Barw Medical Journal | 2025;3(2):15-22
Journal home page: https://barw.krd/index.php/BMJ

Original Article

Tracing Hematological Shifts in Pregnancy: How Anemia and Thrombocytopenia Evolve Across Trimesters

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Keywords:
Maternal health
Thrombocytopenia
Anemia
Antenatal care

Received: January 15, 2025
Revised: January 30, 2025
Accepted: February 10, 2025
First Published: February 17, 2025

Citation: Kareem DO, Amin AMS, Mustafa AM, Qadir AK, Ahmed MN, Omer SN, et al. Hematological Changes in Pregnancy: Prevalence and Trends of Anemia and Thrombocytopenia Across Trimesters. Barw Medical Journal. 2025;3(2):15-22.
https://doi.org/10.58742/bmj.v3i2.171

Abstract

Introduction
Given pregnancy's significant impact on hematological parameters, monitoring these changes across trimesters is crucial. This study aims to evaluate hematological profiles in pregnant women, primarily focusing on the prevalence of anemia and thrombocytopenia throughout the different trimesters.

Methods
This retrospective cross-sectional study was conducted at Smart Health Tower from March to December 2024, with ethical approval from Kscien Organization. Pregnant women aged 18-45 years in any trimester were included, excluding those with pre-existing hematological disorders or significant complications. Blood samples were collected during routine antenatal visits for hematological analysis. Data were analyzed using IBM SPSS version 26.0, with statistical significance set at $p<0.05$.

Results
This study included 243 pregnant women, with a mean age of 29.91 ± 6.32 years. The average hematological parameters were as follows: white blood cell count 9.45 ± 2.10 × 10^9/L, red blood cell count 4.21 ± 0.45 × 10^{12}/L, hemoglobin 11.93 ± 1.03 g/dL, and platelet count 239.11 ± 59.47 × 10^9/L. Anemia and thrombocytopenia were identified in 16.0% and 5.0% of participants, respectively, with significant trimester-related variations (p= 0.033, p= 0.006). The highest prevalence of anemia (30.8%) was observed in women aged 26–30 years.

Conclusion
Significant changes in hematological parameters across pregnancy trimesters highlight the need for regular monitoring to diagnose and manage anemia, thrombocytopenia, and other abnormalities, ensuring optimal maternal and fetal health.

1. Introduction

Alterations in hematological profiles are critical factors influencing pregnancy and its outcomes. These changes occur to support the growing fetus and placenta, resulting in significant modifications in blood volume. Consequently, hematological profiles are commonly assessed as a reliable, cost-effective

means of evaluating overall health during pregnancy [1]. One of the key changes during pregnancy is an increase in plasma volume by an average of 40 to 45%. This rise is triggered by the direct effects of progesterone and estrogen on the kidneys, which stimulate the release of renin and activate the renin-angiotensin-aldosterone system [2]. Additionally, pregnancy-induced physiological stress leads to an elevation in the peripheral white blood cell (WBC) count, especially neutrophils. However, platelet levels tend to decrease due to hemodilution and increased platelet activation, particularly in the third trimester [3].

While most hematological changes during pregnancy are physiological, abnormal blood profiles can have significant impacts on both pregnancy outcomes and maternal health. Hematological complications, including anemia and thrombocytopenia, are among the leading causes of maternal mortality [4]. Anemia increases the risks of maternal, fetal, and neonatal mortality, as well as poor pregnancy outcomes and long-term developmental issues for children [5]. Thrombocytopenia affects 8-10% of pregnant women, particularly in the third trimester. Although 75% of cases are mild and benign (gestational thrombocytopenia), it can also signal more severe conditions like preeclampsia or hemolysis, elevated liver enzymes and low platelets syndrome, which pose life-threatening risks for both mother and baby [6].

Anemia in pregnancy, defined by a hemoglobin concentration below 110 g/L, has a global prevalence of 36.5% [7]. The condition is especially prevalent in Africa and Asia, with Ethiopia reporting a notably high prevalence of 62.7%. Severe anemia during pregnancy can lead to complications such as preterm birth, miscarriage, low birth weight, surgical delivery, postpartum hemorrhage, and fetal mortality [2].

Given the significant influence of pregnancy on hematological parameters, it is essential to monitor these changes throughout the pregnancy trimesters [8,2]. This study aims to assess the hematological profiles of pregnant women attending two antenatal care centers in Iraq. Specifically, it will examine the prevalence of anemia, other hematological parameters, and the occurrence of thrombocytopenia across different trimesters, providing valuable insights for early detection of complications and appropriate treatment. The references have been thoroughly reviewed and their eligibility has been confirmed [9].

2. Methods

2.1. Study design and setting

This retrospective cross-sectional study was conducted at Maternity Hospital and Smart Health Tower from February 2023 to December 2024. The study was approved by the ethical board at the Kscien Organization (25/No. 29). Informed consent was obtained from the participants to include their data, and all the data were de-identified to ensure confidentiality.

2.2. Participants

The participants were selected based on specific inclusion and exclusion criteria. Pregnant women aged between 18 and 45 years in their first, second, or third trimester and attending Maternity Hospital and Smart Health Tower antenatal clinics were eligible to participate. Women were excluded if they had pre-existing hematological disorders, chronic illnesses such as diabetes or hypertension, or significant pregnancy complications such as pre-eclampsia. Those taking hematological-modifying medications beyond standard prenatal care were also excluded. Recruitment was carried out during routine antenatal visits, where trained research assistants provided detailed information about the study. Written informed consent was obtained from all participants who met the eligibility criteria.

2.3. Data Collection

Demographic and clinical information were collected from all participants through a database and structured questionnaire administered by trained personnel. The data included details such as age, trimesters, education level, occupation, and residential status.

2.4. Blood Collection and Analysis

Blood samples were collected from participants during their scheduled antenatal visits. To standardize the results, samples were drawn in the morning after an overnight fast. Certified phlebotomists performed venipuncture under aseptic conditions, obtaining approximately 5 mL of blood from each participant into ethylene diamine tetra acetic acid -coated vacutainer tubes. The samples were labeled with unique identifiers and transported to the laboratory within 30 minutes in temperature-controlled containers (2–8°C).

Hematological analyses were performed in the diagnostic laboratory. The parameters assessed included red blood cell (RBC) indices such as RBC count, hemoglobin (Hb), hematocrit, mean corpuscular volume (MCV), mean corpuscular hemoglobin (MCH), and mean corpuscular hemoglobin concentration (MCHC). The WBC parameters, including total WBC count, granulocyte count, lymphocyte count, and monocyte count, were also measured, along with platelet parameters such as platelet (PLT) count, mean platelet volume (MPV), and platelet distribution width. The analyzer was calibrated daily to ensure the accuracy and precision of the results, and quality control was maintained through the use of internal control samples and participation in external proficiency testing programs. According to the World Health Organization, anemia in pregnancy is diagnosed when Hb concentration falls below 11.0 g/dL. Anemic pregnant women are classified into three categories based on their Hb levels: mild anemia with Hb between 10.0 and 10.9 g/dL, moderate anemia with Hb between 7.0 and 9.9 g/dL, and severe anemia with Hb levels below 7.0 g/dL [10]. In the case of thrombocytopenia, it is identified when the platelet count drops below 150×10^9/L. Thrombocytopenia is further classified as mild when PLT counts range from 100 to 150×10^9/L, moderate when they are between 50 and 100×10^9/L, and severe when PLT levels are below 50×10^9/L [11].

2.5. Statistical analysis

The collected data were systematically organized and recorded using Microsoft Excel 2021 for effective management. Statistical analysis was performed with IBM SPSS Statistics

version 26.0. The Shapiro-Wilk test was applied to assess the normality of continuous variables. For normally distributed data, means and standard deviations were calculated, and group comparisons were made using independent t-tests. For non-normally distributed data, medians and interquartile ranges were computed, with comparisons conducted using the Mann-Whitney U test. Categorical variables were analyzed using chi-square tests or Fisher's exact test as appropriate. A p-value of less than 0.05 was considered statistically significant for all analyses.

3. Results

3.1. Participant Demographics

The study included 243 pregnant women, with an average age of (29.91± 6.32) years, ranging from 18 to 47 years. Among them, 181 (74.5%) were housewives. Regarding education, 57 individuals (23.5%) had secondary education, while 84(34.6%) had attended college. In terms of residence, 202 (83.1%) were from urban areas (Table 1).

Table 1. Demographic characteristics of study participants

Variables	Frequency, Mean	Percentage (%), SD
Age (Years)	29.91	6.32
Age group (Years)		
≤20	12	4.9
21-25	60	24.7
26-30	67	27.6
31-35	49	20.2
≥36	55	22.6
Trimester		
1st trimester	81	33.3
2nd trimester	81	33.3
3rd trimester	81	33.3
Occupation		
House wife	181	74.5
Public sector	44	18.1
Private sector	12	4.9
Student	6	2.5
Education		
Illiterate	17	7.0
Elementary	47	19.3
Secondary	57	23.5
Diploma	38	15.6
College	84	34.6
Residence		
Urban	202	83.1
Rural	26	10.7
Not specified	15	6.2

SD: Standard deviation

3.2. Hematological Parameters and Their Changes Across Trimesters

The mean values of selected hematological parameters for the study participants were as follows: WBC count, 9.45±2.10 × 10^9/L; RBC count, 4.21±0.45 × 10^{12}/L; Hb, 11.93±1.03 g/dL; hematocrit, 35.75±3.04%; MCV, 85.31±7.04fL; MCH, 30.43±20.59pg; MCHC, 33.46±1.15%; and PLT count, 239.11±59.47× 10^9/L. The mean WBC counts for pregnant women were 9.14 ± 1.65, 10.32 ± 2.28, and 8.89 ± 2.05 (× 10^9/L) during the first, second, and third trimesters, respectively. Statistically significant differences were observed between the second and third trimesters ($P < 0.001$), as well as between the first and second trimesters ($P = 0.001$). Regarding RBC count, the mean value in the first trimester (4.45 ± 0.36 g/dL) was significantly higher than that in the second trimester (4.03 ± 0.42 g/dL) and third trimester (4.15 ± 0.46 g/dL). Likewise, the mean Hb level in the first trimester (12.36 ± 0.94 g/dL) was significantly higher than in the second trimester (11.70 ± 0.92 g/dL) and third trimester (11.73 ± 1.10 g/dL). Although no significant difference was observed in hematocrit values between the first and third trimesters, a significant difference ($P < 0.001$) was noted between the first and second trimesters, with higher values in the first trimester (36.77 ± 2.65) compared to the second trimester (34.72 ± 2.86). Furthermore, the mean PLT count was significantly lower in the second (240 ± 58) and third trimesters (211 ± 53) compared to the first trimester (267 ± 54). On the other hand, the mean values for MCHC, platelet distribution width showed no significant differences across the trimesters (Table 2).

3.3. Prevalence and Variation of Anemia and Thrombocytopenia Across Trimesters

In the present study, 39(16.0%) of study participants were anemic, while 12(5.0%) were thrombocytopenic. Thrombocytopenia differed significantly across trimesters ($P = 0.006$). No thrombocytopenia was observed in 80(34.6%), 79(34.2%), and 72(31.2%) women in the first, second, and third trimesters, respectively, while mild thrombocytopenia increased to 9 (75.0%) in the third trimester from 2(16.7%) in the second and 1(8.3%) in the first trimester. Anemia also varied significantly ($P = 0.033$), with no anemia present in 74(36.3%), 66(32.3%), and 64(31.4%) women in the first, second, and third trimesters, respectively (Table 3).

3.4. Hematological Parameter Variations by Age, Occupation, and Residence

Significant differences in WBC and granulocytes (both $P < 0.001$) were observed across age groups, with the highest values recorded in the 21–25 age group for WBC (10.3 ± 2.32) and granulocytes (7.33 ± 1.95). Other parameters, including lymphocytes, RBC, Hb, hematocrit, and PLT indices, showed no significant variation among age groups ($P > 0.05$). In terms of occupation, no significant differences were found across parameters. For residence, no significant differences were noted in WBC, granulocytes, or other parameters ($P > 0.05$); however, rural residents exhibited slightly higher platelet counts (253 ± 58) compared to urban residents (237 ± 60) (Table 4).

3.5. Socio-Demographic Distribution of Anemia Cases

Regarding the distribution of socio-demographic variables among anemia cases, the 26–30 years age group exhibited the highest prevalence, with 12 cases (30.8%), including 4 cases (57.1%) of moderate anemia. In terms of occupation,

Table 2. Comparative Analysis of CBC Parameters Across Different Trimesters

CBC parameters	Trimester				P-value		
	Overall	1st trimester (Mean ± SD)	2nd trimester (Mean ± SD)	3rd trimester (Mean ± SD)	1st Vs 2nd	1st Vs 3rd	2nd Vs 3rd
WBC × 10^3	9.45±2.10	9.14 ± 1.65	10.32 ± 2.28	8.89 ± 2.05	0.001	0.700	<0.001
GRAN × 10^3	6.60±1.76	6.00 ± 1.39	7.50 ± 1.72	6.30 ± 1.78	<0.001	0.478	<0.001
Lym × 10^3	2.33±0.59	2.50 ± 0.58	2.26 ± 0.64	2.22 ± 0.52	0.027	0.008	0.914
MID × 10^3	0.52±0.33	0.63 ± 0.38	0.57 ± 0.35	0.36 ± 0.19	0.428	<0.001	<0.001
RBC × 10^6	4.21±0.45	4.45 ± 0.36	4.03 ± 0.42	4.15 ± 0.46	<0.001	<0.001	0.171
HGB (g/dL)	11.93±1.03	12.36 ± 0.94	11.70 ± 0.92	11.73 ± 1.10	<0.001	<0.001	0.981
HCT (%)	35.75±3.04	36.77 ± 2.65	34.72 ± 2.86	35.78 ± 3.28	<0.001	0.082	0.059
MCV (fL)	85.31±7.04	82.87 ± 5.53	86.44 ± 6.46	86.63 ± 8.27	0.003	0.002	0.984
MCH (pg)	30.43±20.59	33.54 ± 35.38	29.27 ± 2.47	28.47 ± 3.12	0.384	0.261	0.967
MCHC (%)	33.46±1.15	33.66 ± 0.96	33.83 ± 1.08	32.89 ± 1.20	0.582	<0.001	<0.001
PDW (%)	12.82±2.98	13.1 ± 4.8	12.6 ± 1.0	12.8 ± 1.6	0.611	0.770	0.964
PLT × 10^3	239.11±59.47	267 ± 54	240 ± 58	211 ± 53	0.005	<0.001	0.003
MPV (fL)	9.21±1.01	8.98 ± 0.98	9.04 ± 0.87	9.60 ± 1.06	0.924	<0.001	0.001

WBC: white blood cell, GRAN: granulocyte, Lym: lymphocyte, MID: monocyte, RBC: red blood cell, HGB: hemoglobin, HCT: hematocrit, MCV: mean corpuscular volume, MCH: mean corpuscular hemoglobin, MCHC: mean corpuscular hemoglobin concentration, PDW: platelet distribution width, PLT: Platelet, MPV: mean platelet volume, SD: standard deviation

Table 3. Comparison of Thrombocytopenia and Anemia Status Across Pregnancy Trimesters

Variables	Trimester			P-value
	1st trimester N, %	2nd trimester N, %	3rd trimester N, %	
Thrombocytopenia status				
None	80(34.6%)	79(34.2%)	72(31.2%)	
Mild	1(8.3%)	2(16.7%)	9(75.0%)	
Moderate	0(0.0%)	0(0.0%)	0(0.0%)	0.006
Severe	0(0.0%)	0(0.0%)	0(0.0%)	
Anemia				
None	74(36.3%)	66(32.3%)	64(31.4%)	
Mild	7(21.9%)	13(40.6%)	12(37.5%)	
Moderate	0(0.0%)	2(28.6%)	5(71.4%)	0.033
Severe	0(0.0%)	0(0.0%)	0(0.0%)	

Table 4. Comparison of Hematological Profiles among Pregnant Women based on Age Group, Occupation, and Residence

Variables	WBC	GRAN	Lym	MID	RBC	HGB	HCT	MCV	MCH	MCHC	PDW	PLT	MPV
Age group (Years)													
≤20	8.33 ± 1.46	5.43 ± 1.42	2.35 ± 0.53	0.54 ± 0.23	4.30 ± 0.50	11.89 ± 1.14	35.53 ± 3.18	83.10 ± 6.67	27.85 ± 2.46	33.5 ± 0.79	12.6 ± 1.2	266 ± 73	8.42 ± 0.85
21-25	10.3 ± 2.32	7.33 ± 1.95	2.42 ± 0.62	0.59 ± 0.35	4.23 ± 0.48	11.95 ± 0.96	35.60 ± 2.95	84.45 ± 6.21	28.43 ± 2.21	33.65 ± 1.01	12.8 ± 1.2	248 ± 62	9.29 ± 1.04
26-30	9.25 ± 1.69	6.44 ± 1.54	2.26 ± 0.49	0.49 ± 0.34	4.23 ± 0.45	11.86 ± 1.15	35.53 ± 3.09	84.41 ± 8.01	35.05 ± 38.83	33.42 ± 1.33	12.6 ± 1.6	236 ± 54	9.23 ± 0.97
31-35	9.61 ± 2.31	6.85 ± 1.69	2.39 ± 0.68	0.52 ± 0.32	4.16 ± 0.39	11.99 ± 0.92	35.99 ± 3.12	86.73 ± 6.34	28.97 ± 2.39	33.46 ± 1.16	12.6 ± 1.0	235 ± 53	9.20 ± 0.95
≥36	8.83 ± 1.88	6.04 ± 1.58	2.26 ± 0.61	0.46 ± 0.34	4.17 ± 0.45	11.97 ± 1.05	36.05 ± 3.07	86.58 ± 7.09	28.85 ± 2.83	33.29 ± 1.14	13.5 ± 5.8	231 ± 64	9.28 ± 1.06
P-value	<0.001	<0.001	0.498	0.281	0.793	0.965	0.848	0.137	0.321	0.590	0.480	0.287	0.090
Occupation													
House wife	9.46 ± 2.17	6.62 ± 1.78	2.34 ± 0.61	0.51 ± 0.33	4.23 ± 4.45	11.96 ± 1.04	35.84 ± 3.08	85.15 ± 7.06	30.99 ± 23.80	33.44 ± 1.20	12.9 ± 3.4	239 ± 62	9.23 ± 1.03
Public sector	9.31 ± 1.96	6.50 ± 1.71	2.23 ± 0.53	0.51 ± 0.36	4.12 ± 0.36	11.87 ± 1.00	35.51 ± 2.93	86.36 ± 6.71	28.96 ± 2.54	33.50 ± 1.10	12.6 ± 1.1	239 ± 49	9.13 ± 0.97
Private sector	9.16 ± 1.38	5.97 ± 1.20	2.53 ± 0.66	0.66 ± 0.34	4.38 ± 0.46	12.08 ± 0.78	36.03 ± 1.82	82.98 ± 7.56	27.87 ± 2.89	33.52 ± 0.90	12.4 ± 0.9	252 ± 65	9.06 ± 0.68
Student	10.8 ± 1.93	7.93 ± 1.86	2.27 ± 0.53	0.62 ± 0.31	3.94 ± 0.71	11.42 ± 1.44	34.28 ± 5.24	87.35 ± 7.78	29.32 ± 2.54	33.57 ± 0.78	12.7 ± 1.2	223 ± 55	9.57 ± 1.33
P-value	0.396	0.159	0.425	0.415	0.127	0.583	0.642	0.408	0.906	0.983	0.875	0.796	0.729
Residence													
Urban	9.49 ± 2.14	6.67 ± 1.80	2.34 ± 0.61	0.51 ± 0.34	4.21 ± 0.44	11.91 ± 1.03	35.72 ± 3.04	85.24 ± 7.21	30.76 ± 22.55	33.43 ± 1.16	12.9 ± 3.2	237 ± 60	9.22 ± 1.02
Rural	9.47 ± 1.90	6.47 ± 1.57	2.38 ± 0.47	0.62 ± 0.31	4.20 ± 0.47	11.90 ± 1.18	35.72 ± 3.42	85.25 ± 6.66	28.52 ± 2.45	33.45 ± 1.23	12.8 ± 1.1	253 ± 58	9.11 ± 0.98
None	8.86 ± 1.84	6.34 ± 1.48	2.08 ± 0.57	0.44 ± 0.26	4.21 ± 0.43	12.25 ± 0.72	36.30 ± 2.52	86.47 ± 5.42	29.31 ± 2.20	33.84 ± 0.91	12.3 ± 0.6	244 ± 58	9.23 ± 0.95
P-value	0.530	0.756	0.231	0.212	0.997	0.463	0.778	0.808	0.854	0.417	0.766	0.393	0.873

WBC: white blood cell, GRAN: granulocyte, Lym: lymphocyte, MID: monocyte, RBC: red blood cell, HGB: hemoglobin, HCT: hematocrit, MCV: mean corpuscular volume, MCH: mean corpuscular hemoglobin, MCHC: mean corpuscular hemoglobin concentration, PDW: platelet distribution width, PLT: Platelet, MPV: mean platelet volume.

housewives were the most affected, accounting for 28 cases (71.8%) of anemia, primarily mild 22(68.8%) and moderate 6(85.7%) (Table 5).

4. Discussion

Regular monitoring of hematological profiles is essential for identifying and managing health conditions in pregnant women. Among these, anemia is the most prevalent hematological disorder during pregnancy, followed by thrombocytopenia. The prevalence of anemia varies across regions, with rates of 45.8% in Africa, 47.8% in South-East Asia, and 23.5% in Europe [7]. This study reports a significantly lower anemia prevalence of 16.0% compared to findings from other regions. For instance, higher anemia rates have been documented in countries such as Ethiopia 16.6%, Nigeria 39.8%, and Mexico 27.8% [12-14]. A study conducted at Debre Berhan Referral Hospital in Ethiopia, which included 284 pregnant women, reported an anemia prevalence of 2.8% [15], lower than that observed in the present study. Such variations may be explained by differences in socioeconomic and educational status, dietary patterns, contributing factors to anemia, and unequal access to healthcare services and iron supplementation. Moreover, pregnant women's awareness of antenatal care follow-ups and the methods used to measure hemoglobin levels could influence results, as some studies employed less precise techniques compared to the automated hematology analyzers used in this study.

Severe anemia during pregnancy can lead to serious complications, including impaired fetal growth and development, maternal fatigue, and an increased likelihood of cesarean delivery. This highlights the need for early diagnosis and proper management to improve outcomes for both the mother and the child. In a large cohort study involving over 18 million pregnant women, severe anemia was diagnosed in only 0.21% of cases, while the overall prevalence of anemia was reported at 17.78% [16]. Similarly, a study in Tanzania found that 7.2% of pregnant women had severe anemia, contributing to an overall anemia prevalence of 83.5% [17]. Another study, which included 515,270 women, revealed that severe anemia was present in just 0.02% of cases, with mild and moderate forms of anemia being more common at 11.8% and 0.43%, respectively [18]. In contrast, the current study reports a 0% prevalence of severe anemia, suggesting that effective preventive measures or nutritional interventions may be in place. This significant difference warrants further investigation into the factors contributing to these results.

The age distribution of pregnant women affected by anemia has been extensively studied, revealing varying trends across different populations. In a study conducted in Somaliland, in which 360 pregnant women enrolled, it was found that 46.7% of the participants were aged between 21 and 29 years, and this group exhibited a higher prevalence of anemia compared to younger women aged 20 years or younger, who had a prevalence of only 13.7% [19]. Similarly, according to a study in which a dataset of 21 Sub-Saharan African countries were collected between 2015 and 2022, indicated that women aged 20-24 years were at a higher risk for anemia, while those in older age (25-29

Table 5. Distribution of Anemia Severity by Socio-Demographic Variables

Variables (N, %)	Anemia			Total
	Mild	Moderate	Severe	
Age group (Years)				
≤20	1(3.1)	1(14.3)	0(0.0)	2(5.1)
21-25	10(31.2)	0(0.0)	0(0.0)	10(25.6)
26-30	8(25.0)	4(57.1)	0(0.0)	12(30.8)
31-35	6(18.8)	0(0.0)	0(0.0)	6(15.4)
≥36	7(21.9)	2(28.6)	0(0.0)	9(23.1)
Occupation				
House wife	22(68.8)	6(85.7)	0(0.0)	28(71.8)
Public sector	6(18.8)	1(14.3)	0(0.0)	7(17.9)
Private sector	1(3.1)	0(0.0)	0(0.0)	1(2.6)
Student	3(9.3)	0(0.0)	0(0.0)	3(7.7)
Education				
Illiterate	1(3.1)	2(28.6)	0(0.0)	3(7.7)
Elementary	8(25.0)	0(0.0)	0(0.0)	8(20.5)
Secondary	8(25.0)	4(57.1)	0(0.0)	12(30.8)
Diploma	5(15.6)	0(0.0)	0(0.0)	5(12.8)
College	10(31.3)	1(14.3)	0(0.0)	11(28.2)
Residence				
Urban	25(78.1)	6(85.7)	0(0.0)	31(79.5)
Rural	7(21.9)	1(14.3)	0(0.0)	8(20.5)
Not specified	0(0.0)	0(0.0)	0(0.0)	0(0.0)

years) showed a decreased risk [20]. In contrast, a comprehensive analysis involving over 880,000 women in low- and middle-income countries reported that pregnant women aged 25-34 and 35-49 had a reduced risk of anemia by 12% and 23%, respectively, compared to younger cohorts [21]. The current study, however, found that the 26–30 years age group exhibited the highest prevalence of anemia, at 30.8%. The discrepancy between the findings of these studies and the present study may be attributed to differences in the timing of the studies, variations in lifestyle factors, and disparities in access to healthcare facilities among the participants.

Thrombocytopenia during pregnancy is a notable concern, particularly in the later trimesters, with various studies documenting its prevalence and associated factors. In a study conducted at Gondar University Hospital in Ethiopia, the overall prevalence of thrombocytopenia among pregnant women was 8.8%, predominantly mild cases, with no significant association was observed between the trimester and thrombocytopenia prevalence [22]. A systematic review reported that thrombocytopenia affects approximately 5% to 10% of pregnant women, with a notable increase in cases observed during the third trimester due to physiological changes such as hemodilution [6]. Consistent with these findings, the current study also observed a higher likelihood of thrombocytopenia in the third trimester. This emphasizes the importance of routine platelet count monitoring during antenatal visits, enabling timely diagnosis and facilitating optimal feto-maternal outcomes across all types of thrombocytopenia during pregnancy.

The mean WBC count among pregnant women shows notable variations across different trimesters, as highlighted by several studies. A comprehensive longitudinal study involving 80,637 measurements found that the total WBC count increased significantly during pregnancy, with an upper reference limit elevated by 36% compared to non-pregnant levels, reaching a range of 5.7-15.0 × 10^9/L. This increase was primarily driven by a 55% rise in neutrophils, which remained stable throughout gestation, while lymphocyte counts decreased by approximately 36% [23]. In a study from Jordan, the mean WBC count in the first trimester was reported at 7.52 × 10^9/L, with significant increases observed in subsequent trimesters, reflecting the physiological changes associated with pregnancy [24]. In comparison, the current study found a different trend in WBC count across trimesters. Specifically, the WBC count increased from the first to the second trimester but then decreased from the second to the third trimester. This observed variation may be attributed to study design, life style, or population differences between study groups.

The current study revealed that the RBC count was significantly higher in the first trimester compared to both the second and third trimesters (4.45 ± 0.36 versus 4.03 ± 0.42 and 4.15 ± 0.46, P<0.01), with a similar trend observed for Hb levels. Regarding hematocrit values, although higher in the first trimester, no significant changes were noted between the first and third trimesters. This finding contrasts with studies conducted at Debre Berhan Referral Hospital in North Shoa, Ethiopia, where changes in both Hb and hematocrit values were not statistically significant across the trimesters [15]. In contrast, two studies conducted in Port Harcourt and Nigeria reported a significant decrease in Hct values as gestational age progressed [1,25]. These discrepancies may be attributed to regional variations, and healthcare differences.

The MCV, MCH, and MCHC demonstrate significant variations throughout the trimesters of pregnancy, reflecting the physiological changes that occur during this period. In a longitudinal study involving pregnant women, MCV was observed to decrease in the first trimester, reaching its lowest point before gradually returning to normal levels by the third trimester. Similarly, MCH values fell slightly during the first trimester but increased in the second trimester before declining again in the third trimester. MCHC showed a different trend, initially increasing in the first trimester and then gradually declining throughout the pregnancy [26]. In contrast to these trends, the current study found that MCV increased gradually from the first trimester (82.87 ± 5.53 fL) to the third trimester (86.63 ± 8.27 fL), while MCH values decreased from the first trimester (33.54 ± 35.38 pg) to the third trimester (28.47 ± 3.12 pg), and MCHC showed a slight increase in the second trimester (33.83 ± 1.08%) before decreasing in the third trimester (32.89 ± 1.20%). These differences may reflect variations in iron deficiency prevalence among study populations across countries. Additionally, the increase in MCV with gestational age could be attributed to the lower prevalence of anemia and the adequate supply of micronutrients, such as iron, which supports the maintenance of normal hematologic profiles, in contrast to the plasma volume dilution effect.

This study is limited by its retrospective design, which inherently carries the risk of selection and information biases due to reliance on pre-existing clinical records, potentially leading to incomplete or inaccurate data. Furthermore, the lack of direct assessment of iron and other micronutrient deficiencies represents a significant limitation, as these deficiencies are well-established determinants of hematological parameters in pregnancy.

5. Conclusion

Significant changes in hematological parameters across different trimesters of pregnancy, emphasizing the importance of regular monitoring throughout this period. Consistent evaluation of these parameters is crucial for the timely diagnosis and management of anemia, thrombocytopenia, and other hematological abnormalities, thereby ensuring optimal maternal and fetal health during antenatal care.

Declarations

Conflicts of interest: The author(s) have no conflicts of interest to disclose.

Ethical approval: The study was approved by the ethical committee of the Kscien organization (No.29).

Patient consent (participation and publication): Written informed consent was obtained from patients for publication.

Source of Funding: Smart Health Tower.

Role of Funder: The funder remained independent, refraining from involvement in data collection, analysis, or result formulation, ensuring unbiased research free from external influence.

Acknowledgements: None to be declared.

Authors' contributions: DOK and AMSA were significant contributors to the conception of the study and the literature search for related studies. AKQ, MNA, SNO, HBJ, MTT, and RAE were involved in the literature review, the study's design, the critical revision of the manuscript, they participated in data collection. AMM, BAA, SHM, and RQS involved in the literature review, study design, and manuscript writing. BAA and RQS confirm the authenticity of all the raw data. All authors approved the final version of the manuscript.

Use of AI: AI was not used in the drafting of the manuscript, the production of graphical elements, or the collection and analysis of data.

Data availability statement: Not applicable.

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