Anemia During Pregnancy: A Study Between Booking Visit and Delivery from South Africa

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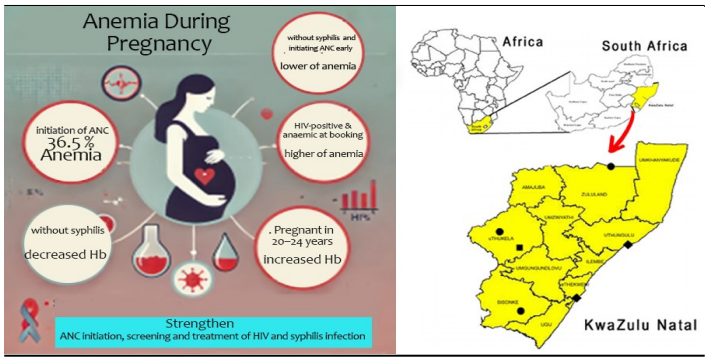
ABSTRACT

In South Africa (SA), the highest prevalence of anemia in pregnancy of 43% is reported in the KwaZulu-Natal province at initial Antenatal Care (ANC) visit. To prevent anemia during pregnancy, iron supplementation is provided during pregnancy. There is no study undertaken to compare anemia at booking ANC visit with the rate at delivery. This study aims to estimate the prevalence of anemia at ANC booking and delivery, and identify risk factors. Facility based retrospective cohort study was conducted among pregnant women who delivered at the health facility. Data were coded, captured and analysed using SPSS software. Logistic regression was performed to determine predictors for anemia. Results showed significantly higher prevalence of anemia (36.5%) at initiation of ANC compared to 18.6% at delivery ($p<0.05$). The mean Hb increased from 11.4 g/dL at ANC initiation to 12.3 g/dL at delivery. Logistic regression showed that women without syphilis (OR=0.14, p=0.014) and those initiating ANC early (OR=0.35, p=0.018) had lower odds of anemia. HIV-positive women (OR=4.2, p=0.022) and those anaemic at booking (OR=10.84, $p<0.001$) had higher odds of anemia at delivery. Pregnant women aged 20–24 years were less likely (OR=0.34, p=0.041) to have increased Hb, while those without syphilis at ANC booking had lower odds (OR=0.46, p=0.04) of decreased Hb. ANC initiation, screening and treatment of HIV and syphilis infection must be strengthened.

ABSTRAK

Di Afrika Selatan (SA), prevalensi anemia tertinggi pada kehamilan sebesar 43% dilaporkan terjadi di provinsi KwaZulu-Natal pada kunjungan awal Antenatal Care (ANC). Untuk mencegah anemia selama kehamilan, suplementasi zat besi diberikan selama kehamilan. Namun, belum ada studi yang membandingkan anemia pada kunjungan awal ANC dengan tingkat anemia saat persalinan. Penelitian ini bertujuan untuk memperkirakan prevalensi anemia pada kunjungan awal ANC dan saat persalinan, serta mengidentifikasi faktor risikonya. Studi kohort retrospektif berbasis fasilitas dilakukan pada wanita hamil yang melahirkan di fasilitas kesehatan. Data dikodekan, dimasukkan, dan dianalisis menggunakan perangkat lunak SPSS. Analisis regresi logistik dilakukan untuk menentukan prediktor anemia. Hasil menunjukkan prevalensi anemia yang signifikan lebih tinggi (36,5%) pada awal ANC dibandingkan dengan 18,6% saat persalinan ($p<0,05$). Rata-rata Hb meningkat dari 11,4 g/dL pada awal ANC menjadi 12,3 g/dL saat persalinan. Regresi logistik menunjukkan bahwa wanita tanpa sifilis (OR=0,14, p=0,014) dan yang memulai ANC lebih awal (OR=0,35, p=0,018) memiliki kemungkinan lebih rendah untuk mengalami anemia. Wanita dengan HIV-positif (OR=4,2, p=0,022) dan yang anemia pada awal ANC (OR=10,84, $p<0,001$) memiliki kemungkinan lebih tinggi mengalami anemia saat persalinan. Wanita hamil berusia 20–24 tahun cenderung lebih kecil kemungkinannya (OR=0,34, p=0,041) mengalami peningkatan Hb, sementara mereka yang tidak menderita sifilis pada awal ANC memiliki kemungkinan lebih rendah (OR=0,46, p=0,04) mengalami penurunan Hb. Inisiasi ANC, skrining, dan pengobatan infeksi HIV serta sifilis harus diperkuat.

GRAPHICAL ABSTRACT



Keyword
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INTRODUCTION

Anemia affects almost half of all pregnant women in low-to-middle-income countries (LMIC) and has serious adverse effects on maternal health and pregnancy outcomes (Lin et al. 2023). Maternal anemia is known to be associated with an increased risk of post-partum haemorrhage, eclampsia, maternal death, low birth weight, preterm birth, and perinatal mortality (Rahman et al. 2016; Daru et al. 2018; Rahmati et al. 2017). In South Africa (SA), almost half of all maternal deaths reported between 2010 and 2013 were related to anemia (National Department of Health [NDOH], 2013).

Anemia in pregnancy, defined as haemoglobin (Hb) levels of less than 11 g/dL, is more prevalent among women in LMIC due to dietary iron deficiency, parasitic infections, and HIV infections (Karami et al. 2022; Rahman et al. 2016; World Health Organization [WHO], 2011). Anemia is further classified into mild (10.0–10.9 g/dL), moderate (8.0–9.9 g/dL), and severe (<8 g/dL), with severe anemia being associated with a higher incidence of adverse events (WHO, 2011).

According to Liyew et al. (2021), the overall prevalence of anemia among pregnant women in East Africa is 41.82%, with rates ranging from 23.36% in Rwanda to as high as 57.10% in Tanzania. Anemia during pregnancy affects more than half of pregnant women in Sub-Saharan Africa, posing a serious public health concern (Benson et al. 2022; Tirore et al. 2024). In comparison to most other African nations, South Africa has a lower overall prevalence rate of anemia at delivery (29%) (Hoque et al., 2022; Turawa et al., 2021). The KwaZulu-Natal province has the greatest prevalence, at 38% (Dorsamy et al., 2022). A systematic review of the prevalence of anemia among pregnant women in SA reported a range of 29% to 42.7%, with the highest prevalence of 42.7% in Durban, KwaZulu-Natal province, while SADHS reported a lower prevalence of 39.1% (Hoque et al. 2022; Tunkyi & Moodley, 2018; Turawa et al. 2021).

Women who are HIV-positive, unmarried, 15–19 years old, and of high parity are at increased risk for anemia during pregnancy (Liyew et al. 2021; Hoque et al., 2022; Turawa et al. 2021). Anemia prevalence rates among women of reproductive age (WRA) in SA are also high, ranging from 22.0% to 44.0% (Turawa et al. 2021). Anemia is an indicator of poor nutrition and well-being and is associated with poor cognitive and motor-neurological development in children (WHO, 2021).

In response to the high prevalence and complications of anemia in pregnancy, the World Health Organization (WHO) has recommended routine screening and treatment of anemia in pregnancy. However, there are still challenges in implementing this in some African countries (Baker et al. 2015; WHO, 2018). The WHO also recommended that all pregnant women enroll for antenatal care at or before 12 weeks of gestation (WHO, 2018). Late booking or poor utilization of antenatal services may result in missed opportunities to identify and treat modifiable conditions in pregnancy, such as anemia, HIV, and syphilis (Arsenault et al., 2024).

Although pregnant women in South Africa have access to free health services at public primary healthcare facilities, many women still do not attend antenatal care (ANC) or enroll late in pregnancy (Drigo et al. 2020; Ebonwu et al. 2018). In South Africa, all pregnant women attending ANC are screened for anemia, syphilis, and HIV at their first ANC visit and again at delivery. Hemoglobin (Hb) levels are typically assessed using a full blood count (FBC) at the booking visit where available. However, in many cases, a point-of-care haemoglobinometer (HemaCue) is used at follow-up visits—at 20 weeks, 26 weeks, between 28–32 weeks, at 36 weeks, and at delivery—to provide immediate results for timely intervention. Despite these measures, poorly resourced primary care facilities often face challenges in

Table 1
Prevalence and comparison of mild, moderate and severe anemia among women

Severity of anemia	Booking visit (%) (N=139/379)	At delivery (%) (N=74/398)	P-values
Overall anemia	36.7	18.6	0.031*
Mild anemia[a]	21.4	10.4	0.029*
Moderate anemia[b]	11.9	7.4	0.041*
Severe anemia[c]	3.4	0.8	0.019*

Note: * = significant ($p < 0.05$); a = Hb 10.0-10.9 gm/dl; b = Hb 8.0-9.9 gm/dl; c = Hb < 8.0 gm/dl

managing anemia due to limited access to blood transfusions. Treatment primarily involves oral iron supplementation, with a standard prophylactic dose of 200 mg ferrous sulphate twice daily and 5 mg folic acid once daily. If a woman's Hb level falls between 8–10 g/dL, the ferrous sulphate dose is increased to three times daily. Referral for blood transfusion is reserved for severe anemia, defined as Hb <6.0 g/dL, or Hb between 6.0–7.9 g/dL with anemia symptoms, or Hb <10 g/dL in pregnancies beyond 36 weeks. These guidelines aim to optimize anemia management within the constraints of available resources (NDOH, 2015).

Although anemia during pregnancy has been extensively studied, most research has focused on the prevalence of anemia at the initial Antenatal Care (ANC) visit or its association with pregnancy and delivery complications (Kejela et al., 2020; Wemakor, 2019; Yesuf & Agegniche, 2021). In countries with a high prevalence of HIV, such as South Africa, it remains unclear how HIV infection affects the presentation of anemia during pregnancy and the response to oral hematinic therapy. Furthermore, there is limited data on whether the prevalence of anemia during pregnancy decreases with routine antenatal care. This study aims to address these gaps by evaluating the prevalence of anemia at two critical time points (initial ANC visit and delivery) and analyzing risk factors for anemia, including those influencing changes in hemoglobin levels among women receiving care at midwife-led maternity units.

METHODS

The study was undertaken at a peri-urban setup at the Kwadabeka Community Health Centre (KCHC), a primary health care (PHC) facility in KwaZulu-Natal, South Africa. The facility serves a community of approximately 150,000 people in a low socio-economic area with a midwife-run obstetric unit (MOU). The facility provides comprehensive PHC and maternal reproductive health services, including antenatal care (ANC) and delivery in a 24-hour labour ward for women with low-risk pregnancies. The labour ward conducts an estimated 700 deliveries annually.

Although the facility offers antenatal care to 1,500 pregnant women annually, many pregnant women with complicated pregnancies are referred to hospitals for ANC and delivery. Only vaginal deliveries are undertaken, and women requiring operative delivery are also referred to hospitals. Maternity Case Records (MCRs) of women who gave birth during the study period were examined in a retrospective cohort study. MCRs, or patient-held clinical records, are maintained by patients from the first prenatal appointment until birth.

The clinical records of all women who delivered at the facility between January and June 2021 were included in the study. Data on socio-demographic details, obstetric characteristics, and laboratory results of the women were extracted and captured onto an Excel spreadsheet. The data were then exported into SPSS 26.0 for analysis after coding. Variables included in the study were: age, gravidity, en-

Table 2
Characteristic of women and comparison of anemia at ANC initiation and delivery

Variable names	At booking visit (N=379)				At delivery (N=398)			
	Variables (%)	% anemia (n=139)	X^2 values	P values	Variables (%)	% anemia (n=74)	X^2 values	P values
Age distribution								
< 20 years	12.9	15.5			12.6	18.8		
20 – 24 years	27.4	26.8			27.4	27.5		
25 – 29 years	29.8	31.5	4.05	0.399	29.6	24.6	4.003	0.406
30 – 34 years	21.9	19			22.1	18.8		
> 35 years	7.9	7.1			8.3	10.1		
Marital status								
Single	96.3	99.4			92.3	98.8		
Married	1.7	0.6	2.96	0.086	6.7	1	1.819	0.197
Not known	2	0			2	0.2		
Gravidity								
1	25.1	25			22.7	20.6		
2-3	61.6	63.3	2.33	0.501	61.3	70.6	11.997	0.008*
4-5	12.2	10.1			14.1	6.4		
>5	1.1	0.6			1.9	2.4		
Had miscarriage								
Yes	8.4	7.1	2.166	0.338	8.3	8.7	0.667	0.673
No	93.6	92.9			91.7	91.3		
Initiation of ANC								
Yes	100	36.7	-	-	95.2	91.3	22.57	0.000*
No					4.8	8.7		
Number of ANC visits								
1-3	-	-			60.6	74.2		
4-7	-	-	-	-	38.3	25.8	3.032	0.220
≥8	-	-			1.1	0		
Anemia at initiation of ANC								
Yes	139	36.7	-	-	-	80.8	15.32	0.000*
No	240	63.3			-	19.2		
Gestational								
<13 weeks	19.4	23.3			?	18.8		
13-20 weeks	77.7	73	2.54	0.286	?	75.4	3.311	0.191*
≥21 weeks	2.9	3.7			?	5.8		
Syphilis status								
Positive	3.00%	7.2	3.292	0.053*	2	17.4	4.05 6	0.044*
Negative	97.00%	92.8			98	82.6		
HIV status								
Yes	29.9	32.3	0.062	0.45	43	51.5	5.02	0.014*
No	70.1	69.7			57	48.5		

Note: * = significant ($p < 0.05$)

rolment for antenatal care, and gestational age (GA) at enrolment (<13, 13–20, and >20 weeks) and at delivery (<36, 36–40, and >40 weeks). The Hb levels were measured in grams (g) per decilitre (dL) of plasma/blood. Mean Hb values, with standard deviation (SD), were calculated for comparison at the booking visit and at delivery. Outcome variables included the presence of anemia (Hb <11 g/dL) and changes in Hb levels (increase or decrease) from the booking visit to delivery.

Data were captured in Excel and later exported to SPSS version 26 for analysis. Descriptive statistics, such as mean (SD), were calculated, and frequency distributions for categorical variables were obtained. The Chi-square test was used to compare the prevalence of anemia and the association between categorical variables. Predictors for anemia at booking and delivery, as well as increased and decreased Hb levels during pregnancy, were determined using logistic regression (backward) analysis. This

Table 3
Final step of logistic regression output for anemia at delivery

Independent variables	P-values	Adjusted OR	95% CI for OR	
			Lower	Upper
Syphilis negative at delivery*	0.014	0.14	0.032	0.68
HIV positive**	0.022	4.28	1.232	14.92
Had ANC***	0.018	0.35	0.199	0.431
Anemia at ANC initiation****	0	10.84	4.326	27.206.
Constant	0.999	0		

Note: * = Syphilis positive; ** = HIV negative; *** = had no ANC; **** = had no anemia at ANC initiation

included adjusted odds ratios (OR), 95% confidence intervals (CI), and p-values. P-values <0.05 were deemed statistically significant.

Ethical permission was obtained from the Umgungundlovu Health Ethics Review Board (Reference no. UHERB 015/2020). Gatekeeper permission was granted by the KwaZulu-Natal Provincial Health Research Committee and facility management. Informed consent was waived by the ethics committee as the study was a retrospective record review with no direct participation of patients. All data were anonymized.

RESULTS

There were 398 women who delivered during the study period, of whom 379 women had initiated ANC. Of these, 36.7% (139/379) met the criteria for anemia at their first antenatal visit, which significantly reduced to 18.6% at delivery ($p < 0.05$). The mean Hb at the ANC booking visit was 11.4 g/dL (±1.5) and significantly increased to 12.3 g/dL (±1.6) ($p < 0.05$) at delivery. Hb levels increased in 227 (59.8%) of the women. The mean Hb increase was 2.02 g/dL (SD = 1.48) and ranged between 0.5 and 5.2 g/dL.

On the other hand, the mean Hb reduction was 1.23 g/dL (SD = 1.05), with a range of 0.3 to 3.9 g/dL. The different types of anemia decreased significantly from ANC initiation to the time of delivery: mild anemia decreased from 21.4% to 10.4%, moderate anemia from 11.9% to 7.4%, and severe anemia from 3.4% to 0.8% (See Table 1).

The ages of the women ranged from 15 to 41 years, with a mean of 26.3 years (±5.6). Teenage pregnancies (<19 years) accounted for 13% of the cases. The majority (80%) of the women were between 20–34 years; however, age distribution showed no significant association with anemia (See Table 2). Most women (96%) were reported as single (unmarried but cohabiting) and had 2–3 previous pregnancies (61.3%). Gravidity rates showed significantly different rates of anemia at delivery ($p = 0.008$).

Of the 398 women who delivered during the study period, the majority (95.2%) were enrolled for ANC. Most of these women (76.8%) enrolled for ANC between 12 and 20 weeks of gestational age (GA). The mean GA at ANC booking was 16.2 weeks (±2.4), ranging from 2 to 26 weeks. Neither the gestational age at booking, the number of ANC visits, nor previous miscarriage was associated with anemia at delivery. However, ANC initiation showed significantly different rates of anemia at delivery ($p < 0.05$).

Thirty-three (8.3%) women had experienced miscarriages in previous pregnancies, which was not associated with anemia. ANC initiation (yes/no) and anemia at initiation (yes/no) showed significantly different rates of anemia at delivery ($p < 0.05$). Results for syphilis screening at ANC initiation were available for 96.6% (n = 366/379) of antenatal attendees, of whom 3.0% (n = 11/366) tested positive. The prevalence of syphilis at delivery was 2.0% (n = 8/398). Women with a positive syph-

Table 4
Crosstable analysis for increased and decreased of Hb level at delivery

Variables	Hb level increased (n= 227)			Hb level decreased (n= 152)		
	Hb increased (%)	X^2 values	P values	Hb decreased	X^2 values	P values
Age in years						
< 20	11.9			12.5		
20 - 24	23.8			30.8		
25 - 29	32.6	6.634	0.021*	25.8	2.43	0.55
30 - 34	22.9			23.3		
> 35	8.8			7.5		
Marital status						
Single	96.9			99.2		
Married	3.1	1.87	0.161	0.8	1.574	0.195
Not known	0			0		
Gravidity						
1 (primigravid)	26.4			19.3		
2-3	61.2	3.03	0.083	93	3.964	0.048*
4-5	11.5			16		
>5	0.9			1.7		
Had miscarriage						
Yes	8.4	0.435	0.804	10.8	0.17	0.722
No	91.6			89.2		
Booking Gestational						
<13 weeks	20.4			16.7		
13-20 weeks	76.9	1.019	0.601	80	0.899	0.344
>21 weeks	2.7			3.3		
Nos of ANC visits						
1-3	56			67.8		
3-7	43.1	2.28	0.32	30.4	2.69	0.26
≥8	0.9			1.8		
Syphilis status						
Reactive	6.6	3.947	0.039*	2.2	0.923	0.312
No	93.4			97.8		
HIV status (n=398)						
Positive	46.3	0.605	0.253	41.7	0.467	0.281
No	53.7			58.3		

Note: * = significant ($p < 0.05$)

ilis result had a significantly higher rate of anemia at delivery ($p < 0.05$).

There were no significant independent variables associated with anemia at the booking visit ($p > 0.05$). However, gravidity, ANC initiation (yes/no), anemia at booking (yes/no), HIV infection, and syphilis infection showed significantly different rates of anemia at delivery. Three-quarters (77.7%) of the women delivered at term, while the preterm delivery rate was 18.8%. Gestational age at delivery was not associated with anemia ($p > 0.05$). HIV infection rates at booking and delivery were 29.9% and 43.5% ($p = 0.014$), respectively, with significantly higher rates of anemia observed among HIV-infected women ($p < 0.05$).

Logistic regression analysis showed that women without syphilis who initiated ANC had lower odds ratios (ORs) of 0.14 (95% CI: 0.03–0.68, $p = 0.014$) and 0.35 (95% CI: 0.199–0.431), respectively, for anemia at delivery. Conversely, HIV-infected women had higher odds ratios of 4.2 (95% CI: 1.23–14.9, $p = 0.022$), and pregnant women with anemia at the booking visit had an OR of 10.84 (95% CI: 4.32–27.20, $p < 0.001$) for anemia at delivery. No predictors for anemia at ANC initiation were identified from the study variables.

Table 4 shows significantly different rates of Hb level increases among different age groups and syphilis statuses ($p < 0.05$). On the other hand, women aged 20–24 years were 76%

Table 5
Final step of logistic regression output for increased Hb at delivery

Independent variables	Significance (p values)	Adjusted odds ratio (OR)	95% CI for OR	
			Lower	Upper
Age group*				
< 20 years	0.055	0.3	0.088	1.026
20-24 years	0.041	0.34	0.125	0.957
25-29 years	0.957	0.77	0.297	2.03
30-34 years	0.427	0.67	0.259	1.773
Gravidity**				
1	0.184	4.3	0.5	37.114
2-3	0.515	1.98	0.252	15.69
4-5	0.902	1.14	0.138	4.177
Constant	0.878	0.84		

Note: * = Age > 35 years; ** = gravidity > 6

less likely (OR = 0.34, 95% CI: 0.12–0.95, p = 0.041) to have increased Hb at delivery (See Table 5). Table 6 indicates that women without syphilis infection were 56% less likely (OR = 0.46, 95% CI: 0.22–0.99, p = 0.04) to have decreased Hb levels.

DISCUSSION

To the best of our knowledge, this study is the first to estimate the prevalence of anemia in a cohort of pregnant women from ANC initiation to delivery, including changes in Hb levels (both increases and decreases) and the associated factors in South Africa. The results confirm that the prevalence of anemia at the initial ANC booking was significantly higher at 36.5% compared to 18.5% at delivery (p < 0.05). This prevalence is higher than the 22% reported in a similar study in Fiji but much lower than the 54.5% prevalence found in studies conducted in Nigeria and rural KwaZulu-Natal, SA (Baker et al., 2015).

The study attributes the lower prevalence of anemia at the booking visit to the fortification of staple foods such as maize meal and wheat flour in South Africa (Shubham et al., 2022). However, despite this fortification program, the prevalence of anemia in pregnant women remains high, suggesting other contributing factors. This underscores the need to evaluate and review the food fortification program in SA. A plausible explanation for the high prevalence of anemia in this study includes educational levels, dietary habits, and socioeconomic conditions. For example, a lack of income and unhealthy behaviors negatively affect food choices and purchases, increasing the risk of iron deficiency anemia, which is the most common cause of anemia in pregnancy in SA (Ahmed et al., 2019).

The results also show a mean Hb level increase of 2.02 g/dL among 60% of women between ANC initiation and delivery. Prompt treatment of anemia during ANC visits may account for this improvement, reducing anemia prevalence at delivery. A study from Durban, SA, demonstrated good adherence (75%) to prophylactic iron, folate, and calcium supple-

Table 6
Final step of logistic regression output for decreased Hb level at delivery

Variables	P value	OR	95% CI for OR	
			Lower	Upper
Syphilis negative*	0.048	0.46	0.22	0.994
Constant	0	0.08		

Note: * = significant (p < 0.05); a = Hb 10.0-10.9 gm/dl; b = Hb 8.0-9.9 gm/dl; c = Hb < 8.0 gm/dl

mentation through pill counting and self-reporting (Ahmed et al., 2019). Similar to our findings, numerous studies highlight the beneficial effects of iron and folic acid supplementation on improving Hb levels during pregnancy (Caniglia et al., 2022; Kamau et al., 2020; Mekonnen et al., 2021).

Anemia prevalence at prenatal and postpartum stages remains underreported in South Africa. Despite the National Food Fortification Program and iron-folate supplementation, recent studies estimate anemia prevalence among WRA in SA remains high (Turawa et al., 2021). This highlights an urgent need for more effective interventions to reduce anemia prevalence in these populations. A Tanzanian study reported a 34.2% prevalence of anemia during the postpartum period, attributed to ongoing helminthiasis and malaria, which are not significant public health problems in SA.

While severe anemia significantly decreased, mild-to-moderate anemia persisted among most women. The high uptake of ANC (>95%) likely facilitated opportunities for screening, diagnosing, and treating anemia and other medical conditions during pregnancy (Hoque et al., 2022). A reduction in severe anemia reduces demand for blood transfusions and improves maternal and fetal outcomes. Unlike other African countries, SA's lack of endemic malaria and fortified staple foods may contribute to the lower prevalence of anemia.

The majority of pregnant women (57%) in this study were aged 20–29 years, consistent with other studies showing that women in this age group are significantly associated with an increased risk of anemia (Eweis et al., 2021; Li et al., 2020; Woldegebriel et al., 2020). We found that maternal ages 20–24 years were 66% less likely to have increased Hb levels, leading to a higher risk of anemia, a finding similar to studies in other countries (Owais et al., 2021).

HIV infection was found in 43.0% of women at delivery, with all receiving ART. HIV-positive women were 4.2 times more likely to experience anemia at delivery, consistent with findings that HIV-positive pregnant women are 5.8 times more likely to experience severe anemia (Cao et al., 2022; Finkelstein et al., 2022; Tunkyi & Moodley, 2018).

Similarly, syphilis infection during pregnancy was associated with a significantly increased risk of maternal anemia (Raj et al., 2017; Schlueter et al., 2022). Women without syphilis were 85% less likely to experience anemia at delivery. While maternal and neonatal complications from syphilis are well-documented, no prior studies have specifically explored its association with maternal anemia. Further research is needed to understand this relationship, which could improve syphilis management during pregnancy.

This study's retrospective design and focus on low-risk pregnancies at a single MOU are notable limitations. Key variables such as menstrual history, intrauterine device use, and nutritional status were excluded, which may have influenced the results. High-risk pregnancies, including severe anemia cases, were referred for hospital care and excluded. Despite these limitations, the findings remain relevant for pregnant women receiving ANC and delivering at KCHC.

CONCLUSIONS

Pregnant women attending midwife-run obstetric units at PHC settings had lower rates of anemia, particularly severe anemia, when antenatal care was provided. HIV and syphilis infections were significantly associated with higher rates of maternal anemia. Preventing sexually transmitted infections during pregnancy requires enhanced screening and treatment for HIV and syphilis. Intermittent assessments of food fortification and iron supplementation programs are essential.

Future studies should address the underlying causes of anemia, such as poverty and infectious diseases among WRA. Collaborative planning involving policymakers, economists, and program administrators is essential for effective food and nutrition interventions. Evalua-

tions of iron supplementation strategies, micronutrient programs, and food fortification efforts should ensure compliance with national standards and enhance bioavailability and absorption of nutrients. Special attention should be given to WRA, particularly those living with HIV/AIDS, when revising nutrition policies.

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AUTHORS' CONTRIBUTIONS

AKM M. Hoque designed the study, formulated the concept, wrote and revised the manuscript, acquired and analyzed the data, and obtained ethical permission. Maariyah Hoque designed the study, reviewed and revised manuscript. Muhammad. E. Hoque formulated the concept and reviewed manuscript. Kantharuben Naidoo wrote and reviewed the manuscript. Mir Anwar reviewed the manuscript.

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COMPETING INTERESTS

The authors confirm that all of the text, figures, and tables in the submitted manuscript work are original work created by the authors and that there are no competing professional, financial, or personal interests from other parties.

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