pm$ 21.2	43.7 $\pm$ 20.1	2.842	0.040

Table 8 shows the comparison of measured micronutrient levels among pregnant women based on marital status. It indicates that only serum zinc levels (52.9 ± 36.6 vs 31.4 ± 24.1 ; $p = 0.016$) was significantly higher among married pregnant women than single pregnant women. There was no significant difference in the other parameters between married and single pregnant women.

Table 8: Comparison of Micronutrient Levels among Pregnant Women based on Marital Status

Variables	Marital Status		t	p-value
	Married Mean $\pm$ SD n = 147	Single Mean $\pm$ SD n = 18		
Micronutrients				
Iron ($\mu\text{g/dL}$)	39.9 ± 20.7	37.9 ± 21.8	0.363	0.713
TIBC ($\mu\text{g/dL}$)	191.4 ± 92.4	181.1 ± 11.9	0.401	0.689
Transferrin (mg/dL)	185.3 ± 36.3	186.4 ± 34.4	-0.120	0.905
Ferritin (ng/mL)	46.4 ± 29.7	43.4 ± 27.6	0.421	0.674
Copper ($\mu\text{g/dL}$)	29.6 ± 13.1	28.1 ± 8.2	0.466	0.642
Magnesium ($\mu\text{g/dL}$)	0.52 ± 0.30	0.68 ± 0.48	-1.398	0.179
Zinc ($\mu\text{g/dL}$)	52.9 ± 36.6	31.4 ± 24.1	2.430	0.016

Figure 1 shows the incidence of anemia among pregnant women at first booking. Results indicate that 10(6.1%) were anemic based on PCV levels below 25%, while 155(93.9%) were not anemic with PCV levels between 32-42% and hemoglobin concentration $<11\text{g/dL}$.

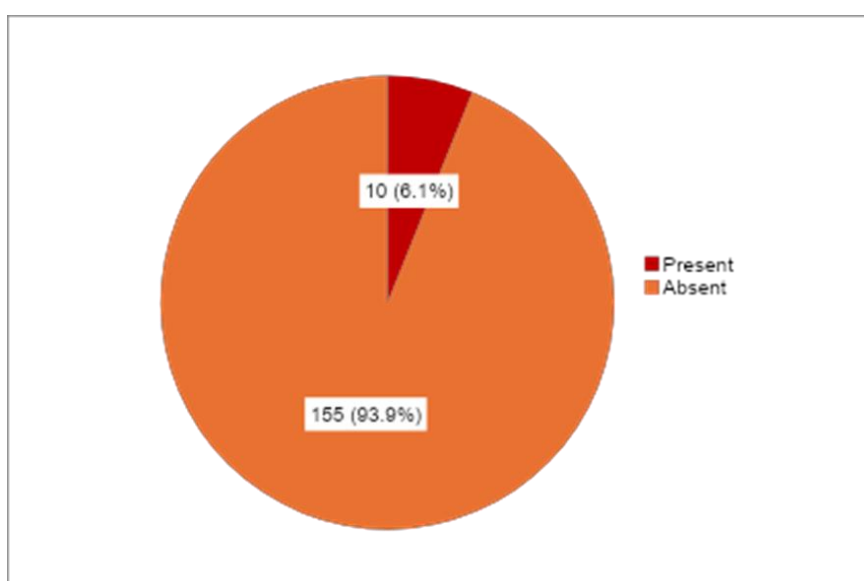


Figure 1: Prevalence of Anemia among Pregnant Women in this Study

Table 9 shows the comparison of micronutrient levels among pregnant women based on educational status. Serum TIBC (199.7 ± 92.9 vs 166.2 ± 94.8 ; $p = 0.040$) was significantly higher among pregnant women with tertiary education than those with secondary education. The differences in the means of other measured parameters were insignificant.

Table 9: Comparison of Micronutrient Levels among Pregnant Women based on Educational Status

Variables	Educational Status		t	p-value
	Secondary Mean $\pm$ SD n = 46	Tertiary Mean $\pm$ SD n = 119		
Micronutrients				
Iron ($\mu\text{g/dL}$)	36.0 $\pm$ 20.1	41.1 $\pm$ 20.9	-1.407	0.161
TIBC ($\mu\text{g/dL}$)	166.2 $\pm$ 94.8	199.7 $\pm$ 92.9	-2.068	0.040
Transferrin (mg/dL)	182.6 $\pm$ 42.5	186.5 $\pm$ 33.2	-0.628	0.531
Ferritin (ng/mL)	46.0 $\pm$ 25.4	46.0 $\pm$ 30.9	-0.017	0.986
Copper ($\mu\text{g/dL}$)	31.2 $\pm$ 16.3	28.8 $\pm$ 11.0	1.086	0.279
Magnesium ($\mu\text{g/dL}$)	0.53 $\pm$ 0.33	0.53 $\pm$ 0.33	0.005	0.996
Zinc ($\mu\text{g/dL}$)	43.6 $\pm$ 25.1	53.3 $\pm$ 39.2	-1.550	0.123

Table 10 shows the comparison of micronutrient levels among pregnant women based on parity. It indicates that serum iron, TIBC and zinc levels were higher among nulliparous (never given birth) than primiparous (given birth once) and multiparous (given birth more than once). The levels of these parameters decreased from primiparous to multiparous pregnant women.

Table 10: Comparison of Micronutrient Levels among Pregnant Women based on Parity

Variables	Parity			F	p-value
	Nulliparous Mean $\pm$ SD n = 44	Primiparous Mean $\pm$ SD n = 20	Multiparous Mean $\pm$ SD n = 101		
Micronutrients					
Iron ($\mu\text{g/dL}$)	56.3 $\pm$ 22.1	39.6 $\pm$ 20.8	32.4 $\pm$ 15.5	26.797	<0.001
TIBC ($\mu\text{g/dL}$)	268.0 $\pm$ 86.8	183.8 $\pm$ 99.0	157.9 $\pm$ 76.0	27.691	<0.001
Transferrin (mg/dL)	182.1 $\pm$ 31.2	185.5 $\pm$ 38.2	186.9 $\pm$ 37.6	0.271	0.763
Ferritin (ng/mL)	51.5 $\pm$ 29.9	35.7 $\pm$ 19.5	45.7 $\pm$ 30.4	2.049	0.132
Copper ($\mu\text{g/dL}$)	28.0 $\pm$ 8.8	25.9 $\pm$ 5.7	30.8 $\pm$ 14.8	1.616	0.202
Magnesium ($\mu\text{g/dL}$)	0.56 $\pm$ 0.31	0.57 $\pm$ 0.38	0.52 $\pm$ 0.33	0.412	0.663
Zinc ($\mu\text{g/dL}$)	60.5 $\pm$ 51.8	48.8 $\pm$ 26.5	46.6 $\pm$ 27.9	2.337	0.042

Table 11 shows the comparison of measured micronutrient levels among pregnant women based on interval of pregnancy. The result shows that there were insignificant differences in the means of measured micronutrients based on interval of pregnancies.

Table 11: Mean Micronutrient Levels among Pregnant Women based on Intervals of Pregnancy

Variables	Interval of pregnancy		t	p-value
	1-2 years Mean $\pm$ SD n = 69	3-4 years Mean $\pm$ SD n = 52		
Micronutrients/Mineral				
Iron ($\mu\text{g/dL}$)	33.7 $\pm$ 16.4	33.4 $\pm$ 17.0	-0.100	0.920
TIBC ($\mu\text{g/dL}$)	160.9 $\pm$ 82.2	163.9 $\pm$ 78.6	-0.207	0.836

Transferrin (mg/dL)	188.6 ± 31.7	184.0 ± 44.4	0.671	0.503
Ferritin (ng/mL)	43.7 ± 30.1	44.4 ± 27.0	-0.144	0.866
Copper (µg/dL)	31.1 ± 14.5	28.4 ± 12.8	1.045	0.298
Magnesium (µg/dL)	0.51 ± 0.34	0.55 ± 33	0.591	0.555
Zinc (µg/dL)	45.5 ± 21.5	49.0 ± 34.1	-0.680	0.498

Table 12 shows the comparison of micronutrient levels among pregnant women based on gestational age at booking. It indicates that there were insignificant differences in the means of micronutrients between the two gestational ages at booking.

Table 12: Comparison of Micronutrient Levels among Pregnant Women based on the Gestational Age at Booking

Variables	Gestational Age (weeks)		t	p-value
	<20 weeks Mean ± SD n = 109	≥20 weeks Mean ± SD n = 56		
Micronutrients/Mineral				
Iron (µg/dL)	41.1 ± 21.8	36.9 ± 18.5	1.223	0.223
TIBC (µg/dL)	199.9 ± 94.2	171.9 ± 92.8	1.820	0.071
Transferrin (mg/dL)	187.4 ± 35.0	181.5 ± 37.8	0.999	0.319
Ferritin (ng/mL)	45.9 ± 27.1	46.2 ± 33.7	-0.062	0.950
Copper (µg/dL)	29.8 ± 13.4	28.7 ± 11.3	0.531	0.596
Magnesium (µg/dL)	0.55 ± 0.34	0.51 ± 0.30	0.653	0.515
Zinc (µg/dL)	51.5 ± 41.6	48.8 ± 21.3	0.447	0.656

Table 13 shows the micronutrients status of anemia pregnant women and the non-anemic pregnant subjects. The results showed that higher significant difference in TIBC (37.3 ± 7.5 vs 191.9 ± 94.8 µg/dL) transferrin (122.6 ± 19.1 vs 186.5 ± 33.5 mg/dL), PCV (23.6 ± 6.1 vs 32.0 ± 3.4 %), hemoglobin (7.8 ± 2.3 vs 11.0 ± 0.2 g/dl), ferritin (14.1 ± 1.7 vs 45.7 ± 29.7 ng/mL) and iron (20.3 ± 2.5 vs 40.0 ± 20.8 µg/dL).

Table 13: Comparison of Micronutrients between Anemia Pregnant Women and Non-anemic Pregnant Women

Variables	Presence of anemia		S.E.M	t	p-value
	Present	Absent			
	Mean ± SD n = 10	Mean ± SD n = 155			
Micronutrients/Mineral					
Iron (µg/dL)	20.3 ± 2.5	40.0 ± 20.8	1.674	-2.987	0.003
TIBC (µg/dL)	37.3 ± 7.5	191.9 ± 94.8	7.613	-5.141	<0.001
Transferrin (mg/dL)	122.6 ± 19.1	186.5 ± 33.5	2.693	-5.811	<0.001

Ferritin (ng/mL)	14.1 ± 1.7	0.548	45.7 ± 29.7	2.383	-3.352	<0.001
Copper (µg/dL)	24.0 ± 5.4	1.713	29.4 ± 12.9	1.039	-1.320	0.189
Magnesium (µg/dL)	0.35 ± 0.18	0.056	0.52 ± 0.31	0.025	-1.735	0.085
Zinc (µg/dL)	49.8 ± 33.8	2.715	62.6 ± 62.3	19.700	-0.835	0.405
PCV (%)	23.6 ± 6.1	1.932	32.0 ± 3.4	0.270	-7.212	<0.001
Hb(g/dL)	7.8 ± 2.3	0.727	11.0 ± 0.2	0.016	17.077	<0.001

Figure 2 shows the living location of the pregnant women involved in this study at first booking. 94(57%) individuals were urban dwellers while 71(43%) are rural dwellers.

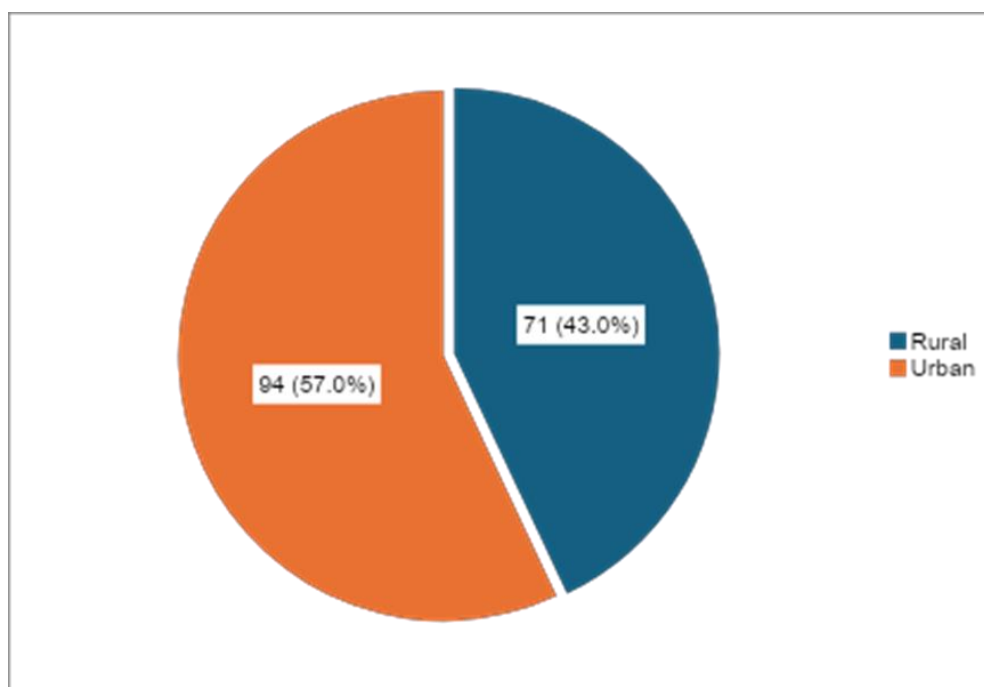


Figure 2: Location of Pregnant Subjects

IV. DISCUSSION

Micronutrient requirements are increased during pregnancy due to the greater needs of the mother's own increase in body tissue reserves and metabolic demands, and the development of placenta and the fetus. In this study, the socio-demographic characteristics of pregnant women compared with those of non-pregnant controls (Table 1) show that ages 26-30 years and 31-35 years had the highest prevalence rate of 46(27.9%) and 45(27.3%) respectively. This might be because these are the age groups that mostly get married in this geographical location and it agrees with that reported by Fagbamigbe et al. [11] The authors reported that the southwest sub-region of Nigeria has lower rates of adolescent

pregnancy than the northwest because of cultural norms, socio economic and education which may lead to high prevalence of pregnancy between the ages 26-35 years. [11] The marital status of the subjects showed that there were more married subjects (89.1%) compared to unmarried (10.9%). The educational status of the subjects showed that subjects with tertiary education are more than the secondary level. The highest rate of participation recorded among those with tertiary education could be that both males and females around the southwest geographical location had more access to tertiary education compared to other geopolitical regions within the country. This is also consistent with a previous study by Fagbamigbe et al. [11] it was reported that females around the southwest state are well educated which has influenced the knowledge and perceptions of antenatal care services among pregnant women and nursing mothers in southwest Nigeria. [11]

The rate of antenatal booking among the pregnant women in this study (Table 2) showed that the subjects with gestational age of less than 20 weeks at first booking were higher (66.1%) than women that booked at gestational age above 20 weeks (33.9%). The highest booking at gestational age less than 20 weeks, might be because there were more educated subjects than non-educated. This aligns with a previous study by Lindsay et al. [12] it was observed that the gestational age at which women booked for antenatal clinics can be greatly influenced by their level of education. [12] Women with a tertiary level of education were more likely to book earlier than their counterparts. A study carried out by Fagbamigbe et al. showed that the education of the wife can be affected by the gestational age of booking. [11] This study showed that parity did not significantly influence gestational age at booking, previous experience and childbirth did not influence the decision of the pregnant women to book. [11] Fagbamigbe et al. also reported that late booking could be an attitudinal problem in the community or when there is no medical problem in previous pregnancies. [11] Nevertheless, in this study, multiparous women were 101(61.2%) compared to nulliparous women with an occurrence rate of 44(26.7%). This is in agreement with a study conducted at Ibadan Nigeria by Oshodi and Salami, who reported that despite the health consequences on women with high parity, the prevalence rate of multiparity in Nigeria is still high. [13] The interval of pregnancy in this study was 1-2 years with an occurrence rate of 69(57.0%). The highest body mass index of the pregnant women in this study is overweight (25-29.9kg/m²) with an occurrence rate of (66.1%). This agrees with the study conducted by Chigbu and Ajah in Southeast Nigeria. [14] This can reflect maternal nutritional status during pregnancy as a result of the upsurge of fast-food outlets leading to the consumption of energy dense foods. [14] This is probably fuelling the high prevalence and is considered a problem of affluent societies. [14] The pregnant subjects with normal body mass index (18.5-24.9 kg/m²) in this study were 42(25.5%).

The awareness and uptake of micronutrients among pregnant women (Table 3) showed that 72.1% women had previous knowledge of micro-nutrients supplements and the high rate of awareness of micronutrients reported in this study might be because most pregnant women that participated in this study were educated. This may suggest that the pregnant women could have obtained the prior knowledge of micronutrients by virtue of their educational status and previous pregnancy. Out of 57.6% pregnant women on micronutrients at the time of this study, 61.1% of them took the micronutrients based on doctor's prescription while 38.9% pregnant women took micronutrients on self-prescription. In this study some 42.4% of pregnant women had not started taking micronutrients at booking which is consistent with a previous study by Onyeneho et al. [15] the authors reported that most

pregnant women do not wait for the clinicians to recommend the micronutrients before they commence. [15] Also Onyeneho et al. had observed that some of the factors associated with compliance with recommended regime in preventing other medical conditions include patient factors such as ethnic origin, educational attainment as well as knowledge and perceptions about the conditions. [15]

The intake of some food items among pregnant women (Table 4) showed that pregnant women in this study consumed more red meat, eggs, vegetables, potatoes and peanuts at least twice daily. This suggests that most of the pregnant women are knowledgeable about nutritional uptake during pregnancy. This is also consistent with a previous study by Sholeye et al. in the Southwest region of Nigeria. [16] This was attributed to the continuous nutrition education of women of reproductive age in the region. [16] About 79(47.9%) of the pregnant women had consumed foods rich in micronutrients. Previous documented studies such as Olayiwola et al. have confirmed the fact that diet during pregnancy has a significant impact on the mother and child. [17]

The haematological parameters of pregnant women compared with non-pregnant women (Table 5) showed that the packed cell volume of the pregnant women was lower than that of the non-pregnant women. This agrees with the study conducted by Akinbami et al. who reported that there was a decrease in PCV of the pregnant women due to increased plasma volume during pregnancy because of hem dilution, infections e.g malaria, hormonal changes that increase fluid retention and iron deficiency. [18] Also, the white blood cell count (WBC) of pregnant women was significantly higher than the non-pregnant women. This aligns with a previous study by Kadas et al. where it was reported that white cell counts increase steadily in pregnancy from the first to the third trimester due to neutrophilia attributed to physiological stress and increased inflammatory response associated with pregnancy. [19] This study also showed a significantly lower lymphocyte count among the pregnant women compared to the controls. [19]

The micronutrients and mineral elements assessed in the study were iron, zinc, copper, magnesium, ferritin, transferrin and total iron binding capacity (TIBC). Iron, TIBC, transferrin, copper, magnesium and zinc levels were significantly lower in pregnant women than non-pregnant women (Table 6). Adequate nutrition is important during pregnancy for optimal health of both the mother and foetus. Chronic deficiencies in macronutrients and micronutrients are well recognized in developing countries such as Nigeria even though the proportion varies from one region of the country to another. Micronutrient deficiency or toxicity during pregnancy or early life can permanently affect developing tissues, resulting in adverse growth and development of the infant, which is associated with chronic diseases in adulthood. [1] Abnormal micronutrient intake during pregnancy can also have a detrimental effect on the mother, both in the neonatal period and in later life. [1] Micronutrient deficiencies during pregnancy, particularly iron and folate, contribute significantly to the prevalence of low birth weight (LBW). [20] Low Birth Weight is a major contributor to neonatal and infant morbidity and mortality in most developing countries of the world.

In a report by Wang et al. from China, correction of micronutrient deficiency in pregnancy with prenatal supplementation improved birth outcomes. [20] Studies have shown that self-reported intake of iron and folate during pregnancy reduced the risk of LBW. [20,21] Women

who took more than 60 iron and folate supplements (pills) had significantly lower odds of delivering LBW babies, compared with pregnant women who took less than 30 pills. [20] This has suggested that the more prenatal iron and folate supplements taken by pregnant women, the lower the risk of giving birth to babies with LBW. [20] Similarly, in a study by Nisar and Dibley in Pakistan, it was also observed that self-reported intake of iron and folate pills of any amount during pregnancy was positively associated with better pregnancy outcomes in terms of birth size and birth weight. [22] Another study in India, observed an inverse association between anaemia prevalence and iron intake among pregnant women. [23] Natarajan et al. reported that in areas where the burden of anaemia is severe, the intake of iron and folate supplements during pregnancy was significantly associated with low incidence of LBW. [23] It was therefore concluded that the implementation of the prenatal supplementation program may probably help improve India's burden of LBW. [23] The situation in Nigeria may not be different from those described in India, Pakistan and Malawi, as all of them are countries with food security challenges. The compliance to prenatal iron and folate supplement use among pregnant women might directly be associated with increased levels of maternal haemoglobin in our setting. This aligns with previous studies that show that maternal haemoglobin has modifying effects on infant birth weight in women receiving prenatal iron-containing supplements. [20]

The reasons for the significantly lower levels of measured micronutrients and minerals observed in this study are not fully understood but could be due to low socioeconomic status and educational status of some of the pregnant women, late booking and inadequate child spacing. Other authors from Nigeria have attributed the reduction in the micronutrient levels of pregnant women to the increased iron demand and increased fetal and placental demand during the first trimester. Also, Amah-Tariah et al. reported that TIBC levels may be due to the corollary which lowers values of serum iron concentration. [24] Magnesium levels in pregnant women were lower than non-pregnant women and is consistent with previous report by Shuklar et al., where it was reported that nutrients such as magnesium should be included as part of the dietary supplement for pregnant women. [25] Zinc status of the pregnant women in this study is lower than the control population. [26] Chaffee and King observed that low zinc status in pregnancy is associated with fetal loss, congenital malformations, intrauterine growth retardation, and reduced birth weight, prolonged labour and pre-term and post-term deliveries. [26] Their study also suggests zinc deficiency affects several organs of the body such as malformations of the heart, lungs, brain, urogenital system and skeletal system. [26] Also, experimental studies have shown that maternal zinc deficiency has long-term implications on growth, immunity and metabolic status on the offspring. [27] The causes of zinc deficiency are not known but it can result from poor dietary intake, increased loss, food insecurity, poor household food distribution, and presence of fibre and/or phytate in diets, infection, inappropriate food preparation and storage. [27]

The micronutrient levels of the pregnant women in relation to the age group (Table 7) showed that all the age groups have high consumption of iron, TIBC and zinc which are statistically significantly. This suggested that iron is the major micronutrient that is required for the development of red blood cells in the growing fetus and placenta and increase in maternal red cell mass, iron transport and oxygen transportation. [28] This is supported by Sangkhae et al. [28] Nevertheless, the outcome of this study showed that all other micronutrients assayed in relation to the age groups were not statistically significant.

The micronutrient levels of pregnant women in relation to their marital status (Table 8) indicate that there was no statistically significant difference in the levels of the micronutrients among married pregnant women and pregnant single women. This suggested that marital status does not seem to have any influence on the levels of micronutrient in this study area. This is supported by Badi et al. who reported that consumption of a balanced diet is not dependent on marital status but availability of good quality food and nutrient contents of the commonly consumed vegetables in Nigeria are usually adequate for pregnancy. [29]

The micronutrient levels among pregnant women based on educational status (Table 9) showed that serum TIBC was significantly higher among pregnant women with tertiary education than those with secondary education. The micronutrient levels among pregnant women based on parity (Table 10) indicates that iron level among the nulliparous was higher than other parity. This might be because of the storage of iron level which has not been utilized in any previous pregnancy. [30] Okafor et al. reported that the physiologic importance of iron storage provides a rapidly available supply in the event of blood loss. [30] However, zinc was also higher in nulliparous compared to other parities. [31] Ota et al. reported that the role of zinc cannot be over emphasized in cell division, protein synthesis and growth in the development of foetus. [31]

Mean micronutrient levels among pregnant women in relation to the intervals of pregnancy (Table 11) revealed that interval of pregnancy had no visible effects on micronutrient levels. This suggested that irrespective of the interval of the pregnancy, it doesn't affect the levels of the micronutrients among the pregnant women. The micronutrient levels among pregnant women in relation to the gestational age at booking (Table 12) showed that there were 109 pregnant women at booking with gestational age of less than 20 weeks compared to 56 pregnant women in the gestational age greater than twenty weeks of booking. This study also showed that all the micronutrients were not statistically different irrespective of the time of bookings. This is particularly so because most of the women reported for booking before 20 weeks gestation.

The prevalence of anaemia among pregnant women observed in this study was 6.1% (Figure 1). The proportion of anaemic pregnant women observed in this study is lower than 47.2% reported among pregnant women in Ogun State, Nigeria by Adesina and Emokpae. [32] Anaemia in pregnancy (haemoglobin concentration <11g/dL) is a public health challenge among pregnant women in developing countries. The global prevalence of anaemia in pregnancy is estimated to be about 36.8%, with Africa's prevalence being recorded as 41.7%. [33] Anaemia in pregnancy has an effect on both mother and foetus. It increases the risk of infant mortality, fetal growth restriction and LBW as well as preterm delivery and moderate haemorrhage in an anaemic pregnant woman can be risky. [33] On the part of the foetus, anaemia can adversely affect cognitive performance, behaviour and physical growth of infants. [33] The low prevalence rate observed in this study may be attributed to the educational and socio-economic status of these pregnant women, knowledge and awareness of micronutrient supplementation even without doctor's prescription and the food and nutrient intake by pregnant women. It was earlier suggested that women who had higher education and better income were less likely to be anaemic compared to their counterparts by Alem et al. [34] They reported that pregnant women with higher education can utilize health services medical information optimally.

The micronutrients levels between anaemic pregnant women and non-anaemic pregnant women (Table 13) showed that iron, TIBC, transferrin and ferritin were higher among the non-anaemic pregnant women compared to the anaemic pregnant women. This is supported by Ajepe et al. who reported that the most frequent complications related to pregnancy and iron deficiency is the cause of the overwhelming majority of the cases of anaemia in pregnancy and there is absolute reduction in haemoglobin concentration. [35] This has been linked with adverse foetal and maternal outcomes. [35]

The distribution of the pregnant women in relation to their location (Figure 2) showed that 57.0% of the pregnant subjects are from urban areas compared to the 43.0% from the rural area. This might be because of the location of the hospital as it is a government federal hospital that serves Ekiti state and about 4 neighbouring states of Nigeria. This suggested that people from urban centres access antenatal medical care in the hospital.

V. CONCLUSION

Pregnancy significantly heightens maternal metabolic demands to support fetal development, placental growth, and expanding tissue reserves, rendering women exceptionally vulnerable to trace mineral depletion and anaemia. The findings of this study confirm a substantial decline in key serum micronutrients and haematological indices among women presenting at their first antenatal booking, with 6.1% already presenting with anaemia at first ANC attendance. Ultimately, subclinical micronutrient challenges are widespread in early gestation, hence, commencement of routine care after the first trimester is insufficient to prevent early maternal-fetal nutritional defects.

RECOMMENDATIONS

Therefore, to mitigate these risks, targeted public health strategies must prioritize early antenatal booking alongside baseline screening of maternal trace minerals to identify and correct subclinical deficiencies before complications arise. Healthcare institutions should implement structured nutritional counselling during pre-conception and early antenatal care, emphasizing the vital role of micronutrient-rich diets and early supplementation. Beyond clinical settings, policy makers must focus on empowering women through improved access to formal education, as higher maternal literacy directly correlates with better nutritional awareness and healthcare utilization.

ABBREVIATIONS

- AAS: Atomic Absorption Spectroscopy
- ANC: Antenatal Care
- BMI: Body Mass Index
- ELISA: Enzyme-Linked Immunosorbent Assay
- FETHI: Federal Teaching Hospital, Ido-Ekiti
- Hb: Haemoglobin
- HIV: Human Immunodeficiency Virus

- IUGR: Intrauterine Growth Retardation
- LBW: Low Birth Weight
- MMR: Maternal Mortality Rate
- PCV: Packed Cell Volume
- RBC: Red Blood Cell
- SD: Standard Deviation
- S.E.M: Standard Error of Mean
- SPSS: Statistical Package for the Social Sciences
- TIBC: Total Iron-Binding Capacity
- WBC: White Blood Cell
- WHO: World Health Organization

AUTHORS CONTRIBUTIONS

A. Bunmi Feyisayo Olowolagba:

Conceptualization, research execution, data and sample collection, project coordination, writing of the original draft, writing and review of the final draft.

B. Babajide Adewoyin Adeleke:

Project coordination, journal communication, writing and review of the final draft. Olaoluwa

C. Akindele Adesanoje:

Data and sample collection, writing of the original draft.

D. Kazeem Damilola Suleman:

ata and sample collection, writing of the original draft.

E. Muyiwa Adeleye Moronkeji:

Research execution, writing of the original draft. Boluwatife Samuel Fatokun: research execution, writing and review of the final draft.

DECLARATION

Ethics Approval and Consent to Participate: The ethical approval (Ref No: ERC/2019/12/U4/313A) was obtained from the Human Research and Ethics Committee of Federal Teaching Hospital, Ido-Ekiti (FETHI), Ekiti State, Nigeria.

A. Consent for Publication:

Informed consent was obtained from all participants in this research.

B. Availability of Data and Materials:

The data used to support the findings of this study are included within the article.

C. Competing Interests:

No competing interests were declared.

D. Funding:

We have not received any financial support for this research or manuscript.

E. Acknowledgment:

None.

All co-authors approved the final manuscript.

All co-authors have read and approved the submission.

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