Attahadi Medical Journal
2026;3(4):733-741
https://doi.org/10.69667/amj.26417

OPEN ACCESS

Original article

Anaemia and its Associated Factors Among Pregnant Women Attending a Private Antenatal Clinic in Gharyan, Western Libya: A Cross-Sectional Study

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Keywords.
Anaemia; Pregnancy; Vitamin D; Iron Supplementation; Haemoglobin; Libya

Abstract

Anaemia is common in pregnancy and is associated with adverse maternal and neonatal outcomes. Data from western Libya are limited, and the role of vitamin D status is unclear. To determine the prevalence and severity of anaemia among pregnant women attending a private antenatal clinic in Gharyan, and to identify associated factors, particularly vitamin D status and iron supplementation. This cross-sectional study included 70 pregnant women between September and October 2026. Data were collected with a structured questionnaire. Anaemia was defined as haemoglobin (Hb) <11.0 g/dL, and serum 25-hydroxyvitamin D [25(OH)D] was measured by ELISA, with deficiency defined as <20 ng/mL. Associations were tested with non-parametric and exact tests, and a multivariable logistic regression model with three pre-selected factors was fitted (SPSS version 26). The median age was 32.5 years (IQR 27.0–38.0). Anaemia was present in 28 women (40.0%; 95% CI 29.3–51.7%): mild in 21.4%, moderate in 17.1%, and severe in 1.4% of all participants. Anaemia was more frequent among vitamin D-deficient than non-deficient women (53.8% vs 22.6%; p = 0.008), and Hb correlated positively with serum 25(OH)D (ρ = 0.354; p = 0.003). In the multivariable model, vitamin D deficiency remained associated with anaemia (adjusted OR 5.11; 95% CI 1.58–16.50), whereas current iron supplementation (adjusted OR 2.91; 95% CI 0.77–10.99) and third trimester (adjusted OR 1.52; 95% CI 0.38–6.11) were not. Anaemia was most frequent among irregular iron users (72.7%). Agreement between self-reported and Hb-defined anaemia was 80.0% (κ = 0.59). Anaemia affected four in ten women in this clinic sample. Vitamin D deficiency was independently associated with anaemia, and self-reported anaemia was not a reliable substitute for Hb testing. These exploratory findings should be confirmed in larger studies that include ferritin measurement.

Introduction

Anaemia in pregnancy is defined by the World Health Organisation (WHO) as a haemoglobin (Hb) concentration below 11.0 g/dL [1]. It remains one of the most common nutritional disorders affecting pregnant women. The WHO estimated that about 38% of pregnant women worldwide were anaemic in 2011 [2], and a systematic analysis of population-representative data reached a similar conclusion [3]. The burden falls most heavily on low- and middle-income countries, where inadequate dietary iron, repeated closely spaced pregnancies, infections, and limited access to care combine to sustain high prevalence [4]. The consequences extend beyond maternal fatigue. Severe anaemia during pregnancy and the postpartum period is associated with a higher risk of maternal death [5]. Maternal anaemia is also linked to preterm birth, low birth weight, and other adverse perinatal outcomes [6,7].

Iron deficiency is the leading cause. Maternal iron requirements rise steeply as plasma volume and red cell mass expand and as the fetus and placenta accumulate iron [8,9]. Routine iron supplementation improves maternal Hb and reduces the risk of anaemia at term [10]. Even so, anaemia often persists among women attending antenatal care, which suggests that supplement use, regularity, and other contributing factors deserve closer attention. In Libya, anaemia in pregnancy is a recognised public health problem. A cross-sectional study of 595 women attending a primary health centre in Derna reported a prevalence of 54.6%, with the highest rate in the third trimester [11]. Data on pregnant women in western Libya remain scarce, and information from private antenatal clinics is particularly limited. Local estimates are needed to guide screening and supplementation practices, because prevalence and risk factors differ between settings.

Micronutrient status beyond iron may also influence Hb. Vitamin D deficiency has been proposed as a contributor to anaemia, and the evidence in general populations points to an emerging association [12]. Observational data from adults have linked low serum 25-hydroxyvitamin D [25(OH)D] with a higher frequency of anaemia [13]. Experimental work offers a plausible mechanism, since vitamin D suppresses hepcidin, the master regulator of iron absorption and recycling [14]. Vitamin D deficiency is common in pregnancy and is generally defined as a serum 25(OH)D concentration below 20 ng/mL [15]. The relationship between vitamin D status and anaemia has not been well studied among pregnant women in Libya,

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Received: *12-09-2026 -* ***Accepted:*** *10-11-2026 -* ***Published:*** *18-11-2026*

Attahadi Medical Journal
2026;3(4):733-741
https://doi.org/10.69667/amj.26417

where both conditions are likely to be frequent. This study aimed to determine the prevalence and severity of anaemia among pregnant women attending a private antenatal clinic in Gharyan, western Libya, and to identify the factors associated with it, with particular attention to vitamin D status and iron supplementation. The secondary objectives were to examine the relationship between Hb and serum 25(OH)D concentrations and to assess the agreement between self-reported anaemia and Hb-defined anaemia.

Methods

Study Design and Setting

This cross-sectional study was conducted among pregnant women attending antenatal care at a private clinic in Gharyan Centre, western Libya, between September and October 2026. The study was reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines for cross-sectional studies.

Participants

A convenience sample of pregnant women was recruited during routine antenatal visits at the clinic. Women were eligible if they were pregnant at any gestational age and had available haemoglobin (Hb) and serum 25-hydroxyvitamin D [25(OH)D] results. No eligible woman declined participation. A total of 70 pregnant women were included in the analysis, and none had a missing Hb value. The sample size was determined by the number of eligible women recruited during the study period, and no formal sample size calculation was performed.

Data Collection

Data were collected using a structured, self-administered questionnaire (an online form completed by the participants at the clinic) that covered the following domains: (i) sociodemographic characteristics (age, residence, educational level, and occupation); (ii) obstetric history (gestational age, trimester, gravidity, parity, type of current pregnancy, and interpregnancy interval); (iii) pre-pregnancy anthropometry (weight, height, and body mass index [BMI] category, classified according to the World Health Organization [WHO] criteria as underweight, normal weight, overweight, or obese); (iv) supplement use, including current vitamin D supplement use, prenatal multivitamin use, and current iron supplementation with the approximate dose, route, and regularity; (v) dietary intake (frequency of milk/dairy products, oily fish, and eggs); (vi) anaemia history (whether anaemia had been diagnosed during the current pregnancy and whether iron-deficiency anaemia had been diagnosed previously); and (vii) chronic medical conditions and other medications. Regularity of iron supplementation was defined among women currently taking iron as regular (daily or as advised by the physician) or irregular (most days). Women who reported no current iron use were classified as not taking iron. One woman who reported no current iron use but gave a regularity response was classified according to the current-use item.

Laboratory Assessment

Hb concentration was measured in g/dL from venous blood using the clinic laboratory's automated haematology analyser and recorded for each participant. Serum 25(OH)D concentration was measured by enzyme-linked immunosorbent assay (ELISA) at the clinic's laboratory and classified as deficient (<20 ng/mL), insufficient (20–29.9 ng/mL), or sufficient (≥30 ng/mL). Serum ferritin was recorded only when it was requested as part of routine care; the assay and units were not specified in the source data, so ng/mL was assumed.

Outcome Definition

The primary outcome was anaemia, defined as Hb <11.0 g/dL according to the WHO definition for pregnancy. Anaemia severity was classified as mild (Hb 10.0–10.9 g/dL), moderate (7.0–9.9 g/dL), or severe (<7.0 g/dL). In a sensitivity analysis, trimester-specific thresholds were applied (<11.0 g/dL in the first and third trimesters and <10.5 g/dL in the second trimester). Because serum ferritin was available for only a small subset of women, it was described individually (ferritin <15 ng/mL was taken to indicate depleted iron stores), and the prevalence of iron-deficiency anaemia was not estimated.

Variables

The explanatory variables were age (<25, 25–34, and ≥35 years), educational level, occupation (housewife vs employed/student), pre-pregnancy BMI category, trimester, gravidity, parity, interpregnancy interval, vitamin D status (deficient, insufficient, or sufficient) and vitamin D deficiency (<20 vs ≥20 ng/mL), current vitamin D supplement use, prenatal multivitamin use, current iron supplementation and its regularity, previous iron-deficiency anaemia, dietary intake (milk/dairy and eggs <3 vs ≥3 times/week; oily fish <1 vs ≥1 time/week), chronic medical conditions, and other medication use. Self-reported anaemia during the current pregnancy was compared with Hb-defined anaemia, but it was not entered into the regression models because it describes the same condition as the outcome.

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Received: 12-09-2026 - **Accepted**: 10-11-2026 - **Published**: 18-11-2026

Attahadi Medical Journal
2026;3(4):733-741
https://doi.org/10.69667/amj.26417

Statistical Analysis

Data were analysed using SPSS version 26 (IBM Corp., Armonk, NY, USA). Continuous variables were summarised as mean ± standard deviation (SD) or as median with interquartile range (IQR), and categorical variables as frequencies and percentages. The prevalence of anaemia was presented with its 95% confidence interval (CI) calculated by the Wilson method. Women with and without anaemia were compared using the Mann–Whitney U test for continuous variables, and the Pearson chi-square test, Fisher's exact test (2 × 2 tables with expected counts <5), or the Monte Carlo exact test (larger tables with sparse cells) for categorical variables. The relationship between Hb and serum 25(OH)D was assessed using Spearman's rank correlation coefficient, and Hb was compared across vitamin D categories using the Kruskal–Wallis test and the Mann–Whitney U test. Agreement between self-reported anaemia and Hb-defined anaemia was assessed using the percentage of agreement and Cohen's kappa. Crude odds ratios (ORs) with 95% CIs were estimated using univariable logistic regression. To limit overfitting given the 28 anaemic women (about nine events per variable), a multivariable logistic regression model was fitted that included only three factors selected a priori on clinical grounds: vitamin D deficiency, current iron supplementation, and third trimester. Model performance was assessed using the likelihood-ratio chi-square test, Nagelkerke R^2, and the area under the receiver operating characteristic curve (AUC). All analyses were exploratory; no adjustment was made for multiple comparisons, and a two-sided p-value <0.05 was considered statistically significant.

Ethical Considerations

The study was conducted in accordance with the Declaration of Helsinki. Ethical approval was obtained from the Ethics Committee of the Faculty of Medicine, University of Gharyan, Libya (approval number: 25; date: March 2026), before participant recruitment began in September 2026. The clinic management approved data collection. All participants provided informed consent before participation. Data were collected anonymously and kept confidential.

Results

Characteristics of The Study Participants

A total of 70 pregnant women were included in the analysis. The median age was 32.5 years (IQR 27.0–38.0), and the median gestational age was 24.0 weeks (IQR 11.8–36.2). Eighteen women (25.7%) were in the first trimester, 21 (30.0%) in the second trimester, and 31 (44.3%) in the third trimester. According to pre-pregnancy BMI category, 28 women (40.0%) were of normal weight or underweight, 19 (27.1%) were overweight, and 23 (32.9%) were obese. Thirty-three women (47.1%) were university educated, 9 (12.9%) had postgraduate education, and 28 (40.0%) had secondary education; 28 (40.0%) were housewives. The median gravidity was 4 (IQR 2.0–5.0), the median parity was 3 (IQR 1.0–4.0), and 7 women (10.0%) were pregnant for the first time. Current iron supplementation was reported by 31 women (44.3%); 20 of them (64.5%) took it regularly and 11 (35.5%) irregularly. The route was oral only in 23 users, intramuscular or intravenous (alone or combined with oral tablets) in 4, and not specified in 4. Current vitamin D supplement use was reported by 39 women (55.7%) and prenatal multivitamin use by 62 (88.6%). Five women (7.1%) had a chronic medical condition, and 8 (11.4%) were taking other medications. The mean serum 25(OH)D concentration was 18.5 ± 13.0 ng/mL (median 15.3 ng/mL; IQR 10.0–25.7); 39 women (55.7%) were vitamin D deficient, 18 (25.7%) were insufficient, and 13 (18.6%) were sufficient.

Haemoglobin Concentration and Prevalence of Anaemia

The mean Hb concentration was 10.9 ± 1.5 g/dL (median 11.0 g/dL; IQR 10.0–12.0; range 6.9–14.0). Twenty-eight of the 70 women had an Hb below 11.0 g/dL, corresponding to an anaemia prevalence of 40.0% (95% CI 29.3–51.7%). Anaemia was mild in 15 women (21.4% of all participants), moderate in 12 (17.1%), and severe in 1 (1.4%); that is, 53.6%, 42.9%, and 3.6% of the anaemic women, respectively. The mean Hb was 9.5 ± 1.0 g/dL in anaemic women and 11.9 ± 0.8 g/dL in non-anaemic women. Applying trimester-specific thresholds classified the same 28 women as anaemic. The prevalence of anaemia was 33.3% (6/18) in the first trimester, 33.3% (7/21) in the second trimester, and 48.4% (15/31) in the third trimester (p = 0.442).

Self-Reported Anaemia and Agreement with Haemoglobin

Anaemia during the current pregnancy was self-reported by 32 women (45.7%), and 11 women (15.7%) reported a previous diagnosis of iron-deficiency anaemia. Of the 28 women with Hb-defined anaemia, 23 (82.1%) reported anaemia during the current pregnancy, whereas 9 of the 42 women without Hb-defined anaemia (21.4%) also reported it. The overall agreement between self-reported and Hb-defined anaemia was 80.0% (56/70; Cohen's κ = 0.59). Anaemia by Hb was present in 71.9% of women who reported anaemia and in 13.2% of those who did not (p < 0.001).

Characteristics According to Anaemia Status

(Table 1) compares women with and without anaemia. The two groups were similar in age (median 32.5 vs 32.5 years; p = 0.815), gestational age (median 28.5 vs 21.5 weeks; p = 0.755), gravidity (p = 0.693), and parity (p = 0.597). No significant

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Received: 12-09-2026 - **Accepted**: 10-11-2026 - **Published**: 18-11-2026

Attahadi Medical Journal
2026;3(4):733-741
https://doi.org/10.69667/amj.26417

differences were observed by age group, educational level, occupation, BMI category, trimester, gravidity category, parity category, or interpregnancy interval (all p > 0.05). Anaemia was present in 58.3% of women with an interpregnancy interval <12 months and in 31.2% of those with an interval >2 years (p = 0.332). Current vitamin D supplement use, prenatal multivitamin use, dairy, fish, and egg intake, chronic medical conditions, and other medication use were also not significantly associated with anaemia. A previous diagnosis of iron-deficiency anaemia was more frequent among anaemic women, but the difference was not statistically significant (63.6% vs 35.6%; p = 0.102). Vitamin D status was significantly associated with anaemia (p = 0.022). Anaemia was present in 53.8% of vitamin D-deficient women, 16.7% of insufficient women, and 30.8% of sufficient women. Anaemia was more frequent among deficient than non-deficient women (53.8% vs 22.6%; p = 0.008), and the median 25(OH)D concentration was lower in anaemic than in non-anaemic women (11.0 [IQR 6.2–20.0] vs 20.0 [IQR 11.6–27.4] ng/mL; p = 0.011). Anaemia was also more frequent among women currently taking iron than among those who were not (54.8% vs 28.2%; p = 0.024), and the proportion differed across categories of regularity (not taking 28.2%, irregular use 72.7%, regular use 45.0%; p = 0.030).

Table 1. Characteristics of the pregnant women according to anaemia status (N = 70)

Characteristic	Total (N = 70)	Anaemic (n = 28)	Non-anaemic (n = 42)	p-value
Continuous variables, median (IQR)				
Age, years	32.5 (27.0–38.0)	32.5 (27.2–36.0)	32.5 (27.0–38.2)	0.815[a]
Gestational age, weeks	24.0 (11.8–36.2)	28.5 (13.8–36.0)	21.5 (10.8–37.2)	0.755[a]
Gravidity	4.0 (2.0–5.0)	4.5 (2.2–5.8)	4.0 (2.0–5.0)	0.693[a]
Parity	3.0 (1.0–4.0)	3.0 (1.2–4.0)	2.0 (1.0–4.0)	0.597[a]
Serum 25(OH)D, ng/mL	15.3 (10.0–25.7)	11.0 (6.2–20.0)	20.0 (11.6–27.4)	0.011[a]
Categorical variables, n (%)				
Age group, years				0.937[d]
<25	7 (10.0)	3 (42.9)	4 (57.1)	
25–34	33 (47.1)	14 (42.4)	19 (57.6)	
≥35	30 (42.9)	11 (36.7)	19 (63.3)	
Educational level				0.362[d]
Secondary	28 (40.0)	14 (50.0)	14 (50.0)	
University	33 (47.1)	11 (33.3)	22 (66.7)	
Postgraduate	9 (12.9)	3 (33.3)	6 (66.7)	
Occupation				0.163[b]
Housewife	28 (40.0)	14 (50.0)	14 (50.0)	
Employed/student	42 (60.0)	14 (33.3)	28 (66.7)	
Pre-pregnancy BMI category				0.913[b]
Normal/underweight	28 (40.0)	12 (42.9)	16 (57.1)	
Overweight	19 (27.1)	7 (36.8)	12 (63.2)	
Obese	23 (32.9)	9 (39.1)	14 (60.9)	
Trimester				0.442[b]
First	18 (25.7)	6 (33.3)	12 (66.7)	
Second	21 (30.0)	7 (33.3)	14 (66.7)	
Third	31 (44.3)	15 (48.4)	16 (51.6)	
Gravidity				0.064[d]
Primigravida (1)	8 (11.4)	5 (62.5)	3 (37.5)	
2–3	20 (28.6)	4 (20.0)	16 (80.0)	
≥4	42 (60.0)	19 (45.2)	23 (54.8)	
Parity				0.245[d]
Nulliparous	10 (14.3)	5 (50.0)	5 (50.0)	
1–2	23 (32.9)	6 (26.1)	17 (73.9)	
≥3	37 (52.9)	17 (45.9)	20 (54.1)	
Interpregnancy interval				0.332[d]
First pregnancy	7 (10.0)	4 (57.1)	3 (42.9)	
<12 months	12 (17.1)	7 (58.3)	5 (41.7)	
1–2 years	19 (27.1)	7 (36.8)	12 (63.2)	
>2 years	32 (45.7)	10 (31.2)	22 (68.8)	

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Received: 12-09-2026 - **Accepted**: 10-11-2026 - **Published**: 18-11-2026

Attahadi Medical Journal
2026;3(4):733-741
https://doi.org/10.69667/amj.26417

Vitamin D status				0.022[b]
Deficient (<20 ng/mL)	39 (55.7)	21 (53.8)	18 (46.2)	
Insufficient (20–29.9)	18 (25.7)	3 (16.7)	15 (83.3)	
Sufficient (≥30)	13 (18.6)	4 (30.8)	9 (69.2)	
Vitamin D deficiency				0.008[b]
Deficient (<20 ng/mL)	39 (55.7)	21 (53.8)	18 (46.2)	
Non-deficient (≥20 ng/mL)	31 (44.3)	7 (22.6)	24 (77.4)	
Current vitamin D supplement use				0.492[b]
No	31 (44.3)	11 (35.5)	20 (64.5)	
Yes	39 (55.7)	17 (43.6)	22 (56.4)	
Prenatal multivitamin use				0.462[c]
No	8 (11.4)	2 (25.0)	6 (75.0)	
Yes	62 (88.6)	26 (41.9)	36 (58.1)	
Current iron supplementation				0.024[b]
No	39 (55.7)	11 (28.2)	28 (71.8)	
Yes	31 (44.3)	17 (54.8)	14 (45.2)	
Regularity of iron supplementation				0.030[d]
Not taking	39 (55.7)	11 (28.2)	28 (71.8)	
Irregular (most days)	11 (15.7)	8 (72.7)	3 (27.3)	
Regular (daily/as advised)	20 (28.6)	9 (45.0)	11 (55.0)	
Milk/dairy intake				0.770[b]
<3 times/week	36 (51.4)	15 (41.7)	21 (58.3)	
≥3 times/week	34 (48.6)	13 (38.2)	21 (61.8)	
Oily fish intake				0.911[b]
<1/week	52 (74.3)	21 (40.4)	31 (59.6)	
≥1/week	18 (25.7)	7 (38.9)	11 (61.1)	
Egg intake				0.920[b]
<3 times/week	27 (38.6)	11 (40.7)	16 (59.3)	
≥3 times/week	43 (61.4)	17 (39.5)	26 (60.5)	
Chronic medical condition				1.000[c]
No	65 (92.9)	26 (40.0)	39 (60.0)	
Yes	5 (7.1)	2 (40.0)	3 (60.0)	
Other medication use				1.000[c]
No	62 (88.6)	25 (40.3)	37 (59.7)	
Yes	8 (11.4)	3 (37.5)	5 (62.5)	
Previous iron-deficiency anaemia diagnosis				0.102[c]
No	59 (84.3)	21 (35.6)	38 (64.4)	
Yes	11 (15.7)	7 (63.6)	4 (36.4)	
Anaemia diagnosed during current pregnancy (self-reported)				<0.001[b]
No	38 (54.3)	5 (13.2)	33 (86.8)	
Yes	32 (45.7)	23 (71.9)	9 (28.1)	

Anaemia. haemoglobin <11.0 g/dL (prevalence 28/70, 40.0%; 95% CI 29.3–51.7%). BMI, body mass index; IQR, interquartile range; 25(OH)D, 25-hydroxyvitamin D. For categorical variables, n is the number of women in each category, and percentages show the proportion of women within that category who were anaemic or non-anaemic (the percentage in the total column is of all 70 women). BMI category as recorded in the questionnaire. Regularity of iron supplementation among current users: regular, daily, or as advised by the physician; irregular, most days. [a] Mann–Whitney U test. [b] Pearson chi-square test. [c] Fisher's exact test. [d] Monte Carlo exact test.

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Received: 12-09-2026 - **Accepted**: 10-11-2026 - **Published**: 18-11-2026

Attahadi Medical Journal
2026;3(4):733-741
https://doi.org/10.69667/amj.26417

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Haemoglobin and Vitamin D Status

Hb was positively correlated with serum 25(OH)D (Spearman's ρ = 0.354; p = 0.003; Figure 1). The median Hb was 10.7 g/dL (IQR 9.8–11.7) in vitamin D-deficient women, 11.8 g/dL (IQR 11.0–12.3) in insufficient women, and 12.0 g/dL (IQR 9.7–12.2) in sufficient women (Kruskal–Wallis p = 0.010). Hb was lower in deficient than in non-deficient women (median 10.7 vs 12.0 g/dL; p = 0.003).

Logistic Regression Analysis

(Table 2) presents crude and adjusted odds ratios for anaemia. In univariable analysis, vitamin D deficiency was associated with higher odds of anaemia (crude OR 4.00; 95% CI 1.40–11.45; p = 0.010), as was current iron supplementation (crude OR 3.09; 95% CI 1.14–8.35; p = 0.026). No other factor reached statistical significance. In the multivariable model including vitamin D deficiency, current iron supplementation, and third trimester, vitamin D deficiency remained significantly associated with anaemia (adjusted OR 5.11; 95% CI 1.58–16.50; p = 0.006), whereas current iron supplementation (adjusted OR 2.91; 95% CI 0.77–10.99; p = 0.116) and third trimester (adjusted OR 1.52; 95% CI 0.38–6.11; p = 0.552) were not significantly associated. The model was statistically significant (likelihood-ratio $\chi^2(3)$ = 13.6; p = 0.003), with Nagelkerke R^2 = 0.24 and an AUC of 0.74. The confidence intervals were wide, reflecting the small number of anaemic women.

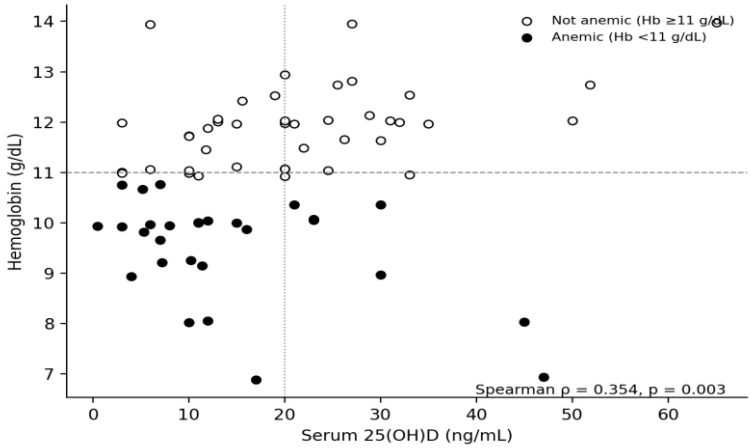


Figure 1. Relationship between serum 25(OH)D and haemoglobin concentration among 70 pregnant women.
The dashed line marks Hb = 11 g/dL and the dotted line marks 25(OH)D = 20 ng/mL. Points were jittered slightly on the vertical axis for visibility.

Table 2. Crude and adjusted odds ratios for anaemia (Hb <11.0 g/dL)

Factor	Anaemic/total, n/N	Crude OR (95% CI)	p	Adjusted OR (95% CI)	p
Age ≥35 years	11/30	0.78 (0.30–2.07)	0.622	—	—
Housewife (vs employed/student)	14/28	2.00 (0.75–5.33)	0.166	—	—
Secondary education or lower (vs university/postgraduate)	14/28	2.00 (0.75–5.33)	0.166	—	—
Overweight or obese (vs normal/underweight)	16/42	0.82 (0.31–2.17)	0.690	—	—
Third trimester (vs first/second)	15/31	1.87 (0.71–4.94)	0.204	1.52 (0.38–6.11)	0.552
Grand multigravida (gravidity ≥4)	19/42	1.74 (0.64–4.74)	0.275	—	—
Parity ≥3	17/37	1.70 (0.64–4.49)	0.284	—	—
Interpregnancy interval <12 months	7/12	2.47 (0.70–8.75)	0.162	—	—
Vitamin D deficiency (<20 ng/mL)	21/39	4.00 (1.40–11.45)	0.010	5.11 (1.58–16.50)	0.006
Current vitamin D supplement use	17/39	1.40 (0.53–3.71)	0.492	—	—
Current iron supplementation	17/31	3.09 (1.14–8.35)	0.026	2.91 (0.77–10.99)	0.116
Previous iron-deficiency anaemia	7/11	3.17 (0.83–12.08)	0.092	—	—
Dairy <3 times/week	15/36	1.15 (0.44–3.01)	0.770	—	—

OR, odds ratio; CI, confidence interval. Crude ORs were obtained from separate univariable logistic regressions. Adjusted ORs are from a single multivariable logistic regression that included the three factors with adjusted estimates shown (likelihood-ratio $\chi^2(3)$ = 13.6, p = 0.003; Nagelkerke R^2 = 0.24; AUC = 0.74).

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Received: 12-09-2026 - **Accepted**: 10-11-2026 - **Published**: 18-11-2026

Attahadi Medical Journal
2026;3(4):733-741
https://doi.org/10.69667/amj.26417

Serum Ferritin

Serum ferritin results were available for only 7 women (10.0%), of whom 5 were anaemic by Hb. Ferritin values ranged from 10 to 155 ng/mL (median 23 ng/mL). Two women, both anaemic and both taking iron supplements, had ferritin <15 ng/mL (10 and 12 ng/mL). Because of the small number of results, iron-deficiency anaemia could not be classified or its prevalence estimated.

Discussion

In this cross-sectional study of 70 pregnant women attending a private antenatal clinic in Gharyan, 40.0% were anaemic (95% CI 29.3–51.7%). Most cases were mild or moderate, and only one woman had severe anaemia. This prevalence is lower than the 54.6% reported from primary care in Derna [11], although the two samples differ in setting, size, and sampling method. The prevalence was higher in the third trimester (48.4%) than in the first and second trimesters (33.3% each), but the difference was not statistically significant. Hb normally falls during pregnancy because plasma volume expands faster than red cell mass [16], and applying trimester-specific thresholds classified the same 28 women as anaemic, so the choice of cut-off did not change our estimate. The main finding was the association between vitamin D status and anaemia. Women with vitamin D deficiency had higher odds of anaemia than women with 25(OH)D of 20 ng/mL or more, and the association persisted after adjustment for iron supplementation and trimester (adjusted OR 5.11; 95% CI 1.58–16.50). Hb also correlated positively with serum 25(OH)D. This agrees with the evidence from other populations. In older adults with anaemia, vitamin D deficiency was more frequent, particularly where anaemia was linked to inflammation [17].

A biological explanation is available through hepcidin: a randomised pilot trial in healthy adults found that high-dose vitamin D3 lowered circulating hepcidin [18], which would favour iron absorption and release from stores. Trials of vitamin D supplementation have not, however, given consistent effects on iron indices [19], and iron and vitamin D metabolism may influence each other in both directions [20]. Because our design is cross-sectional, the association should not be read as causal, and the wide confidence interval reflects the small number of anaemic women. Current iron supplementation was more frequent among anaemic women in the crude analysis (OR 3.09), but the association was no longer significant after adjustment (adjusted OR 2.91; 95% CI 0.77–10.99). This pattern should not be interpreted as iron causing anaemia. Prenatal iron use is generally associated with better pregnancy outcomes [21], and the most likely explanation here is reverse association: women found to be anaemic were the ones prescribed iron, and many of them had not yet responded. Regularity appeared to matter, since anaemia was most frequent among irregular users (72.7%), followed by regular users (45.0%) and non-users (28.2%).

Poor adherence is a recognised weakness of iron–folic acid programs [22], and side effects, forgetfulness, and limited counselling are common barriers [23]. Our data did not allow us to separate these explanations, since dose, duration, and timing of the first prescription were not recorded. Anaemia was not significantly associated with age, education, occupation, pre-pregnancy BMI, gravidity, parity, interpregnancy interval, or dietary intake. Some patterns were in the expected direction, such as a higher prevalence with an interpregnancy interval under 12 months (58.3% vs 31.2% for more than two years) and among women with a previous diagnosis of iron-deficiency anaemia (63.6% vs 35.6%). Neither reached significance, and with 70 participants, the study had limited power to detect moderate differences. Self-reported anaemia agreed reasonably well with the Hb-based classification (80.0%; $\kappa = 0.59$), but about one in five women was misclassified, so self-report cannot replace laboratory testing. This matters because anaemia is associated with adverse maternal and neonatal outcomes [24], and an Hb test at each antenatal visit remains the practical way to identify affected women.

Limitations

This study has several limitations. The sample was small, drawn by convenience from a single private clinic, and may not represent pregnant women in Gharyan or western Libya. The cross-sectional design prevents conclusions about the direction of associations. Serum ferritin was available for only seven women, so iron-deficiency anaemia could not be classified, and other causes of anaemia such as haemoglobinopathies, infection, and folate or vitamin B12 deficiency were not assessed. Iron and vitamin D supplement use, diet, and previous anaemia were self-reported. The multivariable model was restricted to three variables chosen in advance to keep the events-per-variable ratio acceptable [25], and its estimates are imprecise. No adjustment was made for multiple comparisons, so isolated significant findings should be treated as exploratory. Larger studies that measure ferritin and follow women over time are needed to confirm these results.

Conclusion

Anaemia affected about four in ten pregnant women in this clinic sample, mostly in mild or moderate form. Vitamin D deficiency was independently associated with anaemia, and Hb rose with serum 25(OH)D, which supports considering vitamin D status alongside iron status when evaluating anaemia in pregnancy. Irregular iron use was linked to the highest

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Received: 12-09-2026 - **Accepted**: 10-11-2026 - **Published**: 18-11-2026

prevalence, and self-reported anaemia was not a reliable substitute for haemoglobin testing. These exploratory findings need confirmation in larger, multicenter studies with ferritin measurement and follow-up.

Acknowledgements
The authors would like to thank the pregnant women who generously participated in this study, as well as the staff of the private clinic in Gharyan for their cooperation and assistance during data collection. The authors are also grateful to the Faculty of Medicine, University of Gharyan, for its support of this research.
Funding Statement
This research received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

Conflict of Interest
The authors declare that they have no conflict of interest.

Author Contributions
All authors contributed to the study conception and design, data collection, data analysis, and drafting of the manuscript. All authors read and approved the final manuscript.

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Received*: 12-09-2026 -* ***Accepted****: 10-11-2026 -* ***Published****: 18-11-2026*

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Received*: 12-09-2026 -* ***Accepted****: 10-11-2026 -* ***Published****: 18-11-2026*