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Prenatal care and maternal haemoglobin concentration at childbirth: insights from a district hospital

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Abstract

Background: Antenatal care (ANC) encompasses clinical assessments, health advice, and medical guidance on maternal changes, nutrition, and supplements to promote maternal and fetal well-being and thus prevent pregnancy-related complications. Despite these efforts, maternal anaemia remains prevalent in resource-limited settings such as the Kwaebibirim district in the eastern region of Ghana.

Objective: This study aimed to explore the link between the frequency of ANC visits and increased maternal haemoglobin concentration (mHgbc) levels.

Methods: This study employed an analytical cross-sectional design using secondary data from birth registers in the district hospital's labour suite to assess variations in mHgbc levels across different ANC visit frequencies. Statistical analyses included descriptive analysis, one-way ANOVA and unpaired two-sample t-tests.

Results: The mean number of ANC visits was 6.06 (SD 3.23), and the mean mHgbc was 10.34 g/dl (SD 1.42). ANC visits ranged from 0 to 16, while mHgbc levels ranged from 1.6 g/dl to 16.3 g/dl. Most women attended 4 - 8 ANC visits (54.7%), followed by 0 - 3 visits (23.25%) and ≥ 9 visits (22.1%). A higher frequency of ANC visits was associated with higher mHgbc levels. One-way ANOVA revealed significant differences in mean mHgbc among the 0 - 3, 4 - 8, and ≥ 9 ANC visit groups. Post hoc unpaired two-sample t-tests confirmed significant differences in mean mHgbc between 0 - 3 vs. 4 - 8 and 4 - 8 vs ≥ 9 visits. However, no significant differences were observed between 0 - 3 and 4 - 8 visits in women aged 21 – 30 years, those with senior high school education, formal occupations, and multiparae. Similarly, preterm or early-term deliveries and women with blood group A showed no significant differences between 4 - 8 and ≥ 9 visits.

Conclusion: Increased ANC visit frequency is associated with higher mHgbc levels. However, further prospective studies are needed to identify which ANC components underlie this observation and further address the limitations of secondary data.

Keywords: Antenatal, maternal haemoglobin, anaemia

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INTRODUCTION

Prenatal care or antenatal care (ANC) involves clinical assessments, health advice, and the provision of medical information on maternal physiological changes and prenatal nutrition, including vitamin supplements. This comprehensive approach aims to prevent potential health complications during pregnancy while promoting the well-being of both the pregnant woman and the developing foetus [1,2].

In high-income countries, traditional ANC practices typically entail monthly consultations during the initial two trimesters, spanning from the 1st to the 28th week of gestation. From the 28th to the 36th week, appointments are scheduled bi-weekly, transitioning to weekly assessments from the 36th week until delivery, extending to the 38th to 42nd week. These protocols involve evaluating parental needs and family dynamics [3]. Despite the conventional development of ANC since the early 1900s, empirical evidence establishing its superiority as the optimal approach for prenatal care remains insufficient [3]. The World Health Organisation (WHO) recommends at least eight ANC visits during pregnancy, up from the previous

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minimum of four, to better identify and manage health issues and enhance immunisation opportunities. Despite ANC's critical role in maternal and infant health, many pregnant women do not adhere to the recommended eight visits, and evidence supporting its frequency and content is limited [3,4].

Proposals to reduce ANC visits for low-risk pregnancies have been countered by trials suggesting fewer visits may lead to increased Neonatal Intensive Care Unit admissions and longer hospital stays, though chance may influence outcomes [3]. A 2015 Cochrane Review suggested that in resource-limited settings with infrequent visits, reducing visit frequency might lead to higher perinatal mortality rates [3]. The effectiveness of reduced visits models thus remains uncertain, particularly in low-income countries where pregnant women already exhibit limited visits at appointments [2]. Early ANC visits are paramount, and implementing flexible pathways allowing for additional visits from the time of booking could enhance care for individuals initiating care later in pregnancy. Women with fewer visits express lower satisfaction with the care received compared to those adhering to the standard visit count [2,3]. Telemedicine presents novel alternatives for certain appointments [5,6].

In 2015, the WHO reported about 830 daily maternal deaths worldwide from pregnancy and childbirth complications, with only five (5) of such occurrences in high-income countries. This underscores the vast disparity, with most maternal deaths concentrated in low-income countries [6,7]. A Spanish study (1997 – 2008) on early and low-birth weight deliveries among local and immigrant women linked disparities to ANC attendance. Among 21,708 births, immigrants had higher rates of very preterm births (before 32 weeks of gestation) and very low birth weight (< 1500 g), emphasising the importance of universal ANC access [8,9]. ANC involves monitoring prenatal health through regular check-ups, including medical history review, blood pressure (BP) monitoring, anthropometric measurements, pelvic exams, doppler foetal heart rate checks, and blood and urine tests. Effective communication with pregnant women throughout pregnancy is prioritised [10-12]. ANC services include iron and folate supplementation (IFS), nutritional guidance, helminthic infestation therapies, and presumptive Intermittent Preventive Therapy with sulfadoxine-pyrimethamine (IPTp-SP).

ANC services are offered gratis to all pregnant women to improve maternal health during pregnancy. Of particular relevance to this study, these services include iron and folate supplementation (IFS), nutritional guidance, presumptive treatment for helminthic infestations, intermittent preventive treatment with sulfadoxine-pyrimethamine (IPTp-SP), tetanus immunisation, blood pressure monitoring, urine testing, syphilis screening, hepatitis B and HIV screening, and health education. In a recent study conducted in the Kwaebibirem municipal area of the Eastern Region, Ghana, a notably high prevalence of maternal anaemia (MA) was observed, with rates reaching 71.2%. This finding is particularly concerning given that ANC coverage in the region was reported at 60.7% over the period from 2021 to 2023 [13]. This coverage comprises a calculated fraction of statistically projected expected births, representing approximately 4% of the municipal population. Approximately 89.6% of pregnant women made at least four visits.

MATERIALS AND METHODS

Study Area

The study was conducted at Kade Government Hospital in the Eastern administrative region of Ghana. This area exemplifies the common tripartite health model found in Ghanaian districts, consisting of district hospitals, health centres, and Community-Based Health Planning and Services (CHPS), which are akin to community clinics. The district hospital constitutes the primary hub for clinical healthcare services, delivering comprehensive maternal care, including ANC, labour and delivery, postnatal care, and emergency obstetric services. Health centres, operating at an intermediate level, offer basic maternal care services, including ANC, uncomplicated labour/delivery, and postnatal care. CHPS compounds offer limited ANC services, referrals for high-risk pregnancies, health education, and immunisations to pregnant women. This structured approach ensures accessible and comprehensive care for pregnant women across different levels of healthcare facilities. Service availability may vary depending on location and resource availability.

Study design

Although data were collected over a five-year period (2018 – 2023), each observation reflects a single point in time, typically at delivery. The study is described as analytical because it seeks to identify patterns and associations between mHgbc and ANC attendance, including differences across specific subgroups. Particularly notable is the comparison of cohorts of women based on the total number of ANC visits attended throughout pregnancy, irrespective of timing. These absolute visit counts were not aligned with current WHO recommendations, which define quality ANC based on timing and content across trimesters [14,15]. The district hospital records an average of 55.27 (SD ± 10.94) monthly ANC registrants and 449.18 (SD ± 43.56) monthly ANC attendants. We therefore assessed whether different total ANC visit counts during pregnancy were significantly associated with mHgbc at delivery.

Study setting

This study was conducted at the maternity/labour suite of the Kade Government Hospital, the primary referral health facility serving the municipal area. Accredited by the National Health Insurance, the hospital has a bed capacity of eighty-five and serves as the sole referral facility in Kwaebibirem, facilitating approximately 60 - 80 monthly births. Centrally located in Kade's municipal capital, the

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hospital serves an estimated population of 127,434, including approximately 3,114 women of reproductive age, and provides district-level health services. These figures are based on the Ghana Statistical Service's projected 2% annual population growth rate for 2021 (Ghana 2021 Population and Housing Census, Volume 3).

Study population and sampling

The study analysed obstetric records from Kade Government Hospital spanning 2018 to 2023. The sampling frame included all eligible birth records within this period. Systematic sampling was employed, selecting every second entry from the birth registers to enhance statistical rigour and generalizability. The starting point was randomly determined using a dice roll, and the sampling interval (2) was based on this result, with every second record selected thereafter. This approach ensured comprehensive coverage of the entire period. Records lacking mHgbc data were excluded to ensure internal validity. Trained research assistants used a pretested data collection tool, similar to a standardised questionnaire, to extract relevant information. When a record was excluded due to missing mHgbc data, the subsequent record in the sequence became the new starting point, continuing with every second record according to the systematic sampling procedure. Excluded records were not deliberately replaced, as the sample size was sufficient to accommodate exclusions without compromising statistical power or representativeness. Although systematic sampling can introduce periodicity bias, it was deemed appropriate for this study due to its practicality, transparency, and ability to minimise selection bias, thereby providing an accurate representation of the population's diversity. Maternal Anaemia (MA) was defined by mHgbc, with a threshold of less than 11.0 g/dl, aligning with healthy, iron-supplemented women. During the third trimester, MA was operationally defined as mHgbc below 11.0 g/dl, consistent with typical ranges for that period of gestation.

Assumptions included the absence of hemoglobinopathies among parturient women. MA severity was categorised based on mHgbc: 10.9 - 10 g/dl as mild, 9.9 - 7 g/dl as moderate, and 6.9 or less g/dl as severe MA. Analysis did not extend to mHgbc of 4 g/dl or less beyond the severe MA range. Pre-delivery mHgbc, measured within four weeks prior to delivery, was utilised to classify MA to mitigate potential post-delivery fluctuations from blood loss. Hospital protocols further ensure mHgbc is measured close to delivery to guide obstetric management and reduce risks from MA. Although we assumed all recorded mHgbc values were recent and adequate for clinical decisions, we acknowledge that outliers of remote mHgbc measurements, while rare, cannot be entirely excluded. To streamline data abstraction, the birth register was divided into four segments. The first segment comprised personal details of the parturient women: age, residential classification (urban/peri-urban or rural), highest education level, gravidity, and parity. The second segment included ANC indicators such as mHgbc, ANC attendance status and frequency, gestational age at birth, IPTp-SP doses, maternal 'ABO' phenotypic blood groups, and health statuses for syphilis, hepatitis B, and HIV, alongside systolic and diastolic blood pressure (S- & DBP). We used the single predelivery BP available for each patient as the representative value and excluded postdelivery BPs. We calculated the mean SBP and DBP for trichotomised BP groups (< 120, 120 - 139, ≥ 140 mmHg for SBP and < 80, 80 - 89, ≥ 90 mmHg for DBP) as proxies for all predelivery BP values during pregnancy.

The third segment focused on neonatal health evaluation at birth, including the APGAR score, foetal heart rate, fetal respiration within 30 minutes, foetal presentation, and fetal dimensions. The fourth section of the birth register records post-delivery complications such as postpartum haemorrhage, antepartum haemorrhage, and obstructed labour. Urban/peri-urban and rural communities were categorised based on statistical service population thresholds; urban areas have at least 5,000 inhabitants, while peri-urban areas are adjacent to urban areas with similar social dynamics. Married and cohabiting parturient women were grouped together based on perceived similarities in their dynamics. We did not anticipate missing records from the birth register, as professional obstetric nurses are required to document every birth as part of the Civil Registration and Vital Statistics (CRVS) system. Non-ANC attendants were included in the study due to the significance of their mHgbc readings, regardless of their attendance status. Their mHgbc levels corresponded to mean mHgbc estimates analysed for specific strata.

Sample size

The sample size was determined using the openEPI statistical software, considering summary data. The estimated percentage frequency (p) of the outcome factor was based on a prior study of MA prevalence in the Kwaebibirem municipal area, which reported a high prevalence of 71.2% using a similar study design [13]. A total of 1901 observations, representing records of parturient women who delivered at the hospital's maternity/labour suite, were entered into Epi Info 3.5.1 for further data analysis at a 95% confidence level. This choice aimed to enhance internal validity, reinforcing the generalizability of our results to diverse settings. This sample size was considered large enough to improve statistical power, generalizability, precision, reliability, stability, facilitate subgroup analysis, and better control for confounding variables.

Management and analysis of data

The analysis initially examined baseline characteristics of parturient women by proportions across different ANC visit categories and the burden of mHgbc less than 11.0 g/dl. This included stratum-specific analyses of maternal and pregnancy characteristics, presenting absolute numbers and percentages per characteristic. One-way ANOVA assessed the effect of varying ANC visit levels on mHgbc, comparing means across three independent groups (0 - 3, 4

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- 8, and ≥ 9 ANC visits) after confirming the normality of mHgbc distribution using the Shapiro-Wilk test. The test yielded a p-value of 0.069, indicating insufficient evidence to reject the null hypothesis of normality, with a computed W statistic of 0.97, suggesting near unity and indicative of normality. Skewness (-0.44) indicated a slight leftward skew, and excess kurtosis (-0.26) suggested a mesokurtic distribution, with no significant outliers detected. Therefore, the Shapiro-Wilk test suggested that the sample data did not substantially deviate from normal distribution, supporting the use of one-way ANOVA.

The F-statistic, degrees of freedom, and associated p-value from the Chi-squared test were used to evaluate differences in mean mHgbc across trichotomised ANC visit categories. Results from both parametric (assuming normal distribution) and non-parametric Kruskal-Wallis tests were reported. A post hoc assessment using two-sample t-tests, adjusted with Bonferroni correction ($\alpha = 0.01$) to minimise Type I error risk, determined statistically significant differences between ANC visit categories as suggested by the F-statistic. Specifically, we assessed variations in mean mHgbc between 0 - 3 vs. 4 - 8 ANC visits and 4 - 8 vs. ≥ 9 ANC visits. Data were analysed using OpenEpi, Epi Info 3.5.3, the GraphPad Prism version 10.3.1 and a T-test calculator.

RESULTS

ANC visits ranged from 0 to 16, while mHgbc ranged from 1.6 to 16.3 g/dL. Mostly (54.7%), parturient women had 4 - 8 ANC visits, with 23.25% having 0 - 3 visits and 22.1% having ≥ 9 visits. The prevalence of mHgbc, categorised as mild, moderate, and severe MA, decreased with more ANC visits. Increased ANC visits shifted the prevalence of MA toward the 11.0 g/dL threshold, considered the lower limit of normal mHgbc (Table 1). The overall mean mHgbc was 9.85 g/dL (± 1.63) with 0-3 ANC visits, 10.31 g/dL (± 1.30) with 4 - 8 ANC visits, and 10.75 g/dL (± 1.33) with ≥ 9 ANC visits. A linear increase in mean mHgbc with higher ANC visits was observed, except among women aged 40 years and above. Variations in mean mHgbc across ANC visit categories were assessed using one-way ANOVA, focusing on subgroup analyses. Significant differences were found across the 0 - 3, 4 - 8, and ≥ 9 ANC visit categories, indicating a consistent rise with increasing ANC visits. Exceptions included women with tertiary education, grand multiparae, no IPTp-SP exposure during pregnancy, blood group AB, those not screened or positive for syphilis, lack of hepatitis B screening, non-screened or HIV-positive status, and those with SBP ≥ 140 mmHg and DBP ≥ 90 mmHg (Table 2).

The significance of variations in mHgbc between 0 - 3 vs. 4 - 8 ANC visits and 4 - 8 vs ≥ 9 visits was further assessed with an unpaired two-sample t-test as a post hoc analysis. Only ascending trends in mean mHgbc with increasing numbers of ANC visits were analysed. Declines in mean mHgbc for ≥ 9 visits were excluded from the analysis. The results indicated a predominant, significant increase in mean mHgbc with an increasing number of ANC visits. No significant variation in mean mHgbc was found between 0 - 3 and 4 - 8 ANC visits among women aged 21 - 30, those with senior high school education, those in formal occupations, and multiparae. Additionally, no significant variation in mean mHgbc was found between both 0 - 3 vs. 4 - 8 and 4 - 8 vs. ≥ 9 visits in grand multiparae, those not exposed to IPTp-SP, those with blood group AB, syphilis-positive women, those not tested for hepatitis B or HIV during pregnancy, HIV-positive women, and women with

Table 1. Evaluation of the trends and distribution patterns of maternal haemoglobin concentrations <11.0 g/dl by number of ANC visits

Characteristic	Maternal Hemoglobin concentration (in g/dl) – N (%)								
	0-3 ANC visits			4-8 ANC visits			≥9 ANC visits		
	≤6.0	7.0-9.9	10.0-10.9	≤6.0	7.0-9.9	10.0-10.9	≤6.0	7.0-9.9	10.0-10.9
Age group									
≤20 years	8(8.2)	69(70.4)	21(21.4)	2(1.3)	85(54.8)	68(43.9)	0(0.0)	11(45.8)	13(54.2)
21-30 years	3(3.2)	51(53.7)	41(43.2)	3(1.0)	160(54.4)	131(44.6)	3(2.3)	57(44.5)	68(53.1)
31-40 years	3(8.3)	24(66.7)	9(25.0)	1(0.5)	95(49.0)	98(50.5)	1(1.6)	24(39.3)	36(59.0)
≥41 years	1(9.1)	7(63.6)	3(27.3)	0(0.0)	10(55.6)	8(44.4)	0(0.0)	5(100)	0(0.0)
Residence									
Urban	8(7.6)	60(57.1)	37(35.2)	2(0.7)	156(53.1)	136(46.3)	4(3.1)	51(39.2)	75(57.7)
Rural	7(5.3)	89(66.9)	37(27.8)	4(1.1)	187(52.5)	65(46.3)	0(0.0)	46(53.5)	4045.5
Educational background									
≤ Junior high school	13(6.2)	131(62.4)	66(31.4)	4(0.8)	285(55.7)	223(43.6)	2(1.5)	64(47.1)	70951.5)
Senior high school	2(7.4)	18(66.7)	2(25.9)	2(1.6)	60(48.8)	61(49.6)	293.4)	27(46.6)	29(50.0)
Tertiary	0(0.0)	3(75.0)	1(25.0)	0(0.0)	4(20.0)	16(80)	0(0.0	7(29.2)	17(70.8)
Occupation									
Formal	0(0.0)	10(66.7)	5(33.3)	1(2.0)	24(49.0)	24(49.0)	0(0.0)	8(30.8)	18(69.2)
Non-formal	9(5.2)	108(62.1)	57(32.8)	3(0.6)	286(52.8)	253(46.7)	4(2.2)	80(44.4)	96(53.3)

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Table 1. Cont.

Characteristic	Maternal Hemoglobin concentration (in g/dl) – N (%)								
	0-3 ANC visits			4-8 ANC visits			≥9 ANC visits		
	≤6.0	7.0-9.9	10.0-10.9	≤6.0	7.0-9.9	10.0-10.9	≤6.0	7.0-9.9	10.0-10.9
Parity									
Para 1	9(6.1)	101(68.2)	38(25.7)	5(1.4)	191(53.1)	164(45.6)	1(0.8)	55(43.3)	71(55.9)
Para 2-4	6(8.0)	37(49.3)	32(42.7)	0(0.0)	127(53.4)	111(46.6)	3(3.7)	38(46.9)	40(49.4)
≥ Para 5	0(0.0)	14(73.7)	5(26.3)	1(1.6)	32(51.6)	29(46.8)	0(0.0)	5(45.5)	6(54.5)
Term status									
Preterm (< 36 weeks)	5(17.2)	13(44.8)	11(37.9)	1(1.9)	28(51.9)	25(46.3)	0(0.0)	2(66.7)	1(33.3)
Early term (37-38 weeks)	3(4.3)	44(62.9)	23(32.9)	2(1.2)	89(53.9)	74(44.8)	1(1.9)	25(46.3)	28(51.9)
Full term (39-40 weeks)	5(5.5)	57(62.6)	29(31.9)	1(0.3)	156954.2)	131(45.5)	2(1.9)	42(48.9)	64(59.3)
≥ Late term (≥ 41 weeks)	0(0.0)	28(73.7)	10(26.3)	2(1.6)	59(47.6)	63(50.8)	1(2.0)	25(51.0)	23(46.9)
IPTp-SP during pregnancy									
Yes	2(2.6)	48(61.5)	28(35.9)	1(0.3	172(49.6)	174(50.1)	3(2.2)	58(42.3)	76(55.5)
No	2(11.1)	11(61.1)	5(27.8)	1(6.3)	8(50.0)	7(43.8)	0(0.0)	2(66.7)	1(33.3)
ABO Phenotypic blood group									
A	6(14.6)	27(65.9)	8(19.5)	0(0.0)	65(51.6)	61(48.4)	1(2.1)	24(50.0)	23(47.9)
AB	0(0.0)	7(77.8)	2(22.2)	0(0.0)	11(68.8)	5(31.3)	0(0.0)	1(25.0)	3975.0)
B	3(7.5)	22(55.0)	15(37.5)	1(0.9)	54(48.2)	57(50.9)	0(0.0)	17(42.5)	23(57.5)
O	5(4.5)	63(57.3)	42(38.2)	4(1.1)	192(54.9)	154(44.0)	2(1.8)	50(45.0)	59(53.2)
Syphilis status									
Positive	0(0.0)	6(85.7)	1(14.3)	0(0.0)	8(61.5)	5(38.5)	0(0.0)	0(0.0)	2(100)
Negative	14(6.4)	113(61.0)	71(32.6)	6(1.0)	328(52.1)	295(46.9)	4(1.9)	93(44.1)	1143(54.0)
Not done	1(12.5)	6(75.0)	1(12.5)	0(0.0)	4(66.7)	2933.3)	0(0.0)	4(100)	0(0.0)
Hepatitis B status									
Positive	0(0.0)	10(83.3)	2(16.7)	1(4.3)	12(52.2)	10(43.5)	0(0.0)	2(25.0)	6(75.0)
Negative	14(6.5)	135(60.5)	71(32.9)	5(0.8)	326(52.5)	290(46.7)	4(2.0)	91(44.6)	109(53.4)
Not done	1(16.7)	3(50.0)	2(33.3)	0(0.0)	3(50.0)	3(50.0)	0(0.0)	2(66.7)	1933.3)
HIV status									
Positive	0(0.0)	2(66.7)	1(33.3)	0(0.0)	6(50.0)	6(50.0)	0(0.0	2(100)	0(0.0)
Negative	14(6.3)	141(62.9)	69(30.8)	6(1.0)	332(52.8)	291(46.3)	3(1.4)	91(43.8)	114(54.8)
Not done	1(25.0)	2(50.0)	1(25.0)	0(0.0)	2(100)	0(0.0)	1(20.0)	2(40.0)	2(40.0)
Systolic blood pressure									
115.21 mmHg (±10.85)	12(6.7)	114(64.0)	52(29.2)	5(1.0)	269(53.4)	230(45.6)	3(1.8)	78(46.2)	88(52.1)
131.80 mmHg (±5.13)	1(3.8)	15(57.7)	10(38.5)	0(0.0)	27(48.2)	29(51.8)	0(0.0)	8(38.1)	13(61.9)
152.47 mmHg (±15.71)	0(0.0)	12(6.7)	6(33.3)	0(0.0)	31(51.7)	29(48.3)	1(5.6)	6(33.3)	11(61.1)
Diastolic blood pressure									
68.18 mmHg (±7.24)	11(7.5)	100(64.5)	44(28.4)	4(0.9)	232(53.7)	196(45.4)	2(1.4)	71(48.3)	74(50.3)
82.91 mmHg (±3.23)	2(4.3)	30(65.2)	14(30.4)	1(0.8)	69(55.6)	54 (43.5)	1(2.6)	14(35.5)	24(61.5)
98.07 mmHg (±11.34)	0(0.0)	10(50.0)	10(50.0)	0(0.0)	26(41.9)	36(58.1)	1(4.5)	7(31.8)	14(63.6)

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Table 2. Evaluation of patterns of mean maternal hemoglobin concentration analyzed by the number of ANC visits

Characteristic	Mean (±SD) maternal hemoglobin concentration			ANOVA	Mann-Whitney/Wilcoxon Two-Sample Test (Kruskal-Wallis test for two groups)
	0-3 ANC visits	4-8 ANC visits	≥9 ANC visits	F-statistic (p-value)	Chi square (p-value)
Age group					
≤20 years	9.34 (1.78)	10.17 (1.23)	10.60 (0.93)	17.82 (0.00001)	33.65 (0.00001)
21-30 years	10.24 (1.40)	10.35 (1.39)	10.69 (1.42)	5.70 (0.0035)	14.24 (0.0008)
31-40 years	9.98 (1.67)	10.35 (1.23)	10.98 (1.26)	13.12 (0.00001)	26.20 (0.00001)
≥41 years	9.49 (1.52)	10.64 (1.15)	9.75 (0.68)	4.63 (0.01)	7.19 (0.027)
Residence					
Urban	9.78 (1.54)	10.37 (1.34)	10.76 (1.39)	21.68 (0.00001)	43.71 (0.00001)
Rural	9.91 (1.70)	10.31 (1.27)	10.72 (1.23)	14.44 (0.00001)	25.63 (0.00001)
Educational background					
≤Junior high	9.79 (1.63)	10.32 (1.31)	10.69 (1.24)	28.20 (0.00001)	52.23 (0.00001)
Senior high	9.92 (1.71)	10.18 (1.30)	10.54 (1.60)	3.08 (0.047)	8.35 (0.015
Tertiary	10.52 (1.55)	10.90 (1.11)	11.27 (1.08)	2.20 (0.11)	2 (0.18)
Occupation					
Formal	10.23 (1.64)	10.37 (1.41)	11.12 (1.06)	6.11 (0.0028)	12.60 (0.0018)
Non-formal	9.93 (1.53)	10.34 (1.26)	10.70 (1.37)	22.28 (0.00001)	44.38 (0.00001)
Parity					
Para 1	9.65 (1.68)	10.31 (1.40)	10.72 (1.32)	28.80 (0.00001)	57.64 (0.00001)
Para 2-4	10.15 (1.63)	10.37 (1.16)	10.78 (1.37)	8.32 (0.0003)	16.74 (0.0002)
≥Para 5	9.90 (1.15)	10.21 (1.28)	10.46 (1.02)	1.92 (0.14)	4.11 (0.12)
Term status					
Preterm	9.62 (1.93)	10.40 (1.57)	11.03 (1.72)	3.82 (0.024)	4.90 (0.086)
Early term	9.75 (1.64)	10.25 (1.26)	10.49 (1.32)	6.85 (0.0012)	12.00 (0.0025)
Full term	10.01 (1.59)	10.35 (1.22)	10.82 (1.33)	16.14 (0.00001)	35.69 (0.00001)
≥Late term	9.88 (1.39)	10.37 (1.40)	10.75 (1.31)	6.53 (0.0017)	15.63 (0.0004)
IPTp-SP during pregnancy					
Yes	10.06 (1.50)	10.46 (1.29)	10.83 (1.36)	13.57 (0.00001)	32.38 (0.00001)
No	9.68 (1.73)	9.91 (1.65)	10.30 (1.69)	0.34 (0.70)	0.91 (0.63)
ABO Phenotypic blood group					
A	9.85 (1.92)	10.30 (1.19)	10.48 (1.19)	3.76 (0.024)	6.38 (0.041)
AB	9.51 (1.53)	10.46 (1.54)	10.90 (1.31)	2.78 (0.07)	4.83 (0.08)
B	9.76 (1.75)	10.32 (1.29)	10.81 (1.13)	9.38 (0.0001)	13.59 (0.0011)
O	9.86 (1.60)	10.34 (1.31)	10.87 (1.31)	24.72 (0.00001)	44.61 (0.00001)
Syphilis status					
Positive	9.67 (1.65)	10.54 (1.51)	11.30 (0.81)	2.07 (0.14)	4.59 (0.10)
Negative	9.87 (1.66)	10.32 (1.30)	10.75 (1.34)	33.47 (0.00001)	65.13 (0.00001)
Not done	8.80 (1.31)	10.10 (1.32)	9.96 (1.13)	2.42 (0.11)	3.04 (0.21)
Hepatitis B status					
Positive	9.35 (1.04)	10.45 (1.69)	11.15 (0.97)	6.04 (0.0039)	13.33 (0.0013)
Negative	9.85 (1.66)	10.32 (1.29)	10.72 (1.33)	32.03 (0.00001)	60.31 (0.00001)
Not done	9.20 (1.49)	10.17 (1.30)	10.78 (1.07)	2.26 (0.13)	3.54 (0.17)
HIV status					
Positive	10.04 (1.08)	9.95 (1.64)	10.67 (2.93)	0.24 (0.78)	0.23 (0.88)
Negative	9.84 (1.65)	10.33 (1.30)	10.78 (1.23)	40.32 (0.00001)	73.15 (0.00001)
Not done	9.16 (1.94)	10.36 (1.55)	8.70 (3.55)	0.68 (0.52)	1.58 (0.45)
Systolic blood pressure					
115.21 mmHg (±10.85)	9.77 (1.65)	10.29 (1.29)	10.66 (1.34)	26.93 (0.00001)	52.78 (0.00001)
131.80 mmHg (±5.13)	10.09 (1.59)	10.57 (1.17)	11.03 (1.16)	5.65 (0.0042)	8.66 (0.013)
152.47 mmHg (±15.71)	10.26 (1.64)	10.46 (1.24)	10.63 (1.39)	0.57 (0.56)	1.25 (0.53)
Diastolic blood pressure					
68.18 mmHg (±7.24)	9.75 (1.73)	10.26 (1.26)	10.63 (1.22)	23.95 (0.00001)	42.84 (0.00001)
82.91 mmHg (±3.23)	9.77 (1.32)	10.34 (1.29)	10.84 (1.56)	10.22 (0.0001)	25.27 (0.0000)
98.07 mmHg (±11.34)	10.63 (1.32)	10.71 (1.32)	10. 79 (1.44)	0.13 (0.87)	0.81 (0.81)

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Table 3. Evaluation of mean maternal hemoglobin concentration variations by maternal and pregnancy characteristics using unpaired two-sample t-test

Characteristic	0 - 3 vs. 4 - 8 ANC visits			4-8 vs. ≥ 9 ANC visits		
	t-test	df	CI (p-value)	t-test	df	CI (p-value)
Age groups						
≤20 years	4.95	323	-1.15 to -0.50 (0.0001)	2.11	245	-0.82 to -0.03 (0.0350)
21-30 years	0.81	569	-0.37 to 0.15 (0.41)	2.93	649	-0.56 to -0.11 (0.0035)
31-40 years	1.91	325	-0.74 to 0.009 (0.056)	4.35	396	-0.84 to -0.31 (0.0001)
≥41 years	2.74	42	-1.99 to -0.30 (0.0088)	-	-	-
Residence Area						
Urban	4.40	618	-0.85 to -0.32 (0.0001)	3.64	721	-0.60 to -0.17 (0.0003)
Rural	3.33	686	-0.63 to -0.16 (0.0009)	3.49	649	-0.64 to -0.17 (0.0005)
Educational background						
≤Junior high	5.35	1010	-0.72 to -0.33 (0.0001)	3.86	975	-0.55 to -0.18 (0.0001)
Senior high	1.08	200	-0.73 to 0.21 (0.2799)	1.93	249	-0.72 to 0.0056 (0.053)
Tertiary	0.78	43	-1.35 to 0.59 (0.43)	1.63	96	-0.81 to 0.079 (0.10)
Occupation						
Formal	0.027	90	-0.72 to 0.70 (0.97)	3.30	124	-1.19 to -0.30 (0.0013)
Non-formal	4.18	1007	-0.60 to -0.21 (0.0001)	4.17	1083	-0.52 to -0.19 (0.0001)
Parity						
Para 1	5.27	706	-0.90 to -0.41 (0.0001)	3.72	737	-0.62 to -0.19 (0.0002)
Para 2-4	1.55	447	-0.49 to 0.058 (0.1210)	3.42	490	-0.64 to -0.17 (0.0007)
≥Para 5	1.10	110	-0.86 to 0.24 (0.2709)	1.33	102	-1.06 to 0.20 (0.1841)
Term status at birth						
Preterm	2.37	118	-1.43 to -0.12 (0.019)	1.07	86	-1.79 to 0.53 (0.28)
Early term	2.94	323	-0.83 to -0.16 (0.0034)	1.45	312	-0.56 to 0.083 (0.14)
Full term	2.55	538	-0.60 to -0.07 (0.010)	4.35	612	-0.68 to -0.25 (0.0001)
≥Late term	2.18	224	-0.93 to -0.048 (0.029)	2.16	267	-0.72 to -0.034 (0.031)
IPTp-SP						
Yes	2.81	623	-0.67 to -0.12 (0.0050)	3.73	783	-0.56 to -0.17 (0.0002)
No	0.45	43	-1.25 to 0.79 (0.6533)	0.50	24	-1.98 to 1.20 (0.61)
Maternal ABO phenotypic blood groups						
Group A	2.12	229	-0.86 to -0.031 (0.035)	1.09	244	-0.50 to 0.14 (0.27)
Group AB	1.78	337	-2.03 to 0.13 (0.083)	0.85	37	-1.47 to 0.59 (0.39)
Group B	2.52	215	-0.99 to -0.12 (0.012)	2.78	232	-0.83 to -0.14 (0.0058)
Group O	3.69	643	-0.73 to -0.22 (0.0002)	4.96	713	-0.73 to -0.32 (0.0001)
Syphilis						
Positive	1.39	27	-2.14 to 0.40 (0.17)	1.07	23	-2.22 to 0.70 (0.29)
Negative	4.81	1191	-0.63 to -0.26 (0.0001)	5.36	1247	-0.58 to -0.27 (0.0001)
Hepatitis B						
Positive	2.19	47	-2.10 to -0.090 (0.033)	1.62	52	-1.56 to 0.16 (0.11)
Negative	5.03	1176	-0.65 to -0.28 (0.0001)	4.94	1245	-0.55 to -0.24 (0.0001)
Not done	1.33	13	-2.53 to 0.59 (0.20)	0.95	13	-1.99 to 0.77 (0.35)
HIV						
Positive	0.11	17	-1.58 to 1.76 (0.91)	0.65	16	-3.06 to 1.62 (0.52)
Negative	5.29	1198	-0.67 to -0.30 (0.0001)	5.74	1272	-0.60 to -0.29 (0.0001)
Not done	1.14	9	-3.57 to 1.17 (0.28)	1.04	10	-1.86 to 5.18 (0.31)
Systolic blood pressure						
115.21 mmHg (±10.85)	4.97	934	-0.72 to -0.31 (0.0001)	4.04	985	-0.54 to -0.19 (0.0001)
131.80 mmHg (±5.13)	1.91	127	-0.97 to 0.01 (0.05)	2.15	133	-0.88 to -0.038 (0.032)
152.47 mmHg (±15.71)	0.70	123	-0.76to 0.367 (0.48)	0.65	127	-0.68 to 0.34 (0.51)
Diastolic blood pressure						
68.18 mmHg (±7.24)	4.50	794	-0.73 to -0.28 (0.0001)	2.43	837	-0.66 to -0.071 (0.015)
82.91 mmHg (±3.23)	2.96	240	-0.94 to -0.19 (0.0033)	2.63	253	-0.87 to -0.12 (0.0088)
98.07 mmHg (±11.34)	0.31	148	-0.58 to 0.42 (0.75)	0.32	151	-0.56 to 0.40 (0.74)

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SBP ≥ 140 mmHg and DBP ≥ 90 mmHg. Among preterm or early term deliveries and women with blood group A, variations were insignificant only for 4 - 8 vs ≥ 9 ANC visits (Table 3).

DISCUSSION

ANC is a comprehensive framework designed to support pregnant women through critical interventions, including iron and folic acid supplementation (IFS), nutritional counselling, presumptive helminthic infestation therapy, and intermittent preventive treatment with sulfadoxine-pyrimethamine (IPTp-SP). These services are provided from the time of registration through to childbirth, with a primary goal of elevating mHgbc to 11 g/dL or higher, either directly or indirectly. This study employed a stratified, subgroup-focused approach to investigate whether the relationship between ANC visits and mHgbc varies across different subpopulations of pregnant women. By identifying differences among subgroups, this research aimed to generate new hypotheses for future studies, potentially using alternative methodologies to examine the effectiveness of ANC visit frequency on mHgbc within distinct groups. Overall, the findings indicate a general trend of increased mHgbc with a higher number of ANC visits, suggesting a predictive role of ANC in enhancing mHgbc levels. However, some exceptions warrant further investigation into these subgroup-specific variations.

These findings, which are particularly pronounced in certain subgroups, align with existing literature. Ikeanyi et al. conducted a study to assess whether ANC attendance prevents MA at term among Nigerian women [16]. The investigators measured mHgbc levels at the initial booking and at term, comparing the proportion of anaemic individuals at booking with those at term. Using a retrospective cross-sectional comparative approach, 3,442 pregnant women were recruited at a South Nigerian mission hospital from 2009 to 2013. Approximately 33.0% had a hematocrit below 33% at booking, indicating a 32.2% prevalence of MA at this stage. By term or at childbirth, 21.4% of eligible subjects had their anaemia corrected, reflecting a prevention rate of 69.9%, with 9.2% still experiencing MA despite ANC attendance. The investigators concluded that high-quality ANC is a valuable preventive intervention to reduce the prevalence of MA, highlighting the need to ensure its widespread availability, accessibility, and affordability for all pregnant women. Our findings, however, further emphasise that subgroup analysis reveals varying outcomes or factors influencing the effectiveness of ANC [16].

Saapiire et al. conducted a cross-sectional study in Wa Municipality, Ghana, assessing the utilisation of antenatal care (ANC) services and their impact on maternal anaemia (MA) among pregnant women. Their findings are consistent with ours; despite 80.2% of women reporting sufficient ANC services, the overall adequacy of ANC was only 44.2%. After adjusting for confounders, women with inadequate ANC attendance were 2.3 times more likely to experience MA in the third trimester compared to those with adequate ANC attendance [17]. When comparing our study to that of Kofie et al., both studies suggest that increased ANC may reduce MA. Kofie et al. identify specific ANC practices, such as intensified iron and folic acid supplementation, that improve maternal haemoglobin levels. In contrast, our study finds that higher ANC frequency is associated with reduced MA prevalence, but does not specify which ANC services contribute to this reduction. Thus, while Kofie et al. detail effective practices, our study emphasises the general benefit of more frequent ANC visits [18].

Similarly, our findings align with Mishra et al. [19], who highlighted ANC's role in managing MA through iron and folic acid supplementation and educational interventions. However, they also identified poor adherence and limited awareness of MA symptoms as major barriers to its effectiveness. These factors may help explain anomalies in our data—such as among educated or employed women—where higher health literacy did not translate into significantly elevated mHgbc. This indicates that knowledge alone is insufficient without consistent adherence and supportive systems like structured follow-up or individualised counselling. Mishra et al.'s emphasis on personalised care may further clarify why certain subgroups in our study, such as formal workers, showed limited gains, possibly due to time constraints that reduced participation in counselling sessions and weakened the impact of ANC frequency. Massawe et al. [20] emphasised

The results of this study, consistent with existing literature, showed a trend of higher mHgbc with increased ANC visits, though some subgroups deviated from this pattern. Differences in mean mHgbc among these exceptional subgroups across the trichotomised ANC visit categories—and in post hoc comparisons between 0–3 vs 4–8 and 4–8 vs ≥9 ANC visits—were not statistically significant when tested using one-way ANOVA and unpaired t-tests. The unpaired t-test corroborated the findings from the ANOVA F-statistic and Kruskal-Wallis chi-squared test, confirming both significant and insignificant predictive roles of ANC visits on mean mHgbc. Due to data limitations, we did not explore the specific reasons for the exceptional trends in some subgroups. No significant variation in mean mHgbc between 0 - 3 and 4 - 8 ANC visits was observed among women aged 21 - 30, those with senior high school education, formal occupations, and multiparae. Similarly, no significant differences were found between 0 - 3 vs 4 - 8 and 4 - 8 vs ≥ 9 visits in grand multiparae, those not exposed to IPTp-SP, with blood group AB, syphilis-positive women, those untested for hepatitis B or HIV, HIV-positive women, and those with SBP of 153.45 mmHg (± 15.71) and DBP of 98.07 mmHg (± 11.34). Among preterm or early-term deliveries and women with blood group A, differences were insignificant only for 4 - 8 vs ≥ 9 visits.Further studies are needed to explore the few subgroups that showed no significant difference in mean mHgbc acr oss 0 - 3, 4 - 8,

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and ≥ 9 ANC visits, as this exceeds the scope of our study [21]. We recommend investigating these relationships using alternative models in future research. Although this study demonstrates positive correlations between ANC attendance and higher mean mHgbc, it remains unclear why this correlation does not consistently raise mean mHgb concentrations to levels above the optimal 10.99 g/dl. While the study shows associations between higher ANC visits and higher mHgbc, caution is needed when attributing causation due to the limitations of secondary data, which may not capture all factors influencing mHgbc during pregnancy. Future research should explore beyond routine interventions like IFS, IPTp-SP, and presumptive helminthic therapies, focusing on dietary counselling, increased screening for maternal anaemia, and other interventions to address low mHgbc. Evaluating factors that complement ANC services and prevent maternal anaemia is challenging, often requiring speculative hypotheses. This study cannot account for all unrecorded interventions that may have impacted mHgbc, as the birth register data were not originally collected for research. Interventions beyond standard ANC could have significantly influenced the increase in mean mHgbc among attendees.

Attributing our findings to specific interventions like routine IFS, presumptive helminthic therapies, or nutrition counselling is challenging due to the limitations of secondary data. Factors beyond the ANC package likely contribute to the observed rise in mean mHgbc with increasing ANC visits. The observed variations may reflect the influence of diverse clinical interventions that we could not control for, given their complexity and the use of secondary data. While cross-sectional studies limit causal inference, our methodology offers insights into how varying ANC visits may impact mHgbc. We emphasise the critical role of ANC, as any intervention contributing to the observed increase in mHgbc likely occurred within the ANC framework. However, we cannot confidently assert that ANC reduces the risk of MA despite its apparent association with increased mHgbc. Understanding and enhancing this relationship is crucial for achieving mHgbc levels consistent with normal iron-supplemented populations. Identifying specific ANC aspects that impact mHgbc improvement exceeds this study's scope. Prospective studies monitoring pregnant women throughout ANC are needed to better understand the factors influencing mHgbc.

Conclusion

We observed a tendency for mHgbc to increase with a higher frequency of ANC visits, which aligns with previous research. However, exceptions were identified in subgroups such as women aged 21 - 30, preterm deliveries, non-exposure to IPTp-SP, mild and severe MA, positive HIV status, and those with high BP. While our findings offer insights into this association, we acknowledge limitations due to the use of secondary data not routinely collected for research. This limitation made it difficult to control for factors such as blood transfusions used to manage moderate to severe MA, which are not captured in birth registers. We recommend further prospective studies with larger sample sizes to prevent data reduction in subgroup analyses. These studies should aim to better understand the impact of specific ANC services on mHgbc, while controlling for clinical interventions outside traditional ANC services.

DECLARATIONS

Ethical consideration

Ethical approval was obtained from the Ghana Health Service Ethics Review Committee (GHS-ERC: 007/05/24).

Consent to publish

All authors agreed on the content of the final paper.

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None

Competing Interest

The authors declare no conflict of interest

Author contribution

The authors conceptualised and designed the study. The first author conducted data analysis with support from the second author. Both authors prepared the draft manuscript following data collection and analysis.

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Availability of data

Data is available upon request to the corresponding author

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