Factors Associated With Anaemia in Pregnancy: a Retrospective Cross-sectional Study in Northern Ghana

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Research

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Abstract

Background: Anaemia in pregnancy (AIP) is associated with adverse pregnancy outcomes. AIP occurs when a pregnant woman's haemoglobin level falls below 11.0 g/dl, and 10.5g/dl specifically in the second trimester of pregnancy if adjustment for haemodilution is considered. This study assessed the prevalence of AIP at antenatal care (ANC) registration, 28 weeks and 36 weeks of pregnancy gestation and the correlates of AIP in the Bolgatanga Municipality of northern Ghana.

Methods: A retrospective cross-sectional design was implemented among a random sample of 372 pregnant women within 36-40 weeks of pregnancy gestation, who were receiving ANC in the Bolgatanga Municipality. Data were collected via clinical records review and a questionnaire-based survey between October and November, 2020. Using the Statistical Package for Social Science, descriptive analysis of haemoglobin levels and the prevalence of anaemia was done and binary logistic regression was used to identify the correlates of AIP.

Results: At ANC registration, the prevalence of AIP was 35.8% (95%CI:30.9, 40.9) which decreased to 25.3% (95%CI:20.9, 30.0) after Haemodilution. At 28 weeks of gestation, the AIP prevalence was 53.1% (95%CI:45.8, 60.3) which fell to 37.5 (95%CI:30.6, 44.8) with haemodilution. At 36 weeks of pregnancy, AIP prevalence was 44.8% (95%CI:39.2, 50.4) without the need for haemodilution. At 5% significance level, the odds of AIP at registration increased if the woman registered for ANC after the first trimester of pregnancy and at a regional hospital but decreased if she registered at a private hospital. At 28 weeks of gestation, age group 26 – 35 years, Christianity, high wealth and tertiary education were associated with lower odds of AIP. At 36 weeks of gestation, booking after first trimester of pregnancy was associated with higher odds whilst high wealth, higher age groups (26–35 and 36–49 years) and secondary education of spouse were associated with reduced odds of AIP.

Conclusion: AIP consistently increased from registration to 36 weeks of gestation. Given the observed correlates of AIP, we recommend that interventions aimed at encouraging early ANC registration, improved household wealth, and improved maternal education are required to reduce AIP.

Plain English Summary

Pregnant women who have very low blood levels are said to be suffering from anaemia in pregnancy (AIP). AIP can lead to abortion or death of the pregnant woman. Interventions provided during antenatal care (ANC) are expected to contribute to reducing the risk of AIP. We determined the proportion of women that were anaemic at the time of their registration for ANC, during their 28 and 36 weeks of pregnancy, and the characteristics of pregnant women that are associated with AIP in the Bolgatanga Municipality in Ghana. We analysed data extracted from the ANC records of 372 pregnant women and also administered a questionnaire. The results showed that, at ANC registration, 35.8% of the women were already anaemic; at 28 weeks of gestation, 53.1% of them were anaemic; and at 36 weeks of pregnancy, 44.8% of them remained anaemic. At the point of ANC registration, women who delayed in starting ANC or were receiving ANC at the regional hospital were more likely than those receiving ANC at private hospitals to be anaemic. At 28 weeks of gestation, those aged 26 – 35 years, Christians, the rich and those with tertiary education were less likely to be anaemic. At 36 weeks of gestation, the elderly, the rich, educated or early ANC registrants were less likely to experience AIP. We recommend interventions encouraging early ANC registration, improved household wealth, and improved maternal education to address AIP.

Background

Anaemia in pregnancy (AIP) is a pathophysiological state in pregnancy resulting from a woman's haemoglobin level falling below 11.0g/dl [1–3]. The World Health Organisation (WHO) further recommends a threshold of 10.5g/dl for AIP diagnosis in the second trimester of pregnancy, which is the peak of haemodilution [4–6]. However, Ghana uses 11.0g/dl to diagnose AIP in all pregnant women across the three trimesters of pregnancy [2, 3]. AIP is diagnosed by red blood cell counts using Automatic Haemoglobin Analyzer or photometric devices [1, 7, 8]. Since anaemia impairs the functioning of every human organ including that of the human reproductive system [7, 9–11], AIP has been linked to several undesirable pregnancy-related outcomes including intrauterine growth restriction, poor "Appearance, Pulse, Grimace, Activity, and Respiration" score, preterm birth, stillbirths, postpartum haemorrhage, abortion, low birthweight, perinatal and maternal mortalities [7, 12–17]. Pregnancy increases vulnerability to anaemia due to induced physiological changes [7, 17–23]. While poor production or abnormal loss of red blood cells during pregnancy [24] is the immediate cause of AIP, this is often triggered by a preceding hierarchy of factors including malnutrition and food insecurity, pre-existing disease conditions, insanitary and unhealthy environment, poor individual or household level socio-economic characteristics such as low education and unemployment and poor access to appropriate healthcare including antenatal care (ANC).

ANC has been established as an effective means of controlling AIP [3, 5]. ANC composes of a set of interventions that addresses the underlying causes of AIP, including iron folate supplementation, infection prevention, identification and management of non-communicable diseases, early detection and management of AIP as well as referral to higher care level for effective management of AIP [3, 5]. ANC also includes social and behavioural change communication activities including health education, counselling, advocacy, and community mobilization meant to prevent AIP [2, 3, 5, 25]. During ANC, three mandatory haemoglobin level checks are done, at registration, at 28 weeks and at 36 weeks of gestation to enable the detection, prevention and treatment of anaemia [3, 5]. Once AIP is detected and treatment commences, bi-weekly haemoglobin checks are recommended for monitoring progress of treatment [26]. With expansion of geographical service coverage, through the Community-based health Planning and Services (CHPS) model, about 98% of pregnant women attend ANC and about 89% had at least four ANC visits during pregnancy in Ghana [27].

Despite the increased ANC attendance and the comprehensive AIP control interventions, including iron folate supplementation, provided during ANC, studies have shown that the global prevalence of AIP remains around 40.1% [7, 28, 29]. Asia has the highest burden of AIP (48.7%) and Africa being the second hardest hit with a prevalence of 46.3% [30]. The AIP prevalence in Sub-Saharan Africa is estimated between 44% - 48% [31, 32]. Both the Ghana Demographic and Health Survey in 2014 and the Ghana Micronutrients Surveys in 2017 reported the AIP prevalence as 45% in Ghana [33, 34]. An earlier cross-sectional study in the Bolgatanga Municipality of the Upper East Region of Ghana reported a relatively higher AIP prevalence of 50.4% [35]. These studies have mainly assessed the prevalence and determinants of AIP in Ghana and beyond [35–45]. However, only two studies done elsewhere [46, 47] assessed changes in haemoglobin levels and anaemia statuses of women in the course of pregnancy. To the best of our knowledge, we could not identify studies in Ghana assessing how haemoglobin levels and consequently anaemia statuses of pregnant women changed in the course of pregnancy gestation This study, therefore, assessed changes in haemoglobin levels and the prevalence of anaemia at ANC registration, at 28 weeks and 36 weeks of gestation and the socio-economic factors associated with AIP at these stages of pregnancy.

Methods

Study setting

The study was conducted in health facilities providing ANC in the Bolgatanga Municipality of Ghana. The Bolgatanga Municipality has a total population of 130,890; a female population of 67,062 (51.2%) of which 31,414 (24.0%) are women in the reproductive age of 15-49. With a total fertility rate of 3.0 per woman, about 5,236 pregnancies were expected in 2020 [48]. The Municipality has 41 health facilities located in its nine sub-municipalities. These comprises one regional hospital, seven private health facilities, six public health centres, six clinics, 24 CHPS compounds and one maternity home[49]. Out of this, 28 of the facilities were providing ANC services in 2020 but18 have laboratories for running the recommended ANC tests including haemoglobin check-ups. The remaining health facilities used portable devices and test kits for haemoglobin checking or referred their clients to other facilities for haemoglobin check-up. Coverage of ANC in 2019 was 93% with a three-year average of 91% in the Municipality [48]. Nearly three-quarters (72.4%) made a 4th visit before delivery. In 2019, haemoglobin checked at registration was near universal (97%) but only about 52% at 36 weeks of gestation [48].

Study design and sampling

The study employed a quantitative retrospective cross-sectional design. All women in 2020 who registered for ANC before 28 weeks and had reached 36 weeks of gestation during the period of data collection were legible to be included in the study. Those with known genetic causes of anaemia and had encountered severe bleeding were excluded.

With a target population of 4,765 expected ANC registrants in 2020, a confidence interval of 95% and a margin of error of 0.05, the sample size(n) for the study was estimated as 369 using the Yamane Taro's formula[50] given as:

$$\mathrm{n} = \frac{\mathrm{N}}{1 + \mathrm{Ne}^2} = \frac{4765}{1 + 4765 \times 0.05 \times 0.05} = 369$$

Approximately 11.5% was added to cater for potential non-response, resulting in a total sample of 411.

A proportionate sample, based on the number of ANC registrants per facility, was drawn from each of the 28 facilities offering ANC in the Municipality. At the facility level, simple random sampling using random numbers was used to select the number of respondents allotted to each facility. The ANC registers of the various facilities constituted the sampling frame.

Data Collection

A survey and records review were conducted between October 21 and November 19, 2020. Data on the timing of ANC registration, number of ANC visits, haemoglobin check-ups, and other socio-demographic characteristics etc. of the sampled respondents were extracted from the maternal and child health record book and laboratory results slips using a pre-prepared checklist made of indicators of care often recorded in the ANC register. On the other hand, a structured questionnaire was used to collect data on household food security and additional sociodemographic characteristics including household assets, that were not captured in the medical records. Table 1 presents a description of the key variables that were covered by our data collection.

Both the checklist and the questionnaire were pretested. This enabled the researcher to review, identify gaps and refine the tools. The final tools were digitalized using Kobo Collect App. Four data collectors were trained for a face-to-face administration of the questionnaire and the filling of the checklist. All research assistants were either diploma or bachelor's degree holders. The majority of the data collection was done at the premises of the health facilities. It took about 20-30 minutes to administer each of questionnaire. The researchers first made contact visits to the health facilities to identify legible respondents who were then sampled for the study. The midwifes at the sampled health facilities, who know the schedules of the women for ANC, assisted the data collectors in the final contact and selection of the respondents. Where the respondents failed to attend ANC, efforts were made to visit them at their residences to administer the questionnaire to them.

Table 1
Description of the key variables used in the data collection

Variable	Type of variable	Definition of variable	Scale of variable	Categories
Anaemia in Pregnancy (AIP)	Dependent	Hb less than 11g/dl in all trimesters. Hb of 10.5g/dl for second trimester to adjust for haemodilution	Binary	Anaemic or Non-anaemic (normal)
Severity of anaemia	Dependent	Categorization based on the severity of reduced haemoglobin level below the anaemia cut-off point (11g/dL)		≥ 11g/dL = Normal or no anaemia; 10.9 – 9.9g/dL = Mild anaemia; 8.9 – 7g/dL = moderate anaemia; & < 7g/dL = severe anaemic
Marital status	Independent	having customarily or legally bounded or devoted partner the respondent is living with who has initiated the process of meeting the legal or customary requirement for marriage	Binary	single or married
Type of marriage	Independent	Either monogamous or polygamous marriage	Binary	Monogamous, Polygamous
Type of ANC Provider	Independent	The care level of facility the woman receives ANC	Nominal	CHPS, Health Centre, Private /District Hospital, Regional Hospital
Religion	Independent	The religious affiliation of the respondents	Nominal	Christianity, Islam & African Traditional Religion
Type of toilet	Dependent	the means by which respondent's household dispose of human excreta and their abilities to prevent diseases related anaemia classified as improved when it better prevents diseases otherwise unimproved.	Binary	Improved or unimproved
Health status		Self-rated health status of respondents	Ordinal	Poor & Fair, good, very good and excellent
Parity	Independent	The number of deliveries a woman has had	Ordinal	0, 1, 2, and ≥ 3
Age group	Independent	The age category of respondent	Ordinal	15 – 25, 26 – 35 and ≥ 36
Place of residence	Independent	Defined as rural, peri-urban or urban	Nominal	rural, peri-urban or urban
Occupation group (respondents or spouses)	Independent	Sector of the economy respondent or her spouse operates including students or the unemployed.	Nominal	Unemployed, Formal Sector Worker & Informal Sector Worker
Educational status	Independent	Educational level reached by the respondent and spouse	Ordinal	No formal Education, Basic Education, Secondary education, Tertiary education
Household Food Security Status	Independent	The levels of anxiety and uncertainty of food supply, quality, (in)sufficiency and frequency of intake of food by household members measured by the Food Insecurity Access scale.	Ordinal	Severe Food insecure, Mild – Moderate insecure and Food Secure
Household Wealth Index quintile	Independent	Quintile of ranked summary index of principal components analysis of selected 15 household assets (clock, radio, television, telephone, refrigerator, freezer, tablet, TV channel decoder, bed, table, cabinet/cupboard, bank account, toilet facility used, source of drinking water and electricity)	Ordinal	Quintile 1, 2, 3, 4 & 5

Data analysis

All analyses were done using the Statistical Package for Social Science. Univariate analysis of categorical variables such as, parity, level of education and occupation. was done using frequencies and percentages and that of numerical variable such as haemoglobin levels, food insecurity score, age, etc. were summarised using mean, and standard deviations. A wealth index was constructed using principal component analysis based on data collected on household assets [51]. Two parametric inferential statistical analyses were done. First, dependent samples t-test was used to compare means of haemoglobin levels at ANC registration, at 28 weeks, and at 36 weeks of gestation in order to assess the statistical significance of changes in haemoglobin levels over the period of ANC. The corresponding changes in the prevalence of AIP within ANC registration, 28 weeks and 36 weeks of gestation were tested using McNemar test with significant changes accepted at p-values ≤ 0.05., Binary logistic regression was used to assess the association between the various socio-economic and demographic characteristics of the mothers and their anaemia statuses at each of the three stages of haemoglobin assessment and results presented in adjusted odd ratios (AORs) within 95% confidence interval (CI).

Results

Socio-economic characteristics of the respondents

Out of the 411 pregnant women sampled for the study, 375 (91.2%) of them responded. However, due to incomplete data from three respondents, the sample size was reduced to 372 during data analysis. Table 2 presents the basic characteristics of the respondents. The mean and median ages of the respondents were both 27. The highest proportion of the women (47.0%) were within the middle reproductive age group of 26 – 35 years and resided in urban (33.6%) communities. Most (84.1%) of them were Christians, married (94.1%), attained only basic education (44.9%) and were unemployed (44.3%), 42.5% of the respondents lived in food secured households and 45.7% registered for ANC at health centres.

Table 2
Basic characteristics of the respondents (N = 372)

variable	**Frequency**	**Percentage (%)**
Age (years)		
15 - 25	158	42.5
26 - 35	175	47.0
36 - 49	39	10.5
Type of residence		
Rural	131	35.2
Peri urban	116	31.2
Urban	125	33.6
Religion of Woman		
Christian	313	84.2
Islam	12	3.2
African Traditional Religion	47	12.6
Marital status		
Married	350	94.1
Single	22	5.9
Type of marriage		
Monogamy	327	93.4
Polygamy	23	6.6
Woman education		
No formal Education	47	12.6
Basic Education	167	44.9
Secondary	97	26.1
Tertiary	61	16.4
Occupation		
Unemployed	165	44.3
Formal Sector Workers	55	14.8
Informal Sector Workers	152	40.9
Food Security Status		
Severe Food secure	81	21.8
Mild - Moderate	133	35.9
Food Secure	158	42.5
Type of Household toilet		
Unimproved Facility	241	64.8
Improved Facility	131	35.2
Parity		
0	100	26.9
1	121	32.5
2	75	20.2
≥3	76	20.4
Health status		
Poor & Fair	18	4.8

variable	Frequency	Percentage (%)
Good	133	35.8
Very Good	128	34.4
Excellent	93	25.0
Type of ANC Provider		
CHPS	96	25.8
Health Centre	170	45.7
Hospital	44	11.8
Regional Hospital	62	16.7

Haemoglobin levels and AIP at the three stages of assessment

Figure 1 presents the distribution of haemoglobin levels of the women at the three stages of assessment. Haemoglobin levels were recorded for all the 372 pregnant women at ANC registration, 192 at 28 weeks of gestation and 315 at 36 weeks of gestation. The median haemoglobin level at registration was 11.5g/dl with a mean value of 11.37±1.5g/dl. At 28 weeks of pregnancy, the median haemoglobin level decreased to 10.9g/dl with a mean value of 10.84±1.25. A slight rise in haemoglobin levels was observed at 36 weeks with a median of 11.10g/dl and mean of 11.06±1.26g/dl.

As shown in Table 3, 35.8% (95% CI of 30.9% - 40.9%) of the women were anaemic at ANC registration but this AIP prevalence was reduced to 25.3% (95%CI: 20.9% - 30.0%) after adjustment for haemodilution for those registering in their second trimester of pregnancy. At 28 weeks of gestation, 53.1% (95% CI of 45.8% - 60.3%) of the pregnant women were anaemic but when adjustment was made for haemodilution, this prevalence reduced to 37.5% (95%CI 30.6 - 44.8). At the 36 weeks of gestation, the AIP prevalence, decreased slightly to 44.8% (95% CI of 39.2%– 50.4%). At 36 weeks, haemodilution is resolved to levels that no longer require adjustment.

Table 3
Prevalence of anaemia at the three stages of haemoglobin test among pregnant women

Variable	Sample	Number anaemic	Prevalence (%)	95% CI for p		p value
				Lower	Upper	
At Registration	372	133	35.8	30.9	40.9	<0.001
HA* at Registration	372	94	25.3	20.9	30.0	<0.001
At 28 weeks gestation	192	102	53.1	45.8	60.3	<0.001
HA* at 28 weeks	192	72	37.5	30.6	44.8	<0.001
At 36 weeks of gestation	315	141	44.8	39.2	50.4	<0.001
*HA = Haemodiluted adjusted Anaemia (10.5g/dl cut off for anaemia)						

The severity of AIP at the various stages of gestation is illustrated in Figure 2. At registration, 19.9% of the women had mild and 15.8% had either moderate or severe AIP. After haemodilution, 13.7% of the registrants had mild and 11.6% had moderate or severe anaemia at registration. At 28 weeks of gestation, 32.8% of the women had mild and 20.7% had either moderate or severe anaemia, and at 36 weeks of gestation, 27.0% of the women had mild and 17.8% had moderate or severe anaemia

Table 4 presents a paired t-test results showing changes in haemoglobin levels within the three stages of assessment. There were statistically significant differences in haemoglobin levels within the three stages of assessment. Women lost an average of 0.3g/dl of haemoglobin between registration and 28 weeks but after adjusting for haemodilution, the difference was no longer statistically significant. A loss of 0.31g/dl of haemoglobin was observed between registration and 36 weeks. An average gain of 0.25 was observed between 28 weeks and 36 weeks but a loss of similar proportion was seen after adjusting for haemodilution. A segregated analysis showed that haemoglobin loses were only seen among women who registered non-anaemic. For those who registered non-anaemic, an average loss of 0.88g/dl was observed between registration and 28 weeks and 0.80g/dl between registration and 36 weeks. On the other hand, anaemic registrants gained 0.51g/dl, 0.39g/dl and 0.62g/dl between registration and 28 weeks, 28 weeks and 36 weeks and registration and 36 weeks respectively.

Table 4
Paired t-test showing change in haemoglobin levels between the three stages

Time points during ANC	Overall sample	Non-anaemic at registration	Anaemic at registration
Change in unadjusted HB between 28 weeks and Registration			
28weeks (M)	10.84	11.33	10.16
Registration(M)	11.13	12.21	9.65
Mean Diff	-0.30	-0.88	0.51
95% CI	(-0.51) – (-0.09)	(-1.10) – (-0.67)	0.18 – 0.84
t-value	-2.80	-8.15	3.05
df	191	110	80
p-value	0.006	0.000	0.003
Change in between adjusted Hb 28 weeks and unadjusted Registration			
HaHb* at 28 weeks(M)	11.33		
Registration(M)	11.13		
Mean Diff	-0.20		
95% CI	(-0.41) – 0.01		
t-value	-1.92		
df	191		
p-value	0.056		
Change in unadjusted Hb between 36 weeks and 28 weeks			
36 weeks (M)	11.12	11.15	10.55
28weeks(M)	10.87	11.34	10.15
Mean Diff	0.25	0.16	0.39
95% CI	0.09 – 0.42	(-0.06) – 0.38	0.14 – 0.65
t-value	3.02	1.45	3.10
df	132	97	64
p-value	0.003	0.150	0.003
Change between unadjusted Hb at 36 weeks and Adjusted Hb at 28 weeks			
36 weeks(M)	11.12		
HaHb at 28 weeks(M)	11.37		
Mean Diff	-0.25		
95% CI	(-0.41) – 0.08		
t-value	-2.94		
df	161		
p-value	0.004		
Change in unadjusted HB between 36 weeks and Registration			
36weeks (M)	11.06	11.42	10.39
Registration(M)	11.37	12.21	9.77
Mean Diff	-0.31	-0.80	0.62
95% CI	(-0.47) – (-0.15)	(-0.97) – (-0.63)	0.36 – 0.88
t-value	-3.76	-9.38	4.74
df	314	204	109
p-value	0.0000	0.000	0.000
*HaHb Haemodiluted adjusted haemoglobin (at 28 weeks adjusted by +0.5g/dl), M = mean			

Factors associated with AIP during ANC

Table 5 presents the results from the binary logistic regression models on the association between socio-economic characteristics and anaemia status at the three stages of assessment.

Table 5
Socio-economic factors with anaemia at the three stages of haemoglobin check during ANC

Category	Registration		HA at Registration		28 weeks		HA at 28 weeks		36 weeks	
	AOR (95%CI)	P	AOR (95%CI)	P	AOR (95%CI)	P	AOR (95%CI)	P	AOR (95%CI)	P
Age										
15 - 25	Ref		Ref		Ref		Ref		Ref	
26 - 35	0.70(0.41 1.19)	0.706	0.58(0.32, 1.04)	0.070	0.46(0.21,0.98)	0.044	0.32.9(0.13,0.81)	0.016	0.38(0.21,0.68)	0.001
36 - 49	0.85(0.36, 2.01)	0.646	0.90(0.35, 2.31)	0.822	0.78(0.21,2.97)	0.716	0.67(0.16,2.90)	0.595	0.35(0.13,0.90)	0.024
Type of residence										
Rural	Ref		Ref		Ref		Ref		Ref	
Peri urban	0.95(0.51,1.77)	0.877	0.65(0.32, 1.35)	0.128	0.64(0.24,1.79)	0.379	0.56(0.19, 1.62)	0.286	1.01(0.53,1.92)	0.983
Urban	0.78(0.40,1.53)	0.468	0.53(0.25, 1.13)	0.102	0.48(0.17,1.36)	0.167	0.31(0.10,0.95)	0.041	0.86(0.43,1.75)	0.685
Religion										
Others	Ref		Ref		Ref		Ref		Ref	
Christianity	0.53(0.28, 1.02)	0.056	0.65(0.32, 1.35)	0.249	0.34(0.31,0.89)	0.028	0.49(0.18,1.33)	0.162	1.17(0.57,2.39)	0.677
Educational status of women										
None	Ref		Ref		Ref		Ref		Ref	
Basic	0.80(0.38,1.69)	0.578	0.96(0.42, 2.20)	0.925	0.74(0.24, 2.30)	0.597	0.95(0.28,3.201)	0.929	0.65(0.29,1.45)	0.287
Secondary	0.58(0.23,1.43)	0.241	0.42(0.15, 1.18)	0.101	0.55(0.15,2.02)	0.372	0.45(0.11,1.81)	0.265	0.62(0.24,1.66)	0.344
Tertiary	0.79(0.26,2.41)	0.677	0.69(0.19, 2.48)	0.571	0.09(0.01,0.54)	0.009	0.18(0.03,1.20)	0.077	1.15(0.36,3.71)	0.811
Occupational categories of women										
Unemployed	Ref		Ref		Ref		Ref		Ref	
Formal	0.69(0.29,1.64)	0.409	0.89(0.34, 2.32)	0.807	2.23(0.49.10.10)	0.300	2.45(0.47,12.63)	0.285	0.57(0.23,1.40)	0.219
Informal	0.72(0.42,1.23)	0.227	0.76(0.42, 1.40)	0.381	1.06(0.48,2.31)	0.891	0.93(0.39,2.21)	0.867	1.26(0.72, 2.21)	0.428
Educational statuses of spouses										
None	Ref		Ref		Ref		Ref		Ref	
Basic	0.83(0.42, 1.63)	0.577	0.82(0.39, 1.74)	0.604	4.00(1.28,12.49)	0.017	2.01(0.60,6.70)	0.255	0.78(0.38,1.62)	0.506
Secondary	0.98(0.43,2.23)	0.971	1.45(0.59, 3.50)	0.425	3.04(0.90,10.28)	0.074	1.33(0.37,4.79)	0.654	0.35(0.14,0.88)	0.026
Tertiary	0.55(0.20, 1.52)	0.252	0.84(0.27, 2.63)	0.763	4.60(0.98,21.47)	0.052	1.16(0.24,5.71)	0.852	0.66(0.22,1.94)	0.450
Occupational categories of spouses										
Unemployed	Ref		Ref		Ref		Ref		Ref	
Formal	2.60 (0.78,8.61)	0.118	1.08(0.29, 4.03)	0.911	1.98(0.38,10.39)	0.419	6.05(0.79,46.41)	0.0.083	3.80(0.86, 16.85)	0.076
Informal	1.23(0.39,3.89)	0.724	1.00(0.28, 3.50)	0.988	1.69(0.36,7.86)	0.503	1.77(0.26,11.98)	0.561	2.55(0.59,10.93)	0.208
Quintile of household wealth index										
1	Ref		Ref		Ref		Ref		Ref	

FI = Food Insecurity HA = Haemodilution Adjusted R^2 = Chi Square

Category	Registration		HA at Registration		28 weeks		HA at 28 weeks		36 weeks	
	AOR (95%CI)	P	AOR (95%CI)	P	AOR (95%CI)	P	AOR (95%CI)	P	AOR (95%CI)	P
2	0.86(0.41, 1.80)	0.686	1.27(0.53, 3.07)	0.590	0.96(0.29,3.16)	0.941	0.825(0.27,2.70)	0.778	0.82(0.38,1.78)	0.606
3	1.08(0.53, 2.23)	0.827	2.22(0.97, 5.09)	0.061	0.82(0.25,2.63)	0.732	0.78(0.24,2.48)	0.679	0.73(0.34,1.56)	0.416
4	1.04(0.50, 2.17)	0.910	2.30(0.99, 5.35)	0.053	0.42(0.13,1.29)	0.128	0.21(0.06,0.75)	0.015	1.04(0.48,2.24)	0.918
5	0.88(0.42,1.84)	0.727	1.35(0.56, 3.22)	0.505	0.27(0.09,0.83)	0.022	0.20(0.06,0.65)	0.008	0.44(0.20,0.99)	0.049
Household food security Status										
Food Secure	Ref		Ref		Ref		Ref		Ref	
M - M	0.89 (0.46, 1.73)	0.336	0.98(0.52, 1.83)	0.936	1.79(0.66,4.81)	0.488	0.88(0.37,2.10)	0.772	1.56(0.872.80)	0.140
Severe FI	1.17 (0.63,2.19)	0.723	0.76(0.36, 1.57)	0.453	1.34(0.53,3.37)	0.251	0.41(0.13,1.23)	0.112	0.75(0.36,1.59)	0.457
Level of Care Provider										
CHPS	Ref		Ref		Ref		Ref		Ref	
Health Centre	0.97(0.54, 1.74)	0.926	1.00(0.53, 1.91)	0.997	0.60(0.21,1.73)	0.341	0.66(0.21,2.12)	0.483	1.08(0.57,2.05)	0.804
Private Hosp.	0.32(0.11,0.92)	0.035	0.25(0.06, 0.98)	0.047	0.60(0.13,2.82)	0.521	1.35(0.25,7.27)	0.725	1.10(0.44,2.78)	0.838
Regional Hosp.	2.25(1.02,4.97)	0.044	2.80(1.18, 6.68)	0.020	1.76(0.50,6.21)	0.381	3.50(0.90,13.60)	0.071	1.85(0.76,4.50)	0.175
Trimester of Booking										
1st trimester	Ref		Ref		Ref		Ref		Ref	
2nd or 3rd trimester	1.87(1.17, 2.98)	0.009	0.68(0.40, 1.13)	0.135	1.36(0.66,2.80)	0.400	3.22(1.42,7.29)	0.005	1.72(1.05,2.84)	0.033
Constant	1.13	1.00	1.02	0.980	2.38	0.231	0.72	0.731	0.69	0.707
Observations	372		372		192		192		315	
Omnibus test R^2 (df)	42.00(25)	0.018	42.54(25) *	0.016	39.83* (25)	0.030	52.7851(25)	0.001	40.88* (25)	0.024
Hosmer and Lemeshow R^2 (df)	10.56(8)	0.226	4.76(8)	0.783	5.10(8)	0.756	10.09(8)	0.259	11.12(8)	0.195
-2 loglikelihood	443.03		378.02		225.59		199.13		392.34	
Cox & Snell R^2	0.11		0.11		0.19		0.22		0.12	
Nagelkerke R^2	0.15		0.16		0.25		0.30		0.16	
FI = Food Insecurity HA = Haemodilution Adjusted R^2 = Chi Square										

As shown on Table 4, women who registered at the Regional Hospital for ANC were over two times more likely to be anaemic compared to those who registered at a CHPS compound (AOR=2.25, 95%CI: 1.02 -4.97, p<0.05) and the odds even became higher after adjusting for haemodilution for women registering in the 2nd trimester (AOR=2.80, 95%CI: 1.18 - 6.68, p<0.05). However, ANC registrants at private hospitals were less likely to be anaemic compared to those who registered at CHPS compounds (AOR=0.32, 95%CI: 0.11 -0.92), p<0.05) and with more reduced odds after adjusting for haemodilution (AOR=0.25,95%CI: 0.06 -0.98), p<0.05). Late (after 12th week of gestation) registrants were nearly two times more likely to be anaemic at booking compared to those registering in the 1st trimester (AOR =1.87,95%CI: 1.17-2.98, p<0.01). However, the association became statistically insignificant after adjusting for haemodilution (AOR=0.68, 95%CI: 0.4 0- 1.13, p>0.05).

At 28 weeks of gestation, Christians were statistically significantly less likely to be anaemic compared to non-Christians (AOR=0.34,95%CI: 0.31-0.89, p<0.05) but this relationship became statistically insignificant adjusting for haemodilution. Women who attained tertiary education were statistically significantly less likely to be anaemic compared to women with no formal education (AOR=0.09, 95%CI: 0.01-0.54, p<0.01) but the significance of this association was also lost after adjusting for haemodilution (AOR=0.18, 95%CI:0.03-1.15, p>0.05). Women in the 5th wealth quintile were statistically significantly less likely to be anaemic compared to women in the 1st quintile (AOR = 0.27, 95%CI: 0.09 -0.83, $p<0.05$). The reduced risk of anaemia at 28 weeks for wealthier households remained consistent for the highest wealth quintile (AOR=0.27, 95%CI 0.09 - 0.86, $p<0.05$) and extended to cover women in the 4th quintile (AOR=0.20, 95%CI: 0.06 - 0.70, $p<0.01$) after haemodilution was adjusted for. Women in the middle reproductive age group (26–34 years) were less likely to be anaemic at 28 weeks (AOR=0.46, 95%CI: 0.21-0.98 $p<0.05$) which further reduced after accounting for haemodilution, (AOR= 0.33, 95%CI: 0.13-0.81, $p<0.05$). Also, women booking after 1st trimester were over two times more likely to be anaemic after adjusting for haemodilution (AOR=2.57(95%CI: 1.17, 5.63), $p<0.01$). Also, after adjusting for haemodilution, women from urban residence were less likely to be anaemic at 28 weeks compared with those from rural residence (AOR=0.31, 95%CI: 0.10 - 0.95, $p<0.05$). Women with spouses with basic education had four-fold increased odds anaemia at 28 weeks (AOR=4.00, 95%CI: 1.28 - 12.49, $p<0.05$) but this was also lost after adjusting for haemodilution.

At 36 weeks, women in the middle reproductive age group (26–35 years) and in the oldest reproductive age group (35+ years) were statistically significantly less likely to be anaemic compared to women in the early reproductive age group (15–25 years) (AOR=0.38, 95%CI: 0.21 - 0.68, $p<0.01$). Also, the oldest reproductive age group (35+ years) were statistically significantly less likely to be anaemic compared to women in the early reproductive age group (15 – 25 years) (AOR=0.35, 95%CI: 0.13 - 0.90, $p<0.01$). Women from the richest households (5th wealth quintile) were also, statistically significantly less likely to be anaemic compared to those from the poorest households (1st wealth quintile) (AOR=0.44, 95CI: 0.20 - 0.99, $p<0.05$). Lastly, women registering late (after 1st trim) were statistically significantly less likely to be anaemic compared to those registering earlier (1st trim) (AOR=1.72, 95%CI: 1.05, 2.84, $p<0.05$).

Discussion

This study assessed the prevalence of AIP and its correlates at various stages of hemoglobin assessment during ANC. The findings have established the prevalence of AIP at ANC registration as 35.8% without and 25.3 with adjustment for haemodilution; at 28 weeks of gestation as 53.1% without and 37.5% with adjustment for haemodilution; and at 36 weeks as 44.8%. Variations in the AIP statuses of the respondents could be explained by a number of factors including maternal age, religion, education, household wealth, place of residence, type of healthcare facility, and timing of ANC registration, which were found to be statistically significantly associated with AIP at various stages of hemoglobin assessment.

Without adjustment for haemodilution, the observed AIP prevalence reported at ANC registration, was lower compared to similar studies both in Ghana [36, 52] and in neighboring countries [53–55]. Also, the AIP prevalence at 36 weeks in this study was lower compared to a similar study in northern Ghana [56] but higher than that of the finding of a study in the middle belt of Ghana [57]. Contextual differences in study settings [7, 58–60] are more likely to account for these observed differences in AIP prevalence. While maternal healthcare is free in Ghana, the availability, access to, utilization and the quality of healthcare obviously varies [61] between the northern and middle belt of Ghana. Also, a relatively higher availability and accessibility to nutritious foods in the middle belt compared to the north is likely to account for the observed differences in the AIP prevalence. The interventions in ANC are expected to correct anaemia identified at registration and at 28 weeks and prevent non-anaemic registrants from becoming anaemic. AIP prevalence should therefore be lesser in subsequent points of test especially at ≥36 weeks of gestation. This study however, illustrates worsening AIP prevalence after ANC registration. Some previous studies assessing changes in anaemia status after some interventions have also reported worsening situations [54, 62] although others reported reduced prevalence [46, 56, 63]. A worsening situation suggest little or unsuccessful correction of AIP during ANC as evidenced in the non-significant changes between 28 weeks and 36 weeks after accounting for haemodilution. Despite the lower prevalence in the study area, AIP is still of great concern, especially as it is one of the leading cause of maternal mortality [64]. As a moderate public health problem at registration which transitions into a severe one at 36 weeks [7], its impact on maternal outcomes cannot be overemphasized. Stepped up efforts should therefore be taken to address it. Preconception nutrition and healthcare which will prevent or reduce it at registration is recommended.

In current practice, anaemia is diagnosed using a single cut off point of 11g/dl throughout pregnancy regardless of the time of assessment. As seen in this study, this practice presents a totally different pattern of anaemia prevalence along the course of pregnancy taken into account the haemodilution theory (reference). Without adjusting for haemodlition, AIP peaks at 28 weeks with a much higher prevalence. However, after adjusting for haemodilution, a rising straight-line curve pattern, demonstrating a continuous increasing prevalence from registration to 36 weeks, was observed. This could have some serious implication for planning for anaemia control and prevention in pregnancy. Without haemodilution, healthcare providers would expect the highest prevalence of AIP around 28 weeks and may place so much efforts on it. However, this could be deceptive and could lead to poor prioritization of care. Even though the rates of AIP as observed in this study are very high and under no circumstance requires urgent attention, the adjustment changed the prevalence pattern which could affect decision making. For instance, wrong conclusion could have been drawn relying on the observation that AIP prevalence peaks at 28 weeks and declines afterwards without haemodilution, which would have suggested some false level of success in correction. Haemodilution is a natural physiological process in pregnancy that leads to decrease haemoglobin levels by 1 - 2g/dl but does not imply a disease state [23]. Indeed, there is an argument that haemoglobin above 14.30g/dl (43% haematocrit) may signal poor haemodilution which poses danger to mother and baby [65]. Hence, the argument for an adjustment of 0.5g/dl to be made for diagnosis at the 2nd trimester where haemodilution peaks could not be more apt. [4, 25]. Thus, there is the need to review the anaemia diagnosis at 28 weeks of gestation. Perhaps it is time to adopt the cutoff point of 10.5g/dl as recommended in Ghana [4, 25]. The different prevalence pattern of AIP as observed vis a vis haemodilution may also be a diagnosing error in anaemia research where all pregnant women regardless of their state of haemodilution are assessed using a common cutoff and group prevalence is reported.

Age offered significant consistent protection at 36 weeks, as older age groups had reduced risk of AIP. While this finding may be limited to women at 36 weeks of gestation, it agrees with other studies that reported increased AIP risk for younger mothers [42, 55, 66–68] and protection for older mothers [69]. Also, the women in the middle age group had some protection against anaemia at 28 weeks when haemodilution is not taken into consideration. This also falls in line with some studies that found isolated risk for specific age groups [70, 71]. Also, the lack of association between anaemia at registration and age groups as observed in this study has also been reported in other studies [35, 36, 72].

The trimester of booking was a significant correlate of anaemia status throughout the three stages of assessment. The consistence was however achieved after adjusting for haeodilution at 28 weeks. This finding agrees with some assertions of increased risk of anaemia for registering after 1st trimester [36, 44, 73] and echoes the report of increasing risk with increasing trimester of registration [74]. It is however, in variance with Ampiah and Colleagues finding of reduced risk for registering in the 2nd trimester[75]. Several reasons may account for this. Even though feeding issues such as appetite, nausea and vomiting issues are said to predominate in the 1st trimester [76], early booking enable early intervention, thereby enhancing nutrient intake. However, these likely determinants were not assessed in this study. Also, the effects of these are also most likely to be felt in later trimesters than in 1st trimester, thereby increasing the risk in those times. Furthermore, early registration could increase the likelihood of more doses of iron and folic acid consumed thereby reducing the risk of anemia even in later points of haemoglobin check. This suggests the need to enable and encourage women to register early for ANC as a strategy for anaemia control and prevention in pregnancy.

The type of health care provider had significant influence on anaemia status at registration only. Attending ANC at the private hospitals was associated with reduced risk of anaemia at registration but attending ANC at the regional hospital was associated with increased risk of anaemia at registration. Very important to note is that, more women (64%) registered early in the private hospitals than all other facilities. In practice and as may be observed by those not in the healthcare setting, the cost of services at the private facilities are higher than public facilities in Ghana even when the client has NHIS coverage. People registering at private hospital are therefore likely to be more committed to achieving good pregnancy outcomes or are wealthy women with the needed resources. Hence, they will most likely register early and comply with recommended behaviours. On the other hand, more (53.2%) women booked late at the Regional Hospital. Also, as a public facility and referral centre, clients booking there may be less likely to be committed and/or referred there due to previous risky (including anaemia risk) pregnancies. Hence, such women could have chosen the regional hospital because of pre-known anaemia issues before booking.

Resident of urban areas had some protection against anaemia at 28 weeks after adjusting for haemodilution. Previous studies have reported similar findings [12, 42, 77, 78]. Availability, access and utilization of highly skilled and comprehensive ANC or anaemia-related care; and arguably, at a lower cost is an advantage to urban women over their rural counterparts. Certainly, travel expenses disrupts care access and utilization by pregnant women [79] and so will place rural women at the disadvantage side. For instance, NHIS accredited laboratories, pharmacies, drug stores are all located in the urban area of the municipality. Indeed Ayoya and colleagues report that inaccessibility to IFA supplementation is far more common in rural area than in urban areas [77]. Also, women in urban areas are more likely to have higher (tertiary) education and be members of richest households which are both protective factors of anaemia at 28 weeks reported in this study [80]. As such they stand more empowered to carry out recommended anaemia prevention and control behaviours that offer protection.

Christianity offered statistically significant protection against anaemia over non-Christian at 28 weeks. The difference in anaemia in pregnancy risk determined by religion has also been reported in India [78]. Religion as a social determinant of health shapes the beliefs, norms, myths and conventions surrounding health and health-related behaviours [81]. These health-related behaviours could range from food and hygiene norms to health seeking ones that can impact on the incidence and recovery from anaemia. Even though not assessed in this study, the more liberal Christian norms regarding animal foods which are high bioavailable sources of protein, iron and other micronutrients needed for haemoglobin formation could account for this.

Similarly, educational status of spouses offered some protection against anemia at 36 weeks but only at the secondary level. Generally, education as social determinant has been linked to higher nutrition and health literacy [81, 82] and higher economic fortunes [80, 81, 83] which directly impact on healthy behaviour leading to better health outcomes. Women with highest level of education are therefore more likely to have the cognitive and affective ability to access, understand, appraise anaemia prevention and control information as well as the material resources to use that information to stay non-anaemic or quickly recover from anaemia at 28 weeks or 36 weeks. Moreover, such women have good social standing and are therefore more likely to receive the needed attention. They are also more likely to be able to navigate effectively in the healthcare settings to demand care that meets their needs. This therefore calls for the education of the female child for better nutrition and anaemia outcomes in pregnancy.

Last but not the least, women in the first two wealthier households as expected were protected against anaemia at 28 weeks and 36 weeks. Previous studies have also documented similar findings [12, 78]. Wealth has been identified as a determinant of several health outcomes [81, 84].. While how wealth impact on anaemia status may be complex [81], the increase likelihood to have effective demand to anaemia prevention and control related commodities such as drugs, nutritious food, etc. is an advantage for women from wealthy households. This therefore may be the pathway to protection against anaemia in pregnancy. Empowering women economically may therefore be a means to the prevention and control of anaemia.

Strength And Limitations Of The Study

First, this study analyzed the anaemia status of the same women at three critical stages of gestation. This permitted the exploration of progress of anaemia in pregnant women. As such it allowed for paired analysis to detect changes that occurred between points of haemoglobin assessment. Secondly, data on haemoglobin central to this study were collected via case records from three different source documents. This allowed for triangulation of information [88] and hence effectively addressed issues of recall bias and inaccuracies. The design of this study has possible limitations. Measurement of haemoglobin was done at various facilities using different Hb measuring machines of various qualities. This could influence haemoglobin values between cases or between points of assessment. As such errors due to instrumentation were unavoidable [89]. Secondly, the use of secondary data comes with its own demerits. One weakness is the failure to document care given to pregnant women. This could have accounted for the nearly over 48% of the data on haemoglobin checked not available for 28 weeks. The above limitation could have therefore reduced the sample size for some of the analysis.

Conclusion

This study found that anaemic registrants gained 0.36 – 0.88g/dL of haemoglobin, non-anaemic registrants lost 0.63 – 0.97g/dL of haemoglobin between registration with an overall haemoglobin loss 0.15 -0.47g/dL between registration and 36 weeks. Prevalence of anaemia worsened from registration to 36 weeks when haemodilution is taken into account but peaked at 28 weeks if haemodilution is not considered. It also found that correlate of AIP differed between registration, 28 weeks and 36 weeks respectively. Late registration and the type of ANC provider determined AIP risk at registration. At 28 weeks, age groups, religion of mother, residence, trimester of registration, household wealth index and women education influenced the risk of AIP. Finally, determinants of AIP at 36 weeks were household wealth index, age group, spousal education status and trimester of registration. We recommend a review of the haemoglobin cut-off for diagnosing anaemia in pregnancy. Behaviour change communication for the treatment of AIP should be tailored according to individual case scenarios as socioeconomic determinants differ. There must be a deliberate policy to improve the economic status of women and households. Ghana policy to improve the educational status girls must be sustained. It is also recommended that a lager prospective cohort study be carried out to further explore the findings of this study.

Abbreviations

AIP: Anaemia in pregnancy

ANC: Antenatal care

AOR: Adjusted odd ratio

CHPS: Community-based Health Planning and Services

CI: Confidence interval

GHS: Ghana Health Services

GSS: Ghana Statistical Service

WHO: World Health Organization

IFA: Iron and Folic Acid

NHIS: National Health Insurance Scheme

Declarations

Ethics approval and consent to participate: The University for Development Studies Institutional Review Board granted ethical approval for the conduct of this study (date: 21/10/2020). Permission was obtained from the Upper Regional Health Directorate, the Bolgatanga Municipal Health Directorate and the heads of the sampled health facilities. Written informed consent was obtained from respondents.

Consent for publication: Not Applicable

Availability of data and materials: The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

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Authors' contributions: DNA conceived the study; DNA and GAA designed the study; DNA collected the data; DNA and GAA analysed the data; MNA reviewed the data analysis; DNA drafted the manuscript; MNA and GAA critically review the draft for scientific quality; DNA, MNA and GAA read and approved the final manuscript.

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Figures

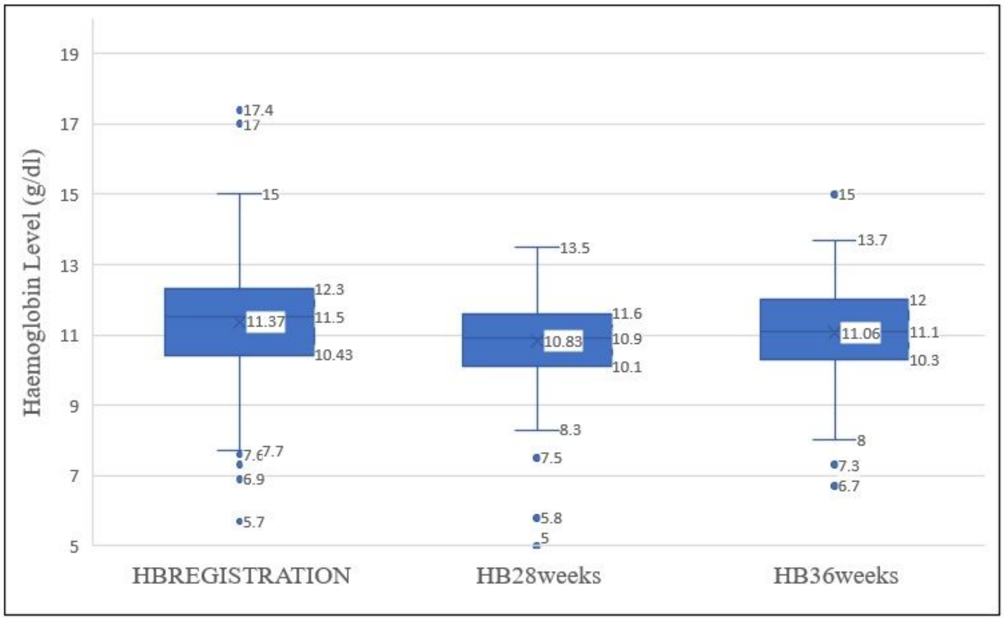

Figure 1

Distribution of haemoglobin levels of women at the three stages of gestation

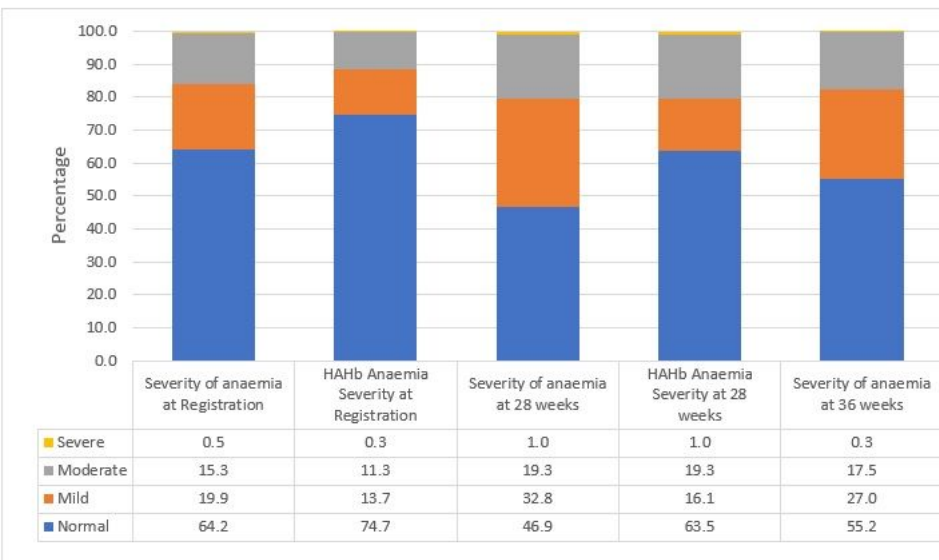

Figure 2

Severity of anaemia status among pregnant women