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ORIGINAL ARTICLE

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Prevalence of anemia, hematocrit variations, and micronutrient supplementation practices among pregnant women attending antenatal clinics in Ibadan, Southwest Nigeria

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ABSTRACT

Background: Anemia is a prevalent complication of pregnancy that poses significant a risk to both maternal and fetal health, potentially leading to adverse pregnancy outcomes. According to the World Health Organization (WHO), anemia is diagnosed when hemoglobin (Hb) levels are below 11g/dL, with nutritional deficiencies being the most common underlying cause.

Aim: This study aimed to evaluate the prevalence of anemia, the intake of common micronutrient supplements, and other factors influencing changes in hematocrit levels among pregnant women.

Patients and Methods: A cross-sectional study was conducted in antenatal clinics in Ibadan from January to February 2023. Data were collected from 309 pregnant women in their third trimester using a pre-tested, interviewer-administered questionnaire. The questionnaire captured socio-demographic details, obstetric characteristics, packed-cell volume, and the intake of micronutrient supplements. Descriptive statistics were performed, and paired sample t-test along with linear regression analyses were used to determine associations. Statistical significance was set at $p < 0.05$.

Results: The mean age of the participants was 30.49 ± 5.03 years, with the majority having tertiary education (77%) and identifying as Christians (57%). At the time of booking, 42.9% of participants were anemic, with a mean packed cell volume (PCV) of 33.46% (SD = 3.83). A significant reduction in anemia prevalence was observed during the interview, with 26.8% f participants classified as anemic (Mean PCV = 34.03, SD=2.90) [t (155) = 2.089, $p = 0.038$]. While 73.5% of participants reported adequate folic acid intake, only 51.1% consumed sufficient ferrous tablets. Fewer than 30% of participants reported adequate intakes of calcium, vitamin A and other micronutrients. Changes in hematocrit levels were not significantly associated with micronutrient intake but were significantly influenced by participants' age group ($p = 0.029$), level of education ($p = 0.041$), and religion ($p = 0.007$).

Conclusion: The study observed a significant reduction anemia prevalence during the third trimester among participants, despite suboptimal micronutrient supplementation. This suggests the possible contribution of alternative sources of micronutrients, likely dietary, with age and educational attainment emerging as significant influencing factors.

Keywords: Anemia, hematocrit changes, micronutrients supplementation, pregnancy, women.

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1 Introduction

Anemia is defined as a reduction in the level of red blood cells or the oxygen-carrying protein hemoglobin (Hb) within these cells (World Health Organization [WHO], 2011). Pregnant women and children are particularly vulnerable to anemia due to increased physiological demand and nutritional deficiencies during pregnancy (Galloway, 2003). This condition poses significant risk to both maternal and fetal health on a global scale (Agbozo *et al.*, 2020). The WHO defines anemia in pregnancy as a Hb level below 11g/dL. Hemoglobin levels vary across the trimesters due to physiological changes, such as increased plasma volume and hemodilution, which are more pronounced in the second trimester, as well as the heightened nutritional demands imposed by fetal growth in the later stages of pregnancy (Chowdhury, 2015).

Globally, anemia affects approximately 41.8% of pregnancies, with a higher prevalence of 46% observed in Africa, where iron deficiency accounts for the majority of cases (WHO, 2020). The prevalence of anemia ranges from 15–19% in high-income countries to between 33% and 75% in low- and middle-income countries (Abdallah *et al.*, 2022; Cappellini & Motta, 2015).

In sub-Saharan Africa, the primary cause of anemia is nutritional deficiency (Chowdhury, 2015). Other contributing factors include hemoglobinopathies, severe infection during pregnancy, chronic medical conditions, and malaria (Kidanto *et al.*, 2009). Among nutritional deficiencies, iron deficiency anemia (IDA) is the most prevalent. The increased resorption and utilization of iron stores during pregnancy exacerbate the condition, particularly for women with inadequate iron reserves before conception. Women with depleted iron stores may struggle to meet the heightened iron requirements during pregnancy, necessitating supplementation of micronutrients to address nutritional deficiencies (Barrett *et al.*, 1994).

An imbalance in the intake of macro- and micro- nutrients can result in deficiencies, which are significant contributors to nutritional disorders, including anemia — especially folate and iron deficiency anemia. Surveys conducted in Ethiopia, Kenya, Nigeria, and South Africa have reported the prevalence of deficiencies in vitamin A, vitamin B12, iodine, zinc, and folate among pregnant women as 21–48%, 8–10%, 87%, 46–76% and 3–12% respectively (Frayne *et al.*, 2014; Harika *et al.*, 2017).

Micronutrient supplementation refers to the provision of additional nutrients, such as vitamins and minerals, to address dietary inadequacies. During pregnancy, the demand for micronutrients increases significantly to meet maternal and fetal requirements. However, women in low- and middle-income countries often fail to achieve adequate micronutrient intake (Frayne *et al.*, 2014; Harika *et al.*, 2017). Beyond the use of iron supplements to prevent anemia, reduce the risk of intrauterine growth restriction, and lower the likelihood of low birth weight, other essential micronutrients are recommended. These include folic acid to prevent neural tube defects, iodine to mitigate cretinism, zinc to reduce the risk of preterm birth, and vitamin D alongside folic acid to improve birth weight (Gernand *et al.*, 2016).

Women in low-income countries are particularly vulnerable to micronutrient deficiencies due to limited access to supplements, insufficient consumption of fortified foods, as well as the frequent occurrence of infectious diseases (Darnton-Hill, 2012). The WHO advocates for pregnant women to receive adequate nutrition and encourages the use of micronutrient supplements, including iron, folic acid, vitamins A and B, and calcium, as required (WHO, 2020). Consistent use of these supplements enhances maternal micronutrient stores and unsure their availability for the developing fetus.

Despite these recommendations, compliance with micronutrient supplementation during pregnancy remains suboptimal. For instance, a survey conducted in Nigeria revealed that only 21% of women took iron tablets daily for 90 or more days during their last pregnancy (National Population Commission (NPC) [Nigeria] and ICF International, 2014). While numerous studies have examined the relationship between single micronutrient supplementation— especially iron—and hematocrit levels during pregnancy, and showed a paucity of research evaluating the effect of multiple micronutrient supplementation. Hence, it is important to evaluate the use of various micronutrients, compliance benefits and barriers to use among pregnant women. This study, therefore, assessed the prevalence of anemia, the intake of commonly recommended micronutrient supplements, and the factors associated with changes in hematocrit level during pregnancy.

2 Methods

This cross-sectional study was carried out in the antenatal clinics of University College Hospital (UCH) and Adeoyo Maternity Hospital, both located in Ibadan-North Local Government Area of Oyo State, South-west, Nigeria. The study period spanned January to February 2023.

Eligible participants included pregnant women in their third trimester who were receiving antenatal care at the selected study sites. Inclusion criteria required participants to provide informed consent and meet the study's predefined eligibility requirements. Pregnant women with hemoglobinopathies, chronic infections, antepartum hemorrhage, chronic medical conditions, multiple pregnancies, or a history of allergies to iron or other micronutrients were excluded.

The sample size was calculated using the Leslie Kish formula (Kish, 1965), with a prevalence of anemia of 25.6% from a previous study (Abdallah *et al.*, 2022), $Z\alpha = 1.96$, and an allowance for 10% attrition. The resulting required sample size was 293 participants; however, 309 participants were ultimately recruited to enhance the study's statistical power. All participants were thoroughly briefed on the study's objectives and procedures, and written informed consent was obtained before enrollment.

Data collection was conducted using a pre-tested, semi-structured, interviewer-administered questionnaire. The questionnaire gathered information on socio-demographic and obstetric characteristics, participants' packed cell volume (PCV) at their first antenatal clinic visit (booking) and at the time of study enrolment, the pattern of intake of various micronutrient supplements, and other medications taken by the pregnant woman.

For pregnant women taking prenatal vitamins containing combined/multiple micronutrient supplements, such as "*Pregnacare*®", "*Astyfer*®", "*Obron-6*®", etc., the specific micronutrient composition of these drugs was reviewed and recorded individually. This was achieved by examining and extracting information from the respective drug leaflets. The average elemental iron content in these hematinic supplements ranged from 17 mg to 60 mg, with the WHO, (2024) recommending a minimum daily requirement of 30 mg. The folic acid content ranged from 400 µg to 5000 µg, with a minimum daily requirement of 400 µg for non-anemic individuals (WHO, 2024).

The PCV assessment was conducted as a part of routine antenatal care. Capillary blood samples were obtained via finger prick, and centrifugation was performed using a micro-hematocrit centrifuge at 3000 rpm for five minutes. The PCV was then measured using a Hewkley micro-hematocrit reader. For this study, a PCV of less than 33% was categorized as indicative of anemia during pregnancy.

The intake pattern of specific micronutrient supplements, including iron, folic acid, and vitamin B, calcium, zinc, and vitamin A, supplements were categorized into two groups: *adequate intake* (optimal) and *adequate intake.* Adequate intake was defined as consuming the supplements at least four days per week, while inadequate intake was defined as consuming them three days or fewer per week. Dietary intake was assessed using the Spanish Food Frequency Questionnaire (FFQ), that was validated and adapted for use in the local context (Ruiz-Cabello *et al.*, 2017).

The data collected were entered and analyzed using SPSS version 25. Descriptive statistics were performed, and the results were presented in tables displaying frequency counts, percentages and means. To examine the association between participants' demographic and obstetrics characteristics and changes in PCV levels, linear regression for repeated measures was applied. The study center was treated as a control factor, while fixed factors included participants' age, marital status, level of education, income, religion, ethnicity, gravidity, parity, and trimester.

The level of significance was set at $p < 0.05$, with a 95% confidence interval. However, given the multiple tests performed on the outcome variables, a family-wise error rate was calculated to be 14.3%. Consequently, the initial p-value (α) of 0.05 was adjusted to 0.017 using the Bonferroni correction to account for this error rate.

Ethical approval for the study was obtained from the Joint University of Ibadan and University College Hospital Ethics Review Committee (UI/UCH Ethics Committee) under approval number UI/EC/23/0040.

3 Results

This study assessed a total of 309 pregnant women, all of whom were in the third trimester of pregnancy. Table 1 presents the socio-demographic and obstetrics characteristics of the participants. The mean age of the participants was 30.49 ± 5.03 years. A majority (63.8%) were multigravida, while 27.8% were primigravida. Most participants (62.8%) initiated antenatal care during the second trimester. The overwhelming majority (91.6%) were married, and 91.5% identified as Yoruba. Among the participants, 77.0% had

Table 1. Participants' demographic and obstetric characteristics

Variable	Frequency	Pourcentage(%)	Mean ± SD
Age (years)			30.49 ± 5.03
Age group (years)			
Less than 24	32	10.4	
25-29	111	35.9	
30-34	92	29.8	
35 and above	74	23.9	
Marital status			
Single or Serated	26	8.4	
Married	283	91.6	
Religion			
Christianity	176	57.0	
Income < Expenses	60 (37)	20 (38.5)	
Level of education			
None and primary	6	1.9	
secondary	65	21.0	
Tertiary	238	77.0	

Table 1. Continued

Variable	Frequency	Pourcentage(%)	Mean ± SD
Ethnicity			
Yoruba	283	91.6	
Others	26	8.4	
Family Income			
None	19	6.1	
Mow income	88	28.5	
Middle income	166	53.7	
Hign income	36	11.7	
Gravidity			2.46 ± 1.23
Primigravida	86	27.8	
Multi-gravida	197	63.8	
Grand multi-gravida	26	8.4	
Parity			1.05 ± 1.01
Nulliparity	131	42.4	
Multiparity	178	57.6	
GA at booking			
1st Trimester	83	26.9	
2nd Trimester	194	62.8	
3rd Trimester	32	10.4	
Study center (Health facility)			
Tertiary	161	52.1	
Secondary	148	47.9	

Note. *GA – Gestational age

attained tertiary education, 53.7% fell within the middle-income category, and 57.0% were Christians. The mean gestational age at enrolment was 33.4 weeks (SD= 3.60).

3.1 Micronutrient supplements intake among the pregnant women

There intake of most of the micronutrient supplements among the pregnant women was suboptimal. Approximately half of the participants (51.1%) demonstrated adequate intake of ferrous supplements, while 44.7% had sufficient intake of vitamin C (Table 2). Although a significant majority (73.5%) achieved adequate intake of folic acid, only 46 % reported adequate consumption of vitamin B-complex. In contrast, fewer than 30% of the participants exhibited adequate intake of calcium (23.0%), multivitamin (15.2%), omega-3 (11.7%), zinc (9.1%), vitamin D (6.8%) and vitamin A (4.5%). (Table 2).

Table 2. Proportion of participants who had adequate weekly micronutrient supplement intake

Weekly Intake	Number of participants with adequate intake	Percentage
Folic acid	227	73.5
Vitamin B-complex	142	46.0
Ferrous	158	51.1
Vitamin C	138	44.7
Multivitamin	47	15.2
Omega-3	36	11.7
Vitamin A	14	4.5
Zink	28	9.1
Calcium	71	23.0
Vitamin D	21	6.8

Note. Adequate intake implies 4 or more consumptions per week

3.2 Change in PCV levels after receiving ANC care

Figure 1 illustrates the changes in hematocrit levels among participants, comparing the prevalence of anemia at the initial antenatal care (ANC) booking to that observed at the time of enrolment in the study after receiving ANC care, including hematinic supplementation. The average duration of supplement intake was 14.9 weeks (SD=6.32). At booking, 42.9% of participants were classified as anemic, while this proportion significantly declined to 26.8% by the time of enrolment in the third trimester. Table 3 highlights the mean PCV levels at enrolment (Mean=34.03, SD=2.90) compared to booking (Mean=33.46, SD=3.83); with the difference being statistically significant ($p = 0.038$). This indicates a notable

Table 3. Test of change in PCV level using paired samples *t*-test

Repeated Measures	Mean	SD	*t*	Df	Effect size	*p*-value
PCV level at enrolment	34.03	2.903	2.089	155	155	0.038**
PCV level at booking	33.46	3.826				

Note. ** Significant at 5% level of significance ($p < 0.05$); Df: Degree of Freedom improvement in PCV levels following ANC care. Moreover, 91% of women classified as anemic in the third trimester had mild anemia, with only 4% experiencing severe anemia.

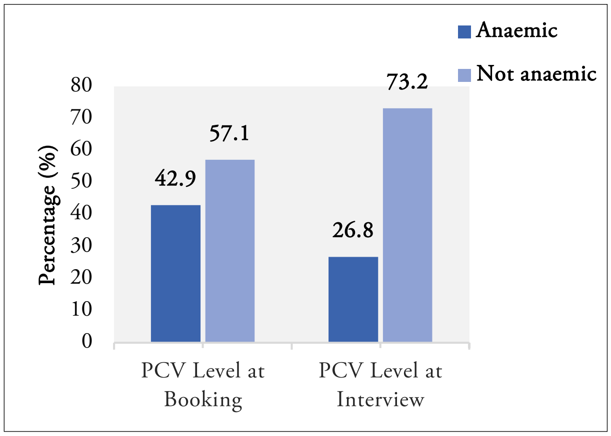

Figure 1. Comparing prevalence of anemia at point of booking and enrolment (Interview)

3.3 Association between demographic and obstetrics characteristics and changes in PCV levels

Linear regression analysis revealed significant associations between participants' demographic and obstetric characteristics and changes in PCV levels. Age group 25 – 29 years (β = 1.186, *p*-value = 0.029, CI of β = 0.124 – 2.247), level of education (β = 2.734, *p*-value = 0.041, CI of β = 0.118 – 5.349) and religion (β = -0.918, *p*-value = 0.007, CI of β = -1.586 – -0.251) were significantly associated with increases in PCV levels. However, factors such as income level, gravidity, parity, use of intermittent preventive therapy for malaria (IPTp), and gestational age at booking did not show significant association with changes in hematocrit levels.

Specifically, participants aged 25 – 29 years experienced a 1.19-unit greater increase in PCV levels in the third trimester (at enrolment) after receiving ANC care, including hematinic supplementation, compared to those under 25 years. However, the change in PCV levels among participants aged 30 – 34 years and 35 years or older were not significantly different from those observed in the group below 25 years. Furthermore, participants with a tertiary education level showed a 2.73-unit grater increase in PCV levels after ANC care compared to those with primary education or no formal education. Meanwhile, participants practicing Islam demonstrated a lower effect (-0.918) of PCV level improvement following ANC compared to their Christian counterparts (Table 4).

3.4 Association between micronutrient supplement intake and changes in PCV Levels after a period of ANC care

A model diagnostic test was performed to evaluate the fitness of the Linear Mixed Model (LMM). The diagnostic process included examining a histogram of error terms and performing the Shapiro-Wilk test. The histogram indicated approximately normally distributed errors terms, a finding supported by the Shapiro-Wilk test (*statistic* = 0.935, *p* = 0.143). Similarly, the fitness of the Linear Regression Model for Repeated Measures (LRMRM) was assessed using the same diagnostic methods. The histogram again suggested approximately normal distribution of error terms, corroborated by the Shapiro-Wilk test (*statistic* = 0.993, *p* = 0.215).

The analysis revealed that adequate intake of folic acid, vitamin B-complex, vitamin C, omega-3, zinc, and calcium appeared to improve the PCV levels of participants. Conversely, the intake of ferrous supplements, multivitamins, vitamin A, and vitamin D did not demonstrate a positive effect. However, none of these associations reached statistical significance, as indicated in Table 5.

Table 4. Demographic and Obstetrics Factors Influencing Change in PCV Level Using Linear Mixed Model (LMM)

Control Factor	Estimate	Std. Err	z-value	Partial Eta Squared	*p*-value	95% Confidence Interval	
						Lower Limit	Upper Limit
Study Centre							
Centre 1 = UCH	0.684	0.317	2.157	**0.015**	**0.032***	0.061	1.307
Centre 2 = Adeoyo	1.03	0.05	20.07	0.00	0.89	0.80	
Fixed Factor							
Age (years)							
35 and above	0.834	1.592	1.324	0.006	0.186	-0.404	2.072
30-34	0.478	0.630	0.841	0.002	0.401	-0.639	1.595
25-29	1.186	0.568	2.195	**0.016**	**0.029***	0124	2.247
Less than 25	0						

Table 4. Continued

Control Factor	Estimate	Std. Err	z-value	Partial Eta Squared	*p*-value	95% Confidence Interval Lower Limit	Upper Limit
Marita Status							
Married	0.390	0.560	0.697	0.002	0.486	-0.710	1.491
Single							
Level of Education							
Tertiary	2.734	1.331	2.054	**0.012**	**0.041***	0.118	5.349
Secondary	1.818	1.370	1.327	0.006	0.185	-0.875	4.511
Primary or none	0						
Religion							
Islam	-0.918	0.340	-2.705	**0.025**	**0.007****	-1.586	-0.251
Christianity	0						
Ethnicity							
Others	-0.9069	0.585	1.658	0.009	0.098	-0.180	2.119
Yoruba	0						
Gravidity at Booking							
Grand multigravida	0.949	0.759	1.250	???	0.212	-0.543	2.441
Multi-gravid	0.880	0.505	1.742	0.005	0.082	-0.113	1.873
Primigravid	0			0.010			
Parity							
Multipara	-0.784	0.470	-1.668	0.009	0.096	-1.708	0.140
Nullipara	0						
GA at Booking							
3rd Trimester	-0.238	0.595	-0.399	0.001	0.690	-1.408	0.999
2nd trimester	0.212	0.362	0.585	0.002	0.559	-0.500	0.924
1st Trimester	0						

Note. * Significant at 5% level of significance; ** significant at 1.7% level of significance (Bonferroni Adjusted *p*-value)

Table 5. Association between micronutrient supplement intake and change in PCV level using linear regression model for repeated measures (LRMRM)

Micronutrient Intake	Estimate	Std. Err	z-value	Partial Eta Squared	*p*-value	95% Confidence Interval Lower Limit	Upper Limit
Folic Acid							
Adequate	0.106	0.456	0.233	0.002	0.816	-0.791	1.003
Poor	0						
Vitamin B-complex							
Adequate	0.104	0.415	0.250	0.002	0.803	-0.712	0.919
Poor	0						
Ferrous							
Adequate	-0.808	0.400	-0.771	0.0019	0.441	-1.095	0.478
Poor	0						
Vitamin C							
Adequate	0.148	0.391	0.377	0.0005	0.706	-0.622	0.917
Poor	0						
Multivitamin							
Adequate	-0.180	0.538	-0.334	0.0004	0.738	-1.237	0.879
Poor	0						
Omega3							
Adequate	0.599	0.606	0.988	0.0031	0.324	-0.593	1.791
Poor	0						

Table 5. Continued

Micronutrient Intake	Estimate	Std. Err	z-value	Partial Eta Squared	*p*-value	95% Confidence Interval Lower Limit	Upper Limit
Vitamin A							
Adequate	-0.560	1.098	-0.510	0.0008	0.610	-2.719	1.599
Poor	0						
Zinc							
Adequate	0.482	0.706	0.681	0.0016	0.496	-0.909	1.873
Poor	0						
Calcium							
Adequate	0.574	0.478	1.200	0.0048	0.231	-0.366	1.514
Poor	0						
Vitamin D							
Adequate	-0.849	0.843	-1.007	0.0035	0.314	-2.506	0.808
Poor	0						

Note. * Significant at 5% level of significance; ** Significant at 1.7% level of significance (Bonferroni Adjusted *p*-value)

3.5 Association between intake of diets rich in agents that impair iron absorption and change in PCV levels

Table 6 depicts the association between the intake of diet rich in agents that impair iron absorption and changes in PCV levels. The analysis indicated that adequate milk intake (β= -0.819, p = 0.029, CI of β = 0.124 – 2.247) had a significant negative effect on change in PCV level, while adequate intake of soya beans (β= -0.334, p = 0.580, CI of β = -1.520 – 0.852) and cocoa-based beverages (β= -0.304, p = 0.397, CI of β = -1.009 – 0.401) demonstrated a negative effect on changes in hematocrit levels; however, these effects were not statistically significant. Conversely, tea intake (β= 0.351, p = 0.396, CI of β = -0.461 – 1.163) was associated with a positive effect on hematocrit changes, though this effect also did not reach statistical significance.

Table 6. Association between Intake of diet rich in agents that impair Fe absorption and change in PCV levels

Micronutrient Intake	Estimate	Std. Err	z-value	Partial Eta Squared	*p*-value	95% Confidence Interval Lower Limit	Upper Limit
Milk							
Adequate	-0.719	0.360	-1.999	**0.0138**	**0.046***	-1.426	-0.012
Poor	0						
Soya beans							
Adequate	-0.334	0.603	-0.554	0.0013	0.580	-1.520	0.852
Poor	0						
Tea							
Adequate	0.351	0.413	0.850	0.0028	0.396	0.461	1.163
Poor	0						
Chocolate							
Adequate	-0.304	0.359	-0.847	0.0025	0.397	-1.009	0.401
Poor	0						

Note. Poor intake implies consumption less than four days per week. * Significant at 5% level of significance ** significant at 1.7% level of significance (Bonferroni Adjusted *p*-value)

4 Discussion

This study evaluated the micronutrients supplementation among pregnant women receiving ANC and its impact on hematocrit levels. Key findings include: approximately three-quarters of the participants initiated ANC in the second trimester or later, and around two in five women were anemic at the time of booking. While, about half of the participants demonstrated adequate intake of iron supplements, three-quarters reported adequate folic acid intake. However, fewer than half had adequate vitamin B-complex intake, and only a minority used additional multivitamins, vitamin A, vitamin D, or calcium supplements. Adequate intake was defined as supplement use for at least four days per week. By the time of the study interview, less than one-third of the participants were anemic, indicating improved hematocrit levels during the third trimester.

4.1 Sociodemographic and obstetric characteristics

The mean age of participants in this study was 30.49 years (± 5.03), consistent with findings from studies conducted in Enugu and Algeria that reported mean ages of 30.2 (± 5.2) years and 30.3 (± 6.2) years, respectively (Bayazid *et al.*, 2021; Dim & Onah, 2007). This is expected, as the participants were pregnant women within the reproductive age group and predominantly multiparous.

Unlike studies in Uyo and Abeokuta, which found associations between obstetric factors (e.g., gestational age, and use of intermittent preventive treatment in pregnancy [IPTp]) and anemia, this study observed no significant association between these factors and low hematocrit levels (Idowu *et al.*, 2005; Olatunbosun *et al.*, 2014). This discrepancy could be attributed to the higher socioeconomic status of the study participants, which likely ensured food security and access to balanced diets rich in essential micronutrients.

4.2 Prevalence of anemia and hematocrit levels

At booking, the prevalence of anemia was 42.9%, higher than the 32.5% reported in Sagamu by Sholeye *et al.* (2017) but lower than the 54.5% reported in Uyo by Olatunbosun *et al.*, (2014). Over 90% of anemic participants in this study had mild anemia, exceeding the 70% reported in Sagamu (Olatunbosun *et al.*, 2014; Sholeye *et al.*, 2017). Few participants experienced moderate to severe anemia. These variations may be due to differences in study settings; this study included secondary and tertiary healthcare facilities with participants of diverse socioeconomic backgrounds, whereas the Sagamu study was conducted in primary healthcare centers, where low socioeconomic status and food insecurity were prevalent.

Age and educational status were significantly associated with hematocrit levels in the current study, aligning with findings from previous studies (Olatunbosun *et al.*, 2014; Omote *et al.*, 2020). Religion was also significantly associated with hematocrit levels, though this study could not establish a clear association between Islamic practice and anemia. Sociocultural and religious dietary restrictions may influence nutritional intake and anemia, as documented in previous studies (Major-Smith *et al.*, 2023). For instance, vegetarians avoid animal protein sources rich in iron and, and members of certain religious groups, such as Jehovah's Witnesses, abstain from blood transfusions even in severe anemia, instead prioritizing hematinic supplementation (Major-Smith *et al.*, 2023; Berg et *al.*, 2022). Interestingly, adequate micronutrient supplementation alone was not significantly associated with positive changes in PCV levels. This finding aligns with earlier studies suggesting that socioeconomic status and food security are critical determinants of anemia in pregnancy (Olatunbosun *et al.*, 2014; Omote *et al.*, 2020). Some women may compensate for inconsistent supplementation with optimal dietary intake, while others may rely heavily on supplements due to dietary inadequacies. The multifactorial nature of anemia is evident in this study. Factors such as the socioeconomic status (closely associated with education level), healthcare facilities, age, and possibly preconception use of hematinics, as well as booking gestational age, may have contributed to the observed outcomes.

4.3 Micronutrient supplementation and dietary intake

The micronutrient supplements most commonly consumed by the participants included folic acid, iron, vitamin C and B-complex tablets. These supplements constitute the primary hematinics routinely prescribed to pregnant women by antenatal healthcare providers. However, the frequency of micronutrients intake among participants was suboptimal, consistent with findings from Bayazid et *al.*, (2021) in western Algeria, but lower than the rates reported by Amadi-Joy *et al.*, (2017) in Imo, Nigeria, where over 80% of participants adhered to daily intake of iron, folic acid, vitamin C, and B-complex tablets. Similarly, Enyew *et al.* (2023) observed suboptimal micronutrient intake among pregnant women in East Africa. However, evidence indicates that optimal prophylactic iron supplementation can reduce maternal anemia at term by 70% (Peña-Rosas *et al.*, 2015).

The intake of other critical micronutrients, such as calcium, vitamins A and D, and omega 3 fatty acids, was also low, consistent with findings by Amadi-Joy *et al.*, (2017). According to the WHO recommendations, these supplements especially calcium, zinc, vitamin A and Vitamin D should be incorporated into routine antenatal care in regions with documented deficiencies (Amadi-Joy *et al.*, 2017; WHO, 2020). Despite evidence of high prevalence of deficiencies across different socioeconomic groups in Nigeria, the utilization of these micronutrients remains insufficient. For instance, calcium deficiency prevalence ranges from 29.2 to 58.76%, vitamin A deficiency from 21 to 35%, and vitamin D deficiency is from 4.8 to 32.3% (Ajong *et al.*, 2019; Bako *et al.*, 2021; Hanson *et al.*, 2019; Owie & Afolabi, 2018).

Adequate supplementation with these micronutrients is necessary, not only to prevent deficiencies but also to prevent potential feto-maternal complications. Deficiencies in these nutrients have been associated with congenital malformations, cretinism, preterm birth, low birthweight, intrauterine growth restriction, pre-eclampsia, and inadequate lactation that may arise from their deficiencies (Gernand *et al.*, 2016; Harika *et al.*, 2017; Parisi *et al.*, 2019).

The ingestion of substances such as milk, cocoa or soy products, which are known to impair iron absorption, was associated with limited improvements in hematocrit levels. Among these, only adequate milk intake was significantly associated with negative hematocrit changes, reinforcing the inhibitory role of certain compounds in milk on iron absorption (Al Hasan *et al.*, 2016; Armah *et al.*, 2015). Studies have shown that milk, cocoa, tea or soya beans contain either phytates, polyphenol, oxalic acid which chelates iron and impair its absorption. Nevertheless, as suggested by some authors, effects of intake of these iron inhibitors on availability of iron for hemopoiesis in the body is dose dependent and are countered by effect of iron absorption enhancing substances such as ascorbic acid and animal source food which are also contained in the diets (Al Hasan *et al.*, 2016; Armah *et al.*, 2015; Björn-Rasmussen & Hallberg, 1979; He *et al.*, 2018).

4.4 Strategies for addressing anemia in pregnancy

To mitigate anemia during pregnancy, several strategies should be implemented. First, comprehensive health education programs targeting young women are essential to emphasize the importance of early antenatal booking and the timely initiation of hematinic supplements. Specific health talks should be designed to promote the intake of iron, folic acid, vitamins A, B12, and C as well as multiple micronutrient supplement (MMS) as recommended by the WHO.

Early detection and prompt management of anemia at the initial antenatal visit can significantly improve hematocrit levels, reducing the prevalence of anemia by the time of delivery. Additionally, the implementation of effective malaria preventive measures, including the use of insecticide-treated nets (ITNs) and IPTp, will also reduce incidence of anemia caused by malaria in pregnancy. The prophylactic treatment of helminthiasis in areas with high prevalence can reduce anemia caused by parasitic infections.

Counselling women on family planning to encourage adequate inter-pregnancy intervals using modern contraceptives and uptake of other components of preconception care can provide women with sufficient time to restore optimal hematocrit levels before conception.

Socioeconomic factors also play a critical role. Policies aimed at providing employment opportunities for women, subsidizing food prizes to enhance access to nutritious meals, and promoting food fortification with essential micronutrients are vital to improving hematocrit levels during pregnancy women and preventing adverse obstetric outcomes relayed to anemia (Cappellini & Motta, 2015; Jugha *et al.*, 2020; Lebso *et al.*, 2017; Ramachandran, 2021; WHO, 2020; Zerfu *et al.*, 2016).

Limitations of the study

This study is not without some limitations. Most participants initiated antenatal care late, typically in the second trimester, and nearly half were anemic at the time of booking. A longitudinal study would have provided more comprehensive insights into the progression of hematocrit levels across trimesters of pregnancy. Such an approach would have also allowed for a more robust analysis of the relationship between the dose and duration of micronutrient supplementation and changes in hematocrit levels. The study was unable to ascertain the proportion of women who had initiated micronutrient supplements prior their antenatal care booking. Additionally, reliance on participants' self-reported dietary habits and compliance with micronutrient supplementation introduces potential recall bias. Conducting a complete blood count for all participants, complemented by peripheral blood smear analysis for those with low hematocrit levels, could have provided valuable information regarding the type, cause and severity of anemia.

Despite its limitations, this study offers valuable insights into the patterns of micronutrient supplementation among pregnant women, including less commonly discussed supplements such as zinc and vitamins A and D, and their impact on hematocrit levels.

5 Conclusions

In conclusion, despite the routine prescription of micronutrient supplements by antenatal care providers, the participants demonstrated suboptimal intake of essential hematinics, including iron and vitamin B complex, as well as other key supplements such as vitamins A, D, calcium, multivitamins, omega-3, and zinc. The prevalence of anemia in the third trimester was 26.8%, remains a significant concern for antenatal and delivery healthcare providers.

The findings indicate that low hematocrit levels during pregnancy are associated with demographic and socioeconomic factors, including maternal age, education level, and food security. It is imperative that every antenatal care visit serves as an opportunity to enhance patient education and counselling regarding the benefits of maintaining optimal hematocrit levels and the risk associated with anemia during pregnancy.

The frequency of intake and compliance with intake of hematinic and micronutrients must be assessed at every antenatal clinic visit and impeding factors must be addressed to improve the utilization of these micronutrient supplements among pregnant women. While self-reported adherence is subjective, introducing frequency logs for micronutrient intake could serve as a motivational and monitoring tool, encouraging compliance and facilitating more effective interventions.

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