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Prevalence, Morphological Classification, and Determinants of Anaemia among Pregnant Women Attending Antenatal Care at Korle Bu Teaching Hospital

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Abstract:

Background: Anaemia in pregnancy remains a pressing public health concern in low- and middle-income countries. This study assessed the prevalence, morphological classification, and associated risk factors of anaemia among pregnant women attending antenatal care at Korle Bu Teaching Hospital, Ghana.

Methods: A cross-sectional study was conducted involving 297 pregnant women. Sociodemographic, clinical, and dietary data were collected using structured questionnaires. Haematological parameters were analyzed to classify anaemia morphologically. Associations between anaemia and various risk factors were explored using logistic regression.

Results: The prevalence of anaemia was 47.8%, with normocytic normochromic anaemia being the most common type (62.7%), followed by microcytic hypochromic (34.5%) and macrocytic anaemia (2.8%). Anaemia was significantly associated with the second trimester, short interpregnancy intervals (≤2 years), self-reported infections, poor knowledge about anaemia, physically strenuous work, and inadequate folate supplementation. Folic acid use was protective, reducing the odds of anaemia by 72%. While most participants had inadequate intake of iron- and vitamin-rich foods, only folate deficiency was significantly linked to anaemia risk. Morphological patterns revealed that microcytic hypochromic anaemia correlated more with nutritional deficiencies, while normocytic anaemia was associated with infections and gestational stage.

Conclusion: Anaemia in pregnancy at this tertiary facility is common, with multifactorial causes involving infections, short birth spacing, poor nutritional status, and inadequate supplementation. Targeted interventions including early antenatal care, nutritional support, infection prevention, and education on anaemia risks are essential to mitigate its burden.

Keywords: Fungal infections, Dermatophytosis, Superficial mycoses, Skin infections, Hair infections, Nail infections, Etiology, Epidemiology, Treatment, Prevention.

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Introduction

The World Health Organization (WHO) defines anaemia as a condition in which the number of red blood cells and consequently, their oxygen carrying capacity is insufficient to meet the body's physiologic needs (WHO, 2011). The WHO defines anaemia as decreased concentration of haemoglobin level less that 11g/dL (WHO, 2015). With no regards to economic status, anaemia affects the global population qualifying it as a public health problem (De Benoist & Mclean, 2008). It affects roughly a third of the world's population (Chaparro & Suchdev, 2019). In the quantitative sense, anaemia globally affects 1.62 billion people corresponding to 24.8% of the population with the lowest prevalence in men (12.7%) followed by the elderly (23.9%), school age children (25.4%), non-pregnant women (30.2%), pregnant women (41.8%) and then pre-school age children (47.7%) according to De Benoist and Mclean's estimates from 1993 to 2005 from the survey data of WHO's 192 member states extracted from their database. Due to the vulnerability of women and children to anaemia, many researches and surveys on anaemia have been centred around them particularly, pregnant women. The WHO in their annual health report in 2021 stated that, in 2019 the global prevalence of anaemia was 29.9% among women of reproductive age, 29.6% among non pregnant women and 36.5% among pregnant women acknowledging a slow global decline in pregnant women from 40.9% in 2000 (WHO, 2021e). Pregnancy-related anaemia is a worldwide health problem affecting low-, middle- and high-income countries impacting on health and socio-economic progress (Okia et al., 2019). It is estimated that 2 pregnancy-related anaemia has highest prevalence in South East Asia (48.7%) and Africa (46.3%), medium prevalence in the Eastern Mediterranean Region (38.9%) and lowest prevalence in the Western Pacific (24.3%), the Americas (24.9%) and Europe (25.8%) (WHO, 2016). It is imperative from the above data to ascertain that; pregnant women are one of the groups most vulnerable to anaemia. This is attributable to the fact that even in physiological conditions, pregnancy imposes significant demands on the woman's body and triggers many physiologic adaptations which lead to a gradual increase in blood volume (Agarwal & Rets, 2021) by 40 to 45% on average with subsequent increase in red cell mass by 15 to 20% which is relatively smaller than that of the plasma volume and hence a net reduction in the concentration of haemoglobin (Hb) by 1-2g/dL, classified as physiological anaemia of pregnancy (Gebreweld, Bekele, & Tsegaye, 2018). In Ghana, it is estimated that 45% of pregnant women are anaemic (Ghana Statistical Service (GSS) ICF International, 2015). Diverse circumstances contribute to anaemia in pregnant women (Ndegwa, 2019a). Associated risk factors include poor nutrition, chronic infections, lack of access to health care facilities, poor compliance with micronutrient supplementation among others (Dorsamy, Bagwandeen, & Moodley, 2020). Since iron-deficiency anaemia is the most prevalent form of anaemia worldwide, most researches have seemed to target iron deficiency anaemia, finding its prevalence, associated risk factors and measures of prevention with little or no regard to the other forms of anaemia. This is backed by the study (WHO, 2020) that states "Among the known causes of anaemia, iron deficiency is the most common cause. The terms anaemia, iron deficiency and iron- deficiency anaemia (IDA) are too often used interchangeably, masking the need to address the full scope of causes of anaemia. Although iron deficiency leads to decreased 3 haemoglobin and production of red blood cells, which in turn decreases haemoglobin concentrations and haematocrit (used to identify anaemia), there are many other causes of anaemia that do not involve iron. There are multiple determinants of anaemia, and successful anaemia reduction efforts must identify the major contributing factors in order to develop and implement an evidence-based package of interventions that may achieve effective results." Those other forms of anaemia fall within the morphological classifications: macrocytic and normochromic anaemia (aside microcytic anaemia comprising mainly of iron-deficiency anaemia). This study aims to not only measure the prevalence of the morphological classifications of anaemia but also to relate them to corresponding risk factors or aetiology.

Methods

Study design and setting

We conducted a facility-based cross-sectional study at the Korle Bu Teaching Hospital (KBTH), the largest tertiary referral hospital in Ghana, located within the Ablekuma South Sub-Metropolitan District of the Greater Accra Region. The study population consisted of pregnant women attending antenatal care (ANC) services at KBTH during the study period.

Study population

All pregnant women presenting for ANC were eligible for recruitment. Women were enrolled across all trimesters to ensure representation of the physiological and haematological variations that occur throughout gestation.

Inclusion criteria

- ➢ Ghanaian pregnant women receiving ANC at KBTH.
- ➢ Provision of written informed consent.

Exclusion criteria

- ➢ Declined consent.
- ➢ Known hereditary anaemias (e.g., sickle cell disease, thalassaemia), as these conditions could confound morphological classification of anaemia.

Sample size and sampling

The minimum sample size required for this study is determined by the formula:

N = Z2 x p(1- p)

d2

Where Z is the confidence level at 95% of the value, 1.96

p is the expected proportion in population based on recent surveys

d is the absolute error, preferably, 5% (0.05)

According to the Ghana Statistical Service, the prevalence of pregnancy anaemia is 40.5%, thus,

p = 0.405

Therefore,

N = (1.96)2 x 0.405(1- 0.405)

0.052

N = 370.29 = 370

Hence a convenience sample of 370 participants was used for the study.

Data collection

Biological sample collection and laboratory analysis

Three millilitres of venous blood were collected into EDTA tubes following standard aseptic procedures. Samples were analysed at the KBTH Haematology Laboratory using a Biobase three-part automated haematology analyser to obtain full blood count parameters, including haemoglobin concentration, MCV, MCH, and MCHC.

To confirm anaemia morphology, peripheral blood smears were prepared using 3 μL of whole blood and stained using the Leishman technique. Slides were examined under oil immersion (×100 objective) by trained laboratory scientists.

Morphological classification of anaemia

Anaemia was defined as haemoglobin <11.0 g/dL. Morphological classes were determined using MCV and MCH values and confirmed by microscopic smear examination:

- ➢ **Microcytic hypochromic anaemia:** MCV < 80 fL and MCH < 27 pg
- ➢ **Normocytic normochromic anaemia:** MCV 80–95 fL
- ➢ **Macrocytic anaemia:** MCV > 95 fL

Data management and statistical analysis

Data were entered into SPSS version 28.0.1. Descriptive statistics (means, standard deviations, frequencies, and proportions) summarized baseline characteristics.

Bivariate associations between anaemia status and sociodemographic, clinical, nutritional, and knowledge variables were assessed using chi-square tests. Variables with $p < 0.05$ at bivariate level were entered into multivariable logistic regression models to estimate adjusted odds ratios and 95% confidence intervals.

A multinomial logistic regression model was further used to assess predictors of morphological classes of anaemia. Statistical significance was defined as $p < 0.05$.

Ethical considerations

Ethical approval was obtained from the Ethical and Protocol Review Committee. All participants provided written informed consent after receiving information about the study aims, procedures, risks, and confidentiality safeguards. Unique identification codes were used to maintain anonymity; electronic data were stored on password-protected systems with secure cloud-based backups.

Results

Sociodemographic characteristics of the pregnant women

A total of 297 pregnant women attending antenatal care at Korle Bu Teaching Hospital were enrolled. The mean age was 27 years (range 16–44), with women aged 25–29 years representing the largest subgroup **(**33.7%**).** Adolescents (<20 years) constituted 7.7% of the study population, indicating a continued occurrence of early pregnancy within the catchment area as shown in Table 1.

Most participants identified as Christian (76.8%)**,** with the remaining 23.2% identifying as Muslim. Nearly all women (98.7%**)** lived in nuclear family households, consistent with typical urban living arrangements in metropolitan Accra.

Educational attainment varied substantially: 48.5% had completed basic education, 29.0% had secondary education, 6.7% had tertiary education, while 15.8% had no formal education. These trends reflect the persistent disparities in women's educational status in urban Ghana and have important implications for health literacy and care-seeking behaviours.

In terms of occupation, 55.6% of respondents were self-employed, 28.3% were formally employed, and 16.2% were unemployed. Notably, 34.4% reported engaging in physically strenuous work—an important consideration given its potential contribution to adverse maternal outcomes, including anaemia.

Awareness regarding anaemia was moderate: 57.6% of participants reported knowledge of anaemia, and 56.2% recognized increased susceptibility during pregnancy. Nearly all respondents ***(98.7%)*** acknowledged the need for increased dietary intake during pregnancy, reflecting good acceptance of nutritional guidance despite gaps in broader anaemia-related knowledge.

The socio-demographic profile reflects a predominantly young, urban population with heterogeneous educational attainment and varying levels of health awareness. These characteristics are consistent with demographic patterns observed among antenatal populations in other urban Ghanaian centres and underscore the importance of targeted maternal health education and nutritional counseling.

Table 1: Sociodemographic characteristics of pregnant women

Sociodemographic characteristics		**Frequency (N=297)**	**Percentage %**
Maternal age	<20	23	7.7%
	20-24	82	27.6%
	25-29	100	33.7%
	30-34	54	18.2%
	35-39	32	10.8%
	>/=40	6	2.0%
Religion	Christianity	228	76.8%
	Islam	69	23.2%
African Traditional Religion		0	0.0%
	Other	0	0.0%
Sociodemographic characteristics		**Frequency (N=297)**	**Percentage %**
Education	No formal education	47	15.8%
	Basic education	144	48.5%
	Secondary	86	29.0%

	Tertiary	20	6.7%
Family type	Nuclear	293	98.7%
	Joint	0	0.0%
	Extended	4	1.3%
Employment status	Employed	84	28.3%
	Self-employed	165	55.6%
	Unemployed	48	16.2%
Nature of work	Light and normal	162	65.6%
	Exhaustive	85	34.4%
Knowledge about anaemia	Yes	171	57.6%
	No	126	42.4%
Knowledge about	Yes	167	56.2%
vulnerability of pregnant	No	130	43.8%
women to anaemia			
Knowledge about need for	Yes	293	98.7%
double diet	No	4	1.3%

Clinical characteristics of pregnant women

The clinical profiles of the 297 pregnant women enrolled in the study demonstrated considerable variation across gestational age, obstetric history, and maternal health indicators. As shown in Table 2, 21.9% of participants were in their first trimester, while 39.4% and 38.7% were in their second and third trimesters, respectively.

A substantial proportion (69.7%) were multigravidae, consistent with demographic trends reported in similar studies conducted in sub-Saharan Africa, where multiparity remains common among women attending antenatal clinics (Belachew & Legesse, 2006; Bh et al., 2017)

Approximately 63.3% had attended at least one previous antenatal visit at the time of recruitment, while 36.7% were presenting for the first time. This pattern aligns with findings from other Ghanaian and regional cohorts, where late initiation of antenatal care persists as a public health concern (Frimpong et al., 2022). Regarding the timing of the first ANC visit, 44.0% of women began care during the second trimester, with only 33.0% initiating in the first trimester, echoing earlier reports highlighting delayed ANC uptake among pregnant women in West Africa.

The majority of participants (93.9%) reported no apparent infection at the time of assessment, whereas 6.1% acknowledged the presence of an infection. Maternal infections—particularly malaria, urinary tract infections, and helminthic infestations—are well-established contributors to anaemia during pregnancy, and similar prevalence rates have been documented across the region (Bashawri et al., 2002; Means, 2019).

These clinical characteristics provide essential insight into the obstetric and health-related determinants of anaemia in pregnancy. Consistent with global literature, gestational age, interpregnancy spacing, and infection status remain critical clinical predictors of anaemia risk, underscoring the importance of early ANC initiation and routine screening throughout pregnancy.

Table 2:Clinical characteristics of the pregnant women

Clinical characteristics		**Frequency (N = 297)**	**Percentage (%)**
Gestational age	first trimester	69	21.9%
Second trimester		119	39.4%
Third trimester		115	38.7%
ANC visits	First time	109	36.7%
Had earlier visit(s)		188	63.3%
Gravida	Primigravida	90	30.3%
Multigravida		207	69.7%
Gravidity	First pregnancy	89	30.0%
Second pregnancy		51	17.2%

Third pregnancy		69	23.2%
Fourth pregnancy		48	16.2%
Fifth and above pregnancy		40	13.5%
Birth spacing	</= 2years	79	26.6%
	>2years	129	43.4%
	No birth	89	30.0%
Existing infection	Yes	19	6.1%
	No	355	93.9%

Consumption of nutrient rich foods and supplements

The consumption patterns of nutrient-rich foods and supplements among pregnant women in this study reveal important gaps in dietary quality and micronutrient intake. As shown in Table 3, the majority of women reported inadequate daily consumption of iron-rich foods, fruits, and vegetables, despite recognising the importance of increased dietary intake during pregnancy. Only a subset of participants consistently consumed foods such as beans, leafy vegetables, eggs, fish, and fortified cereals, indicating suboptimal adherence to recommended antenatal nutrition practices.

Supplement intake showed similar variability. Although iron and folic acid supplementation is routinely provided during antenatal care in Ghana, adherence among participants was inconsistent. Several women reported irregular intake of these supplements, which may contribute to the persistence of anaemia and other micronutrient deficiencies in pregnancy. This pattern aligns with previous findings from urban Ghana, where adherence to antenatal supplements is often limited by gastrointestinal side effects, forgetfulness, and misconceptions about supplement safety (Gyamfi et al., 2020; Adu-Afarwuah et al., 2017).

The low consumption of nutrient-dense foods is particularly concerning given the increased physiological demands of pregnancy. Evidence indicates that insufficient intake of iron-rich foods, vitamin-C-rich fruits, and folate-containing vegetables substantially elevates the risk of anaemia, preterm birth, and intrauterine growth restriction (WHO, 2021; Black et al., 2013). Moreover, dietary insufficiency combined with suboptimal supplement adherence exacerbates micronutrient depletion, especially in populations with high baseline anaemia prevalence.

Table 3: Consumption of nutrient rich foods and supplements

		Frequency	Percentage (%)
Daily eating frequency	Twice a day	52	17.5%
Thrice a day		201	67.7%
Four times a day		14	4.7%
More frequently		30	10.1%
Fruits	Daily	116	39.1%
At least twice a week		103	34.7%
Weekly		43	14.5%
Rarely		35	11.8%
Green leafy vegetables	Daily	97	32.7%
At least twice a week		113	38.0%
Weekly		45	15.2%
Rarely		42	14.1%
Milk	Daily	49	16.5%
At least twice a week		57	19.2%
Weekly		53	17.8%
Rarely		138	46.5%
Red meat	Daily	60	20.2%
At least twice a week		84	28.3%

Weekly		62	20.9%
Rarely		91	30.6%
Iron supplement	Yes	175	58.9%
No		122	41.1%
Iron supplement frequency	Just as prescribed	158	90.3%
Not as frequently as prescribed		17	9.7%
Multivitamin	Yes	149	50.2%
No		148	49.8%
Multivitamin frequency	Just as prescribed	147	98.7%
Not as frequently as prescribed		2	1.3%
Folate supplement	Yes	104	35.0%
No		193	65.0%
Folate supplement frequency	Just as prescribed	103	99.0%
Not as frequently as prescribed		1	1.0%

Prevalence of anaemia among pregnant women

The pie chart below represents the prevalence of anaemia among pregnant women as derived from this study. Of the 297 pregnant women 142(47.8%) were anaemic, presenting Hb<11.0g/dL and 155(52.2%) being normal. The mean and median Haemoglobin level was 11.1g/dL and 11.0g/dL, respectively with standard deviation ± 2.0g/dL.

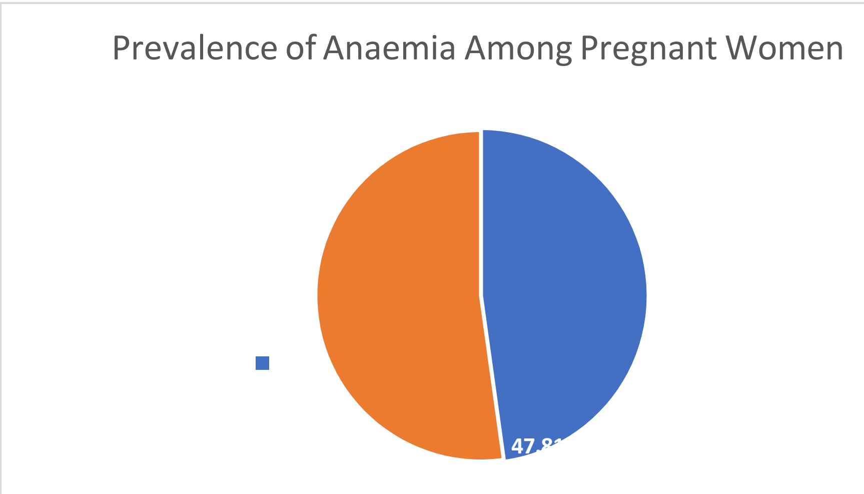

Figure 1: Prevalence of anaemia in pregnant women

Bivariate association between demographic characteristics of the women and anaemia

The bivariate analysis examined the relationship between socio-demographic characteristics and anaemia status among the 297 pregnant women enrolled in the study. The results showed that **age, education level, maternal occupation, religion,** and **family type** were **not significantly associated** with anaemia ($p > 0.05$). Although anaemia prevalence varied across categories, none of the differences reached statistical significance.

Anaemia prevalence was highest among women aged **25–29 years**, who also constituted the largest age group in the cohort. Women with **no formal education** showed a slightly higher proportion of anaemia compared with their more educated counterparts, consistent with patterns reported in other maternal health studies; however, the association was not statistically significant in the present analysis.

Occupational status similarly demonstrated no significant association with anaemia. Women engaged in **self-employment** and **physically demanding work** had marginally higher anaemia prevalence, but the relationship did not reach significance. This aligns with previous findings from Ghanaian urban antenatal populations, where occupational differences often fail to independently predict maternal anaemia once dietary and obstetric factors are considered.

Religion and family structure also showed no significant associations with anaemia. Although women from nuclear households constituted the vast majority of the study population, anaemia distribution across household types did not differ significantly.

The bivariate findings indicate that **demographic factors alone did not significantly predict anaemia** within this antenatal population. This underscores the stronger influence of **nutritional intake, parity, gestational age, infection status, and supplementation practices** factors examined in the subsequent multivariate analyses.

Table 4: Bivariate association and multivariate regression between demographic characteristics of pregnant women and anaemia

Demographic characteristics	**Not anaemic n(%)**	**Anaemic n(%)**	**χ2**	**P-value**	**Odds Ratio**	**95% CI**	**p-value**
Maternal age			10.84	0.055			
<20	9(39.1%)	14(60.9%)					
20-24	36(43.9%)	46(56.1%)					
25-29	64(64.0%)	36(36.0%)					
30-34	28(51.9%)	26(48.1%)					
35-39	14(43.8%)	18(56.3%)					
>/=40	4(66.7%)	2(33.3%)					
Educational level			17.13	**0.001**			
None	22(46.8%)	25(53.2%)			1.379	0.29-6.62	0.688
Basic	61(42.4%)	83(57.6%)			2.063	0.51-8.37	0.311
Secondary	57(66.3%)	29(33.7%)			0.917	0.22-3.80	0.905
Tertiary	15(75.0%)	5(25.0%)			1		
Religion			0.000	0.998			
Christianity	119(52.2%)	109(47.8%)					
Islam	36(52.2%)	33(47.8%)					
Family type			0.008	0.930			
Nuclear	153(52.2%)	140(47.8%)					
Extended	2(50.0%)	2(50.0%)					

Demographic characteristics	**Not anaemic n(%)**	**Anaemic n(%)**	**χ2**	**p- value**	**Odds Ratio**	**95% CI**	**p- value**
Employment			4.888	0.087			
Employed	48(57.1%)	36(42.9%)					
Self employed	77(46.7%)	88(53.3%)					
Unemployed	30(62.5%)	18(37.5%)					
Nature of work			3.853	**0.050**			

Light and normal	88(54.3%)	74(45.7%)			0.59	0.31-1.10	0.094
Exhaustive	35(41.2%)	50(58.8%)			1		

Bivariate association between knowledge and anaemia

The pregnant women's availability of knowledge concerning anaemia turned out to have a significant association with their anaemia status (Chi 8991, p=0.003). Majority of those who exhibited a fair knowledge about anaemia, 102(59.6%), were not anaemic while most of those who had no knowledge about anaemia, 73(57.9%) were anaemic.

Likewise, whether or not they knew that pregnant women are vulnerable to anaemia had a significant association with anaemia status (Chi 7.693, p=0.006) with majority who had the knowledge, 99(59.3%) having normal Hb while majority (74(56.9%)) without that knowledge being anaemic.

There was no significant association between knowledge about need for pregnant women to take a double diet with anaemia status (Chi 0.846, p=0.358).

Table 5: Association and regression between knowledge about anaemia and anaemia status

Subject	Not anaemic n(%)	Anaemic n(%)	χ2	P-value	Odds Ratio	95% CI	p- value
Anaemia			8.991	**0.003**			
Yes	102(59.6%)	69(40.4%)			0.44	0.57-3.46	0.436
No	53(42.1%)	73(57.9%)			1		
Vulnerability to			7.693	**0.006**			
anaemia							
Yes	99(59.3%)	68(40.7%)			1.45	0.19-11.27	0.720
No **Need for double diet**	56(43.1%)	74(56.9%)	0.846	0.358	1		
Yes	152(51.9%)	141(48.1%)					
No	3(75.0%)	1(25.0%)					

Bivariate association between clinical characteristics of the women and anaemia

Gestational age had a significant association with anaemia status (Chi 7.333, p=0.026). Majority of the pregnant women in the study, 117(39.4%) were in their second trimester most of which were anaemic (67(57.3%)). The first and third trimesters however saw the majority (40(61.5%) and 65(56.5%) respectively) being non anaemic.

Birth spacing as well had a significant effect on the haematological status of the women (Chi 10.212, p=0.001). Anaemia was more prevalent among those who had given birth at most two years ago with majority 48(60.8%) being anaemic and with 3 times odds (OR 3.13(1.53-6.40) p=0.002) of being anaemic compared to those with >2 years birth space. Most of those who had had a previous birth more than two years ago, 80(62.0%) had normal Hb.

Also, the presence of existing infection had a significant impact on the Hb status of the women (Chi 4.567, p=0.032). Of those that testified of having an infection, majority, 13(72.2%) , turned out to be anaemic. Most of those without infection, 150(53.8%) had normal Hb.

There was no significant association between ANC visits (Chi 2.754, p=0.097), gravida status (Chi 0.248, p=0.619) and gravidity (Chi 2.551, p=0.636) and anaemia. Most of the women who had earlier ANC visits had normal Hb as opposed to most of the first timers who were anaemic.

Table 6: Association and regression between clinical characteristics of women and anaemia

Clinical characteristics	**Not anaemic n(%)**	**Anaemic n(%)**	**χ2**	**P-value**	**Odds Ratio**	**95% CI**	**p-value**
Gestational age			7.333	**0.026**			
First trimester	40(61.5%)	25(38.5%)			0.58	0.27-1.26	0.167
Second trimester	50(42.7%)	67(57.3%)			1.36	0.70-2.66	0.362
Third trimester	65(56.5%)	50(43.5%)			1		
ANC visits			2.754	0.097			
First time	50(45.9%)	59(54.1%)					
Had earlier visits	105(55.9%)	83(44.1%)					
Gravida			0.248	0.619			
Primigravida	45(50.0%)	45(50.0%)					
Multigravida	110(53.1%)	97(46.9%)					
Gravidity			2.551	0.636			
First pregnancy	44(49.4%)	45(50.6%)					
Second pregnancy	28(54.9%)	23(45.1%)					
Third pregnancy	36(52.2%)	33(47.8%)					
Fourth pregnancy	29(60.4%)	19(39.6%)					
Fifth and above	18(45.0%)	22(55.0%)					
Birth spacing			10.212	**0.001**			
</=2years	31(39.2%)	48(60.8%)			3.13	1.53-6.40	**0.002**
>2years	80(62.0%)	49(38.0%)			1		
Infection			4.576	**0.032**			
Yes	5(27.8%)	13(72.2%)			3.22	0.989-10.47	0.052

No	150(53.8%)	129(46.2%)			1		

Bivariate association between diet and consumption of supplements and anaemia

A significant association exists between multivitamin supplement consumption and Hb level of the women (Chi 5.659, p= 0.017). 88(59.1%) of the women, the majority, who took multivitamin supplements turned out to have normal Hb. Most of those who denied taking multivitamin supplements, 81(54.7%) were anaemic. Likewise, whether or not they consumed folate supplements had an impact on their Hb status (Chi 23.070, p<0.001) with majority of those on folate supplements, 74(71.2%) having normal Hb with 72% reduced likelihood (OR 0.28 (0.14-0.57) p<0.001) of having anaemia than those who were not on folate supplement.

There was no significant impact of daily diet frequency and frequency of consumption of fruits, green leafy vegetables, milk, red meat and iron supplements on Hb status. Majority of those who took iron supplements, 99(55.4%) had normal Hb whiles majority of those who did not (64(32.3%)), were anaemic. Also, most of them who stated of eating green leafy vegetables daily and least twice weekly, 51 (52.6%) and 66 (58.4%) had normal Hb while more than half of those who ate them less regularly (once weekly (25(55.6%) and rarely (57.1%)) were anaemic. The same trend exists in fruit and milkconsumption with majority of the women who took them more regularly (daily and at least twice weekly) having normal Hb and majority of those who took them less frequently (once weekly and rarely) having anaemia.

Table 7: Association and regression between diet and consumption of supplements and anaemia

Nutrition and supplementation	Not anaemic n(%)	Anaemic n(%)	χ2	P-value	Odds Ratio	95% CI	p-value
Diet frequency			3.178	0.365			
Twice a day	25(48.1%)	27(51.9%)					
Thrice a day	102(50.7%)	99(49.3%)					
Four times a day	8(57.1%)	6(42.9%)					
More frequently	20(66.7%)	10(33.3%)					
Fruits			1.009	0.799			
Daily	63(54.3%)	53(45.7%)					
At least twice a week	55(53.4%)	48(46.6%)					
Weekly	20(46.5%)	23(53.5%)					
Rarely	17(48.6%)	18(51.4%)					
Green leafy vegetables			4.304	0.230			
Daily	51(52.6%)	46(47.4%)					
At least twice a week	66(58.4%)	47(41.6%)					
Weekly	20(44.4%)	25(55.6%)					
Rarely	18(42.9%)	24(57.1%)					
Milk			4.248	0.236			
Daily	31(63.3%)	18(36.7%)					
At least twice a week	32(56.1%)	25(43.9%)					
Weekly	24(45.3%)	29(54.7%)					
Rarely	68(49.3%)	70(50.7%)					

	Not anaemic n(%)	**Anaemic n(%)**	**χ2**	**P-value**	**Odds Ratio**	**95% CI**	**p-value**
Red meat			7.036	0.071			
Daily	40(66.7%)	20(33.3%)					
At least twice a week	38(45.2%)	46(54.8%)					
Weekly	30(48.4%)	32(51.6%)					
Rarely	47(51.6%)	44(48.4%)					
Iron supplement			1.792	0.181			
Yes	97(55.4%)	78(44.6%)					
No	58(47.5%)	64(52.5%)					
Multivitamin			5.659	**0.017**			
Yes	88(59.1%)	61(40.9%)			1.02	0.52-2.00	0.947
No	67(45.3%)	81(54.7%)				1	
Folate supplement			23.070	**<0.001**			
Yes	74(71.2%)	30(28.8%)			0.28	0.14-0.57	**<0.001**
No	81(42.0%)	112(58.0%)					

Prevalence of the morphological classifications of anaemia in the pregnant women

The bar chart below shows the distribution of the different morphological anaemias among the 142 pregnant women who were anaemic. The mean Hb amongst this group was 9.9g/dL with SD ±0.9g/dL. Also, the mean MCV and MCH were (86.9 ± 8.5)fL and (27.7 ± 4.4)pg respectively. Based on film comments in confirmation to the red cell indices, of the anaemic women, normocytic normochromic anaemia was most prevalent with 89 pregnant women corresponding to 62.7% of the total. This was followed by microcytic hypochromic anaemia, affecting 49(34.5%) of them. Macrocytic anaemia was the least prevalent with 4(2.8%) being affected.

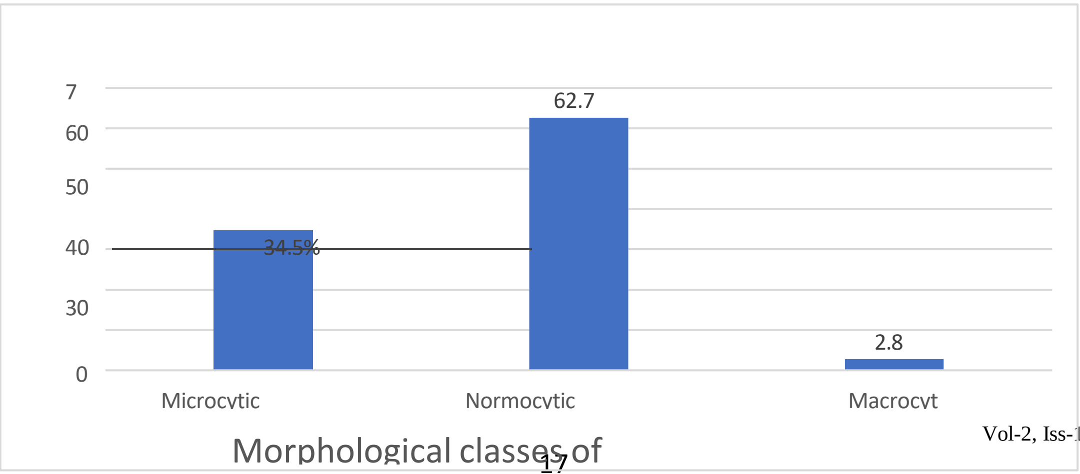

Figure 2: Prevalence of the morphological classes of anaemia in the pregnant women

Multinomial logistic analysis of clinical factors and supplement consumption in association with anaemia in pregnant women

Multinomial regression analysis of the women with regard to iron and multivitamin supplementation and infection was not significantly associated with microcytic hypochromic anaemia. The odds of women having microcytic anaemia was 22% reduced for those taking iron supplements, 0.2% reduced for those taking multivitamins than those who were not. Also, those who had existing infections were 1.3 times more susceptible to microcytic anaemia than those who were not. The association was significant for folate supplementation and birth spacing in that those who took folate supplementation had 78% reduction in odds of getting microcytic anaemia than those who were not. Those who had had previous births at most, 2years ago were 4.8 times likely to have microcytic anaemia than those who had theirs more than 2years ago.

For normocytic anaemia, the association was significant for folate intake, infection, birth spacing and gestational age. The odds of having normocytic anaemia were 83% reduced for those taking folate than those who were not. Also, the likelihood of having normocytic anaemia was 4.2 times higher for those with infections and 3 times higher for those with at most, 2years birth spacing. The second trimester women were 2 and 1.9 times more likely to have normocytic anaemia than the third and first trimester women respectively.

There was no significant association between the factors mentioned and macrocytic anaemia.

Table 8: Multinomial logistic analysis of clinical factors and supplement consumption in association with anaemia in pregnant women

	Factors	**Odds ratio**	**95% CI**	**p-value**
Microcytic hypochromic	**Iron supplement** Yes	0.779	0.35-1.799	0.588
	No	1		
	Multivitamin Yes	0.988	0.455-2.149	0.977
	No	1		
	Folate Yes	0.216	0.088-0.534	**0.001**
	No **Existing infection**	1		
	Yes No	1.340	0.228-7.869	0.746
	Birth spacing </= 2years	4.796	2.009-11.447	**<0.001**
	>2 years	1		
	Gestational age			
	First trimester	0.323	0.101-1.034	0.057
	Second trimester	1.538	0.708-3.338	0.277
	Third trimester	1		

Normocytic	**Iron supplement**			
normochromic	Yes	0.985	0.491-1.977	0.967
	No	1		
anaemia	**Multivitamin**			
	Yes	1.272	0.651-2.484	0.481
	No	1		
	Folate			
	Yes	0.175	0.082-0.376	**<0.001**
	No	1		
	Existing infection			
	Yes	4.200	1.229-14.355	**0.022**
	No	1		
	Birth spacing			
	</= 2years	2.991	1.442-6.205	**0.003**
	>2 years	1		
	Gestational age			
	First trimester	1.085	0.477-2.446	0.846
	Second trimester	2.043	1.031-4.046	**0.041**
	Third trimester	1		
Macrocytic anaemia	**Iron supplement**			
	Yes	0.089	0.008-1.048	0.055
	No	1		
	Multivitamin			
	Yes	8.793	0.459-168.498	0.149
	No	1		
	Folate			
	Yes	0.547	0.053-5.594	0.611
	No	1		
	Existing infection			

	Yes	11.736	0.615-223.876	0.102
	No	1		

Discussion

Prevalence of Anaemia and its Morphological Classes in Pregnancy

This cross-sectional study at Korle Bu Teaching Hospital found an anaemia prevalence of 47.8% among pregnant women (Figure 1). This value closely mirrors the World Health Organization's 2019 estimate of 47.2% anaemia prevalence in pregnant women (WHO, 2021d). Among the 142 women who were anaemic, the majority had normocytic normochromic anaemia (62.7%), followed by microcytic hypochromic anaemia (34.5%), with only 2.8% presenting with macrocytic anaemia (Figure 2). This pattern is consistent with findings from Mahamoud *et al.* (2020) in Uganda and Asafo Akowuah *et al.* (2022) in Ghana's Ashanti region, where normocytic normochromic anaemia was the most common morphology, microcytic (iron-deficiency) anaemia was the second most common, and macrocytic anaemia was relatively rare. Different trends have been reported in other populations – for example, studies in parts of the Middle East and South Asia have found microcytic anaemia (often due to iron deficiency) to dominate (Abusharib, 2019; Behere *et al*., 2021; Singal *et al.*, 2018a) – but in our cohort normocytic anaemia prevailed. One likely explanation for the high proportion of normocytic anaemia in our study is the gestational stage of the participants. As shown in Table 2, a large share of the women were in their second trimester (~39% of participants, compared to 21.9% in first and 38.7% in third trimester). Physiological haemodilution peaks in the second trimester, often causing a normochromic normocytic anaemia of pregnancy (Frayne & Pinchon, 2019; Means, 2019). Thus, the distribution of gestational ages in our sample (with many women in mid-pregnancy) likely contributed to normocytic normochromic anaemia being the predominant morphological type observed.

Factors Associated with Anaemia in Pregnancy

Sociodemographic factors: Several sociodemographic variables showed notable associations with anaemia. Maternal education level was significantly associated with anaemia status in bivariate analysis ($\chi^2 = 17.13$, $p = 0.001$; Table 4). Women with higher education tended to have better haemoglobin levels. In our study, those with tertiary education had the lowest anaemia prevalence (only 25.0% were anaemic), whereas women with no formal education or only basic schooling had over half of their group being anaemic (53.2% and 57.6% respectively). Educated women may have greater awareness of nutritional needs and better socio-economic means to maintain a healthy pregnancy, which could explain this protective effect. Similar trends have been reported in Ghana and elsewhere – for example, Anlaakuu and Anto (2017) and Sumaila (2019) found lower anaemia prevalence among pregnant women with higher education. However, when we controlled for other factors in a multivariate logistic regression, education was not retained as an independent predictor of anaemia (see Table 4, adjusted odds ratios), suggesting that education's effect overlaps with other determinants such as income or health literacy.

Occupational status and work load also influenced anaemia risk. While having any employment (versus being unemployed) was not significantly associated with anaemia in our cohort ($p > 0.05$, Table 4), the *nature of work* showed a borderline significant relationship ($\chi^2 = 3.853$, $p = 0.050$). Women engaged in physically strenuous or "exhaustive" jobs had a higher prevalence of anaemia (58.8% were anaemic) compared to those with light or normal work (45.7% anaemic). In other words, maintaining a physically demanding job during pregnancy appeared to exacerbate the risk of anaemia. The trend persisted in the logistic regression as well: pregnant women with lighter workloads had about 41% lower odds of being anaemic than those with heavy work, although this adjusted difference did not reach statistical significance (adjusted OR ~0.59, 95% CI 0.31–1.10, $p = 0.094$). This finding resonates with observations by Mekonnen *et al.* (2018), who reported that housewives (with presumably less physically strenuous routines) were more protected from anaemia compared to women in employment. It is plausible that physically demanding work increases maternal fatigue and caloric/nutrient requirements, thereby worsening anaemia if nutritional intake is not adequately adjusted.

Other demographic factors such as maternal age, religion, family type, and marital status showed no statistically significant association with anaemia (all $p > 0.05$ in Table 4). Anaemia prevalence was relatively high across all age groups in our sample (ranging from 36% to 60%), and the differences by age did not reach significance ($\chi^2 = 10.84$, $p = 0.055$; Table 4). Nonetheless, we observed certain age-related patterns. The 20–24-year age group had the greatest absolute number of anaemic cases (46 women), likely because this was one of the larger age brackets in our cohort (82 women, about 27.6% of the sample). Notably, the highest *proportion* of anaemia was seen in the youngest mothers: 60.9% of pregnant teenagers under 20 were anaemic. In contrast, women aged 25–29 (the largest group, comprising 33.7% of participants) had a lower anaemia rate (36.0% anaemic). These results suggest that very young pregnant women (adolescents) are particularly vulnerable to anaemia, even though age itself wasn't an independent predictor. Adolescence is a period of ongoing growth and high iron demand; when combined with the demands of pregnancy, it can sharply increase anaemia risk (Tibambuya *et al.*, 2019). Our finding that teenagers had the highest anaemia prevalence aligns with this concern, even if the overall age effect was not significant after adjusting for other factors.

Knowledge and awareness about anaemia emerged as an important correlate of haemoglobin status. In bivariate analysis, pregnant women's knowledge of anaemia was significantly associated with their anaemia status (Table 5). As shown in Table 5, 57.9% of women who lacked any knowledge of anaemia were anaemic, compared to only 40.4% anaemic among those who were aware of anaemia ($\chi^2 = 8.991$, $p = 0.003$). Likewise, awareness that pregnant women are especially vulnerable to anaemia was linked to better outcomes: a majority of women who knew about this vulnerability had normal haemoglobin (59.3% not anaemic), whereas most women who were unaware of it were anaemic (56.9%). This association was also significant in the unadjusted analysis (χ^2 = 7.693, p = 0.006). These findings underscore the value of health education – women who recognize the importance of anaemia and its prevention may be more likely to take preventive actions such as improving diet or taking supplements, leading to lower anaemia rates. Similar conclusions were drawn by Wemakor (2019) and Lestari *et al.* (2018), who found that higher knowledge about anaemia corresponded with significantly lower anaemia prevalence in pregnant women. However, in our multivariate logistic regression, the effects of knowledge did not remain statistically significant (Table 5), implying that knowledge level might be confounded by other factors (for example, more educated women tend to have more knowledge *and* better nutrition, etc.). Interestingly, the regression hinted at a counter-intuitive trend regarding the specific knowledge of pregnancy-related anaemia vulnerability: women who acknowledged that pregnant women are prone to anaemia had *higher* odds of being anaemic themselves (adjusted OR ~1.45). This odds ratio was not significant (p = 0.72) and should be interpreted with caution. One possible explanation is reverse causality or response bias – women who have experienced anaemia (in a previous pregnancy or earlier in the current pregnancy) may be more likely to learn or acknowledge that pregnant women can easily become anaemic. In other words, personal experience of anaemia could increase awareness, rather than awareness preventing the condition. Regardless, the overall trend in our data supports that improving women's knowledge about anaemia (its risk factors, prevention, and the heightened risk during pregnancy) could be beneficial for reducing anaemia rates.

Clinical and obstetric factors: Among the clinical characteristics examined, gestational age and birth spacing had significant associations with anaemia status. In contrast, parity/gravidity and the number of antenatal care visits did not show any significant link (Table 6). Anaemia was observed across all trimesters, but it was most prevalent in the second trimester. As shown in Table 6, 57.3% of women in their second trimester were anaemic, compared to 38.5% in first trimester and 43.5% in third trimester. The difference by trimester was statistically significant (χ^2 = 7.333, p = 0.026, Table 6). Consistently, nearly half of all anaemic women in the study were in the second trimester (67 out of 142 anaemic cases). This pattern contrasts with some studies that have reported the highest anaemia rates in late pregnancy (third trimester) due to cumulative iron depletion (Wemakor, 2019; Abbas, 2020). Our finding of peak anaemia in mid-pregnancy is, however, in line with the concept of physiological anaemia of pregnancy, which tends to manifest in the second trimester as plasma volume expansion outpaces red cell mass increase (Frayne & Pinchon, 2019; Means, 2019). It also aligns with observations by Agbozo *et al.* (2020) in Ghana, who noted lower anaemia prevalence in first trimester compared to second and third trimesters. In our multivariate analysis, trimester was not an independent determinant (the adjusted odds of anaemia in second vs. third trimester were higher but not statistically significant, Table 6), suggesting that second-trimester anaemia in our cohort may be largely driven by other factors (like nutritional deficiencies or infections that become evident by mid-pregnancy). Nonetheless, the high anaemia rate in the second trimester highlights the importance of early antenatal interventions – women who enter pregnancy with marginal iron or folate stores can become anaemic by the middle of gestation if supplementation is not started promptly.

Another key factor was birth spacing. Short inter-pregnancy intervals were strongly associated with anaemia in this study. Women whose current pregnancy occurred within ≤2 years of their previous birth had a significantly higher prevalence of anaemia than those with a longer gap. Specifically, 60.8% of women with ≤2-year birth spacing were anaemic, compared to only 38.0% anaemic among those with more than 2 years since the last birth (Table 6). This difference was highly significant (χ^2 = 10.212, p = 0.001), and the association remained robust in the logistic regression: a short birth interval (≤2 years) was associated with roughly 3.1 times greater odds of anaemia (OR = 3.13, 95% CI 1.53–6.40, p = 0.002) compared to an interval longer than 2 years. In fact, most women who had a prior birth >2 years ago were not anaemic (62.0% had normal Hb), underscoring the protective effect of longer recovery time. These findings are in close agreement with other studies: for instance, Kejela *et al.* (2020) in Ethiopia reported that women with <2-year birth intervals were 2.5 times more likely to be anaemic, and Viveki *et al.* (2012) in India also found a higher anaemia prevalence among women with short interpregnancy gaps. Abbas (2020) similarly noted that most women with less than two years between pregnancies were anaemic. Short birth spacing can leave insufficient time for the mother to replenish her iron stores and other micronutrients depleted by the previous pregnancy and lactation. Pregnancy imposes high demands for iron, folate, and other nutrients; if another pregnancy begins before these reserves are restored, the mother is at much higher risk of anaemia and related complications. Our data strongly support public health advice to space pregnancies by at least two years as a means of improving maternal health and reducing anaemia risk.

Maternal infections proved to be another significant contributor to anaemia. In our study, 93.9% of women reported no current infection, but among the small fraction who did report an ongoing infection (6.1% of participants, which included cases of malaria, UTIs, etc.), anaemia was much more common. Table 6 shows that 72.2% of women who had an infection were anaemic, compared to about 46.2% of those without any infection (only 46.2% of the no-infection group were anaemic, meaning 53.8% had normal Hb). This difference was statistically significant (χ^2 = 4.567, p = 0.032). Moreover, even after adjusting for other factors, infection had a strong effect size: infected pregnant women had roughly 3.2 times higher odds of being anaemic than uninfected women (logistic OR ~3.2, with a borderline p-value of 0.06 in multivariate analysis). The role of infections in precipitating anaemia is well documented. Malaria is a prime example in our region – it causes increased red cell destruction and bone marrow suppression, often leading to significant drops in haemoglobin. Anlaakuu and Anto (2017) reported that pregnant women with malaria in Sunyani, Ghana were over 7 times more likely to be anaemic than those without malaria. Other infections like helminthic infestations, HIV, and chronic urinary tract infections can cause chronic inflammation or nutrient losses contributing to anaemia (Okia *et al.*, 2019; Ndegwa, 2019b). The type of anaemia associated with infection is typically normocytic normochromic, as inflammation interferes with iron utilization and erythropoiesis (the classic anaemia of chronic disease) (Nobili *et al.*, 2014). This aligns with our finding that infections in our cohort were linked to higher odds of normocytic anaemia specifically (see next section). Given that our study was conducted in an area where malaria is endemic, it is likely that subclinical or unreported malaria infections contributed to the anaemia burden even among those who did not acknowledge an infection. Indeed, malaria has been associated with both normocytic and microcytic anaemia in pregnancy, depending on the context (Quintero *et al.*, 2011; Bashawri *et al.*, 2002). Overall, the evidence from our study and others highlights the importance of infection prevention (e.g. mosquito net use, prompt treatment of malaria and other infections) as part of anaemia control in pregnancy.

Dietary and nutritional factors: Nutritional intake and supplement use are modifiable factors that can influence anaemia in pregnancy. In our cohort, nearly all women reported eating at least two meals a day and consuming fruits, vegetables, and protein to varying degrees (Table 3). However, the use of prenatal supplements was not universal. Only about 58.9% of participants reported taking iron supplements, about 50.2% took multivitamins, and only 35.0% were taking folic acid supplements (Table 3). These figures from Table 3 suggest that a substantial proportion of the women were not adhering to or not receiving certain key supplements (particularly folic acid) during their pregnancy. This gap in supplementation is reflected in our anaemia outcomes. Bivariate analysis (Table 7) showed that both folate supplementation and multivitamin use had significant associations with anaemia status, whereas most purely dietary factors (meal frequency, and consumption frequency of fruits, green leafy vegetables, milk, red meat) did not show statistically significant differences ($p > 0.05$ for those, Table 7). Specifically, women who took folate supplements had much lower prevalence of anaemia than those who did not. As shown in Table 7, 71.2% of pregnant women who were on folate supplements were not anaemic, compared to only 44.8% non-anaemic among those without folate supplementation (in other words, 55.2% of non-supplementers were anaemic). This difference was highly significant ($\chi^2 = 23.07$, $p < 0.001$), and corresponded to a markedly reduced risk: folate supplement use was associated with a ~72% lower odds of anaemia (unadjusted OR = 0.28, 95% CI 0.14–0.57). The beneficial impact of folic acid is not surprising, given that folate deficiency can cause megaloblastic anaemia and that folate is crucial for the increased red cell production in pregnancy. The fact that only one-third of our participants took folate may have contributed to both the high overall anaemia rate and the specific cases of macrocytosis/macrocytic anaemia we did observe. Similarly, multivitamin supplementation (which typically included iron and folic acid among other vitamins) was associated with better haemoglobin status. Among women who took prenatal multivitamins, 59.1% were not anaemic, whereas among those who did not take multivitamins the majority (54.7%) were anaemic ($\chi^2 = 5.659$, $p = 0.017$; Table 7). This indicates a protective effect of multivitamins in general. However, when adjusted for other factors in multivariate analysis, multivitamin use itself was not a significant independent predictor (Table 7, adjusted OR ~1.02, $p > 0.05$), possibly because its effect overlaps with folate and iron supplementation (i.e. women on multivitamins often were on iron/folate too).

Interestingly, iron supplementation on its own did not show a statistically significant association with anaemia in this study ($p \approx 0.08$ in χ^2 test, Table 7). There was a positive trend – among women who were taking iron, 55.4% were non-anaemic (i.e. 44.6% were anaemic), whereas among those not on iron supplements, only 47.5% were non-anaemic (52.5% anaemic). This suggests that iron supplements did confer some benefit, but the difference wasn't large enough to reach significance, possibly due to issues of adherence or the presence of other limiting nutrients. It's worth noting that most women were at least receiving iron (nearly 59% as noted), and those not on iron might include women who started pregnancy with better iron status or who couldn't tolerate supplements. The lack of a clear iron effect could also indicate that iron deficiency, while common, was not the only cause of anaemia here – other factors like folate deficiency and infections played a big role, as evidenced by their strong associations. As for dietary intake, we did not find significant differences in anaemia rates based on how frequently women consumed fruits, leafy greens, dairy, or meat (Table 7). For example, women who ate green leafy vegetables daily had about the same anaemia prevalence as those who ate them weekly or rarely (the proportions varied in the expected direction but not significantly, Table 7). A likely explanation is that nearly all participants had relatively similar diets (most ate these foods at least occasionally), and dietary recall may not capture quantity or bioavailability of nutrients. It may also be that supplementation (or lack thereof) overshadowed the contribution of diet in this particular cohort. Nonetheless, the trends did generally favor those with more frequent intake of iron- and vitamin-rich foods – for instance, those who *rarely* ate green vegetables or fruits tended to have higher anaemia percentages than those who ate them more often (Table 7). Overall, our findings highlight that nutritional supplementation, especially with folic acid (and by extension a full prenatal multivitamin), is critical in preventing anaemia in pregnancy. A comprehensive approach addressing all potential deficiencies is needed. This aligns with the recommendations of Khan *et al.* (2010), who identified lack of adequate supplement use as a significant contributor to maternal anaemia. Ensuring better compliance with iron and folate supplementation, as well as improving overall diet quality, could substantially reduce anaemia among pregnant women in Accra.

Factors Associated with Different Classes of Anaemia

Understanding the factors linked to each morphological class of anaemia can provide insights into the underlying causes. We performed a multinomial logistic regression (Table 8) to determine how various risk factors associate with microcytic, normocytic, and macrocytic anaemia specifically (with non-anaemic women as the reference group).

For microcytic hypochromic anaemia, two factors stood out as significant in our analysis: folate supplementation and birth spacing. Lack of folate supplementation was unexpectedly associated with increased risk of microcytic anaemia. Women who were taking folate had dramatically lower odds of developing microcytic anaemia than those who were not taking folate (adjusted OR = 0.22, 95% CI 0.09–0.53; $p = 0.001$, Table 8). This translates to about a 78% reduction in risk for microcytic anaemia among folate users. At first glance, this is surprising because microcytic anaemia is most commonly caused by iron deficiency, not folate deficiency (Massey, 1992). One possible interpretation is that women who diligently took folic acid might also have been more compliant with iron supplementation and overall antenatal care, thus improving their iron status indirectly. In contrast, women who did not take folate might represent generally poorer compliance or access to care, which could coincide with untreated iron deficiency. It is also possible some cases of microcytic anaemia were actually multifactorial (mixed iron and folate deficiency), so folate helped prevent those cases from manifesting as microcytosis. The second significant factor for microcytic anaemia was short birth interval. Women whose previous birth was

$\leq$2 years before the current pregnancy had a much higher likelihood of microcytic anaemia than those with >2 years between pregnancies (OR ~4.8, 95% CI ~2.0–11.4; $p < 0.001$, Table 8). This finding dovetails with our earlier result that short birth spacing increases overall anaemia risk, and it specifically indicates that closely spaced pregnancies are prone to iron-deficiency anaemia (which manifests as microcytic hypochromic blood pictures). Singal *et al.* (2018a) likewise identified interpregnancy interval under 2 years as a significant risk factor for microcytic anaemia, since the maternal iron reserves have insufficient time to recover. Iron supplementation itself did not show a significant effect in the microcytic model (Table 8) – the odds of microcytic anaemia were slightly lower for women on iron, but not to a meaningful extent (OR ~0.78, $p = 0.59$). This again might be due to widespread iron use in both anaemic and non-anaemic groups or varying adherence. Existing infection was also not significantly associated with microcytic anaemia in our multinomial results (OR ~1.34, $p = 0.746$), although the odds ratio >1 hints that infections could contribute to microcytosis in some cases (for instance, chronic inflammation can cause functional iron deficiency). In our context, infections (like malaria) likely caused more of normocytic anaemia (discussed below) than microcytic. It is worth noting, however, that malaria can sometimes present with microcytic anaemia due to iron sequestration and destruction of red cells – Bashawri *et al.* (2002) documented microcytic hypochromic anaemia in malaria cases. In our cohort, any such effect of infection on microcytosis was minimal compared to its effect on normocytosis. In summary, microcytic anaemia in these pregnant women was most strongly linked to inadequate folate (possibly a proxy for overall care) and short pregnancy spacing, reinforcing the need for nutritional support and family planning to prevent iron-deficiency anaemia.

For normocytic normochromic anaemia, the analysis identified infection, short birth spacing, folate supplementation, and gestational age as significant factors (Table 8). These align with the notion that normocytic anaemia often results from systemic or multifactorial stressors. The presence of an infection had the largest impact: pregnant women who had an infection were over four times more likely to have normocytic anaemia than uninfected women (adjusted OR ~4.2, $p < 0.01$, derived from Table 8). This strong association supports the concept of anaemia of inflammation – infections (malaria, HIV, tuberculosis, etc.) trigger inflammatory pathways that lead to a drop in haemoglobin, usually without changing red cell indices (Nobili *et al.*, 2014). Our finding is consistent with Quintero *et al.* (2011), who noted that even acute infections like malaria can cause significant anaemia in pregnancy (often normochromic unless coexistent iron deficiency). Short birth spacing was also associated with higher odds of normocytic anaemia (OR ~3.0 for $\leq$2 year interval vs >2 years). This indicates that close successive pregnancies not only cause iron-deficiency anaemia but can also lead to generalised anaemia (normocytic) perhaps through overall nutritional depletion and stress on the body. We also found that being in the second trimester (as opposed to third) significantly increased the risk of normocytic anaemia (OR ~2.0 vs third trimester; OR ~1.9 vs first trimester, per Table 8). In fact, second-trimester women were more prone to normocytic anaemia than to microcytic anaemia in our data. This again reflects the contribution of physiological anaemia of pregnancy (which is normocytic) in the mid-gestation period. By the third trimester, women who remain anaemic may increasingly include iron-deficient cases (microcytic), but in the second trimester much of the anaemia is dilutional or inflammation-related, hence normocytic. Folate supplementation showed a protective effect for normocytic anaemia as well – folate users had about an 82% lower odds of normocytic anaemia compared to non-users (adjusted OR ~0.18, $p < 0.01$, from Table 8). Folate is crucial for overall red blood cell production, so supplementation likely prevented many cases of mild normochromic anaemia that can develop when pregnant women become folate-deficient (even if iron is sufficient). It is notable that folate deficiency can cause macrocytosis; the fact that folate use is associated here with normocytic anaemia reduction suggests folate also helps prevent the early stages of anaemia that manifest as normocytic before progressing to macrocytic. On the other hand, consistent with the overall results, iron supplementation did not significantly affect the odds of normocytic anaemia in the adjusted model (Table 8). Normocytic anaemia is less directly tied to iron status and more to factors like infections and hemodilution, which explains why iron alone wasn't a key determinant for this class in our study.

Finally, regarding macrocytic anaemia, our study had very few cases (only 4 women had macrocytic anaemia, representing 2.8% of all anaemic cases). Consequently, we did not find any factor that was significantly associated with macrocytic anaemia in the multinomial analysis (Table 8). None of the examined predictors (education, age, supplements, etc.) showed a meaningful adjusted relationship with macrocytic outcomes, likely due to the small numbers and possibly because those few macrocytic cases might each have had distinct causes (e.g. one might be B12< deficient, another folate deficient, another due to an underlying condition). The rarity of macrocytic anaemia in our cohort could be attributed to the moderate folate status – although only a third took folate supplements, many might still get some folate from diet, and Ghana's antenatal care does recommend folic acid which some women took, preventing widespread macrocytosis. Our findings concur with other studies in the region that report macrocytic anaemia is uncommon among pregnant women (Asafo Akowuah *et al.*, 2022). From a public health standpoint, the lack of significant predictors for macrocytic anaemia suggests that the standard interventions (folate supplementation, improved nutrition) are broadly keeping overt macrocytic anaemia low, or that a larger sample would be needed to identify specific risk factors. Future research with a bigger sample of macrocytic cases could explore associations (for example, dietary habits or malabsorption issues) that we could not assess here. For now, ensuring all pregnant women receive folic acid supplementation remains the best strategy to prevent macrocytic anaemia, even though it was not a large problem in this study.

Overall, the discussion above integrates our findings with the existing literature and highlights how the data in our tables and figures support these interpretations. The tables (Tables 1–8) provide the quantitative evidence for each point – from the prevalence rates to the statistical associations – and the figures (Figure 1 and Figure 2) illustrate the overall anaemia burden and morphological breakdown. As shown in Table 8 and the related analyses, addressing identified risk factors such as short birth intervals, infections, and insufficient supplementation (especially folate) could substantially reduce both the overall prevalence of anaemia and its most common forms among pregnant women in Accra. The consistency of many of our findings with other studies reinforces their validity, while any contrasting observations (such as the timing of peak anaemia in pregnancy) offer useful insights for tailoring local antenatal care practices.

Conclusions

In this cross-sectional study of pregnant women at Korle Bu Teaching Hospital, nearly half of the participants were found to be anaemic (47.8%, 142/297), underscoring the high burden of anaemia in this population (Figure 1). Among the anaemic cases, normocytic normochromic anaemia was the most common morphological type (62.7%), followed by microcytic hypochromic anaemia (34.5%) and a small proportion of macrocytic anaemia (2.8%) (Figure 2). These findings indicate that while iron-deficiency (typically manifesting as microcytic hypochromic anaemia) is prevalent, a majority of the anaemia cases in this cohort were normocytic, pointing to multifactorial or non-iron causes in many women.

Several key risk factors for anaemia in pregnancy were identified across sociodemographic, clinical, and nutritional domains.Lower maternal educational attainment, engagement in physically exhaustive work, and poor knowledge about anaemia (including unawareness that pregnant women are particularly vulnerable to anaemia) emerged as significant contributors to the development of anaemia. In contrast, other sociodemographic characteristics such as maternal age, religion, family structure, and employment status showed no statistically significant association with anaemia in this study. Gestational age and pregnancy spacing were important determinants. Women in their second trimester had higher rates of anaemia compared to those in first or third trimesters. Similarly, a short inter-pregnancy interval (≤ 2 years since the last birth) was strongly associated with anaemia – women with close birth spacing had roughly three times the odds of being anaemic compared to those with a longer interval between pregnancies. The presence of an active infection during pregnancy (such as malaria or other illnesses) was also linked to significantly lower haemoglobin levels, with a majority (72.2%) of those reporting an infection being anaemic. On the other hand, clinical factors like gravidity (number of pregnancies) and number of antenatal clinic visits were not significantly related to anaemia risk in our cohort. Adequate micronutrient intake, particularly folate, was found to be protective. Insufficient folate supplementation (and by extension, multivitamin use) was the only dietary-related factor that showed a significant association with anaemia. Women who did not take folic acid supplements had a markedly higher prevalence of anaemia, with folate supplementation associated with a significantly reduced likelihood of anaemia (OR ~0.28). By contrast, adherence to iron supplementation, overall meal frequency, and the consumption of iron- and vitamin-rich foods (e.g. green leafy vegetables, fruits, milk, red meat) did not demonstrate a significant statistical association with anaemia in this analysis. It is notable, however, that most women had suboptimal daily intake of these nutrient-rich foods (as shown in Table 3), indicating that dietary insufficiencies were common even if they did not directly translate into differential anaemia outcomes in the study. This suggests that factors like folate (which is critical for red blood cell production) and possibly overall nutritional status play a more prominent role in anaemia risk than the frequency of consuming specific foods alone, or that our sample size was not large enough to detect smaller effects of diet and iron pill adherence.

Importantly, analysis of anaemia by morphological class revealed distinct patterns of association with risk factors. Short birth spacing and inadequate folate supplementation were more strongly linked to microcytic hypochromic anaemia, consistent with the notion that closely spaced pregnancies and folate/iron deficiencies can deplete maternal reserves and lead to smaller, pale red cells. In contrast, normocytic normochromic anaemia was most strongly associated with second-trimester status and infections. In fact, the influence of infection and mid-gestation on anaemia was more pronounced for normocytic cases than for microcytic cases, suggesting that inflammation or other pregnancy-related changes (rather than nutrient deficiencies alone) underlie much of the normocytic anaemia. Notably, poor folate status was also implicated as a contributor to normocytic anaemia, indicating overlap in how nutritional deficits can manifest in different morphological forms. No specific predictors were identified for the few macrocytic anaemia cases observed, likely due to their low number (only 2.8% of anaemic women) limiting statistical power. Overall, these findings highlight that anaemia in pregnancy at this setting is multifactorial – while iron/folate deficiency remains central, other factors like infections, pregnancy timing, birth spacing, and educational empowerment significantly impact haemoglobin levels.

Recommendations

1. Based on the above findings, we propose the following recommendations to improve antenatal care and maternal health, focusing on prevention, early detection, and education:

2. Invest in robust health education for women of reproductive age and pregnant women. Antenatal care (ANC) sessions should include counseling on anaemia risk factors particularly highlighting the importance of adequate birth spacing and infection prevention and on practical preventive measures (nutrition, hygiene, prompt treatment of illness). Empowering women with knowledge about anaemia has proven benefits, as our study showed that better awareness is associated with lower anaemia risk. Regular community health talks and one-on-one counseling during clinic visits can ensure that women are aware of the need for nutrient-rich diets, the usefulness of supplements, and the vulnerabilities of pregnancy (e.g. higher risk of anaemia).

3. Given the significant contribution of infections (particularly malaria in our region) to anaemia in pregnancy, existing programs for infection control should be intensified. This includes preventive measures such as providing free or subsidized insecticide-treated bed nets to all pregnant women and ensuring they are educated on their consistent use. Routine screening for common infections (e.g. malaria, helminths, urinary tract infections) should be integrated into ANC protocols, especially in endemic areas, so that infections are detected and treated early. Intermittent preventive treatment for malaria and deworming in pregnancy, as per local guidelines, should be strictly implemented. Strengthening infection screening and treatment during pregnancy will help reduce the proportion of normocytic anaemia attributable to chronic infections.

4. Health policies should ensure that essential micronutrient supplements are readily accessible to all pregnant women from the earliest antenatal visits. In our context, folic acid and multivitamins emerged as crucial, so these (along with iron supplements) should be provided free of charge or highly subsidized as soon as pregnancy is confirmed. Early initiation and strict compliance with prenatal iron-folate supplementation regimens should be encouraged through follow-up and possibly reminder systems, as supplementation was a vital determinant of anaemia status in this study. ANC clinics can adopt strategies like directly observed supplement intake or weekly pill counts to improve adherence. By improving both access and adherence to supplementation, we can address nutritional gaps that contribute to maternal anaemia.
5. Family planning and spacing of pregnancies should be promoted as a key strategy to prevent anaemia and improve maternal outcomes. Counseling on postpartum family planning should be a routine part of antenatal and postnatal care. Women (and their partners) should be informed about the benefits of waiting at least 2 years after a birth before conceiving again, as closely spaced pregnancies were associated with significantly higher anaemia risk in our findings. Strengthening family planning services and access to effective contraception will empower women to achieve healthy spacing between pregnancies, thereby allowing time to rebuild nutritional stores (iron, folate) and reduce physiological stress, ultimately lowering the risk of anaemia in subsequent pregnancies.
6. Given that physically strenuous labor was linked to anaemia in our cohort, it is important to advise that pregnant women avoid excessive strenuous work and receive adequate rest. Families and communities should be sensitized to support expectant mothers by sharing workloads and reducing heavy physical tasks for them. Additionally, even though our study did not find a statistically significant link between dietary frequency and anaemia, most women reported inadequate intake of iron- and vitamin-rich foods (Table 3). This highlights the need for continued nutritional support and counseling. Dietary improvement programs – for example, nutrition workshops or cooking demonstrations at ANC clinics – can encourage increased consumption of iron-rich foods (leafy greens, beans, meat), folate sources, and fruits. Where diet alone is insufficient due to socio-economic constraints, linking women with nutritional support programs or fortified foods is recommended. Ensuring a balanced diet and mitigating extreme physical strain during pregnancy are general health measures that, alongside medical interventions, will contribute to better haemoglobin levels and pregnancy outcomes.

Limitations

1. Like all research, this study has limitations that must be acknowledged when interpreting the results:
2. The study's sample (n = 297) was slightly below the initially calculated target (370) and was drawn from a single tertiary hospital's ANC clinic. This relatively small, facility-based sample may limit the power to detect associations, particularly for less common forms of anaemia such as macrocytic anaemia, and it may affect the generalizability of the findings to all pregnant women in the wider community. The convenience sampling of women attending ANC (excluding those who do not seek antenatal care) means the results might not capture the full spectrum of anaemia risk in the general pregnant population.
3. Key data on risk factors were collected through participant self-report (questionnaires), including dietary intake frequencies, supplement adherence, and history of infections. Such self-reported information is subject to recall bias and social desirability bias. For instance, some women might not accurately remember or may over/under-report their intake of certain foods or use of supplements. Similarly, without objective verification, participants' reports of "no infection" could be incorrect if they had asymptomatic or undiagnosed infections. The lack of biochemical validation for nutritional status (e.g. no serum ferritin or folate levels measured) means we inferred deficiencies from self-report and morphological blood indices rather than confirming them biochemically.
4. The study did not include laboratory screening for infections in all participants – it depended on the women's own knowledge and reporting of having an infection. This is a limitation because conditions like malaria, helminth infections, or other illnesses can be present without clear symptoms, potentially leading to misclassification of some anaemic women as "no infection" when in fact an occult infection contributed to their anaemia. Future studies should incorporate routine screening (e.g. blood film for malaria, stool tests for parasites, etc.) to more accurately assess the impact of infections on anaemia in pregnancy.
5. This research was cross-sectional, capturing a single time-point in pregnancy for each participant. As a result, we can identify associations between risk factors and anaemia status, but we cannot establish causality or the temporal sequence of events. For example, while we observed that infections and second trimester were associated with anaemia, we cannot definitively conclude that the infection or being in second trimester *caused* the anaemia – it is possible that anaemia itself (or other unmeasured factors) could predispose to infections, or that women who are anaemic early might progress differently. Longitudinal studies or trials would be needed to confirm causal relationships and the directionality of these associations.

Despite these limitations, the study provides valuable insight into the prevalence and morphological types of anaemia in pregnancy and identifies actionable risk factors within the Ghanaian context. The findings can inform targeted interventions such as educational programs, improved supplement distribution, infection control in pregnancy, and family planning services to help reduce anaemia and improve maternal health outcomes. By addressing the modifiable factors highlighted and strengthening antenatal care strategies accordingly, health practitioners and policymakers can work towards lowering the burden of anaemia among pregnant women.

Conflict of interest

There is no conflict of interest

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