Vol.20, No.3, Page 573- 582, 2026 http://dx.doi.org/10.59628/jchm.v20i3.2878 ISSN 2958-7476 JMCH

Sana'a University Journal of Medical and Health Sciences

Prevalence of Iron Deficiency Anemia among Pregnant Women at Al-Jomhori Teaching Hospital in Sana'a City -Yemen

Ali Yahia Seraj[1*] **and Jameel Al-Ghazaly**[2,3]

[1]**Hematology and Blood Transfusion Department, Faculty of Medicine and Health Sciences, Sana'a University, Yemen,**
[2]**Internal Medicine and Hematology, Department of Medicine, Faculty of Medicine and Health Sciences, Sana'a University, Sana'a, Yemen,**
[3]**Hematology unit, Al-Jomhori Teaching Hospital, Sana'a, Yemen.**

*Corresponding author: Email: aliseraj284@gmail.com

Abstract

Background: Iron deficiency anemia (IDA) is widely recognized as a common type of nutritional disorder among pregnant women and poses substantial risk to both maternal and fetal health worldwide, especially in developing countries such as Yemen. This study was designed to estimate the prevalence of IDA among pregnant women attending obstetric clinics at Al-Jomhori Teaching Hospital in Sana'a City, Yemen.
Materials and methods: Between August 2024 and August 2025**,** a cross-sectional study was conducted on 397 pregnant women. Venous blood samples were analyzed for hematological parameters and iron profile tests to determine IDA using automated methods. Statistical analyses were performed using SPSS version 24.
Results: Among 397 pregnant women, the prevalence of IDA among study subjects was 49.4%, and it was also 87.5% out of the total 224 anemic pregnant women. Statistical analysis showed a highly statistically significant (P = 0.001) role in the development of IDA in pregnant women who were illiterate, had a shorter interpregnancy period of $<$ 1 year, had 4–7 children, and had a low monthly family income.
Conclusion: The high prevalence of IDA among pregnant women in the study area may be attributed to factors such as socioeconomic status, maternal education levels, and reproductive-related factors. This necessitates strengthening health awareness programs that emphasize the importance of birth spacing, improving nutritional care, and providing preventive nutritional supplements to the most vulnerable social groups to reduce health risks.

Article Info

Keywords:
Iron deficiency anemia (IDA), pregnant women, Sana'a, Yemen.

Article History:
Received: 14-March-2026,
Revised: 11-April-2026,
Accepted: 17-April-2026,
Available online: 28-June-2026

1. INTRODUCTION

Iron deficiency anemia (IDA) is a common nutritional anemia in pregnant women and a major risk factor for adverse maternal and fetal complications. This is primarily due to the gradual increase in iron requirements for both the mother and fetus throughout pregnancy, peaking in the final trimester [1]. Furthermore, IDA during pregnancy is a public health issue in many low- and middle-income countries, where malnutrition, limited access to healthcare, and frequent pregnancies exacerbate the problem [2]. Pregnant women may also develop anemia in high-income countries due to poor eating habits, pre-existing health problems, or pregnancies that are too close together [3].

Furthermore, IDA is common during pregnancy and can lead to serious complications for both the mother and the fetus. This results from insufficient iron levels required to produce hemoglobin, which impairs oxygen transport throughout the body. Therefore, IDA during pregnancy increases the risk of complications, such as fatigue, cardiovascular problems, infections, postpartum hemorrhage, and obstetric complications, including low birth weight and premature birth [4]. During pregnancy,

the body's need for iron increases significantly to support both the increased blood volume of the mother and fetal growth [5].

Furthermore, IDA in pregnancy is a serious global health issue that affects millions of women, especially in low- and middle-income countries (LMICs) [6]. The worldwide prevalence is estimated at 41.8%, with over 80% of countries reporting rates of around 29%, and up to 50% in LMICs, including the Middle East[7]. According to the World Health Organization (WHO), approximately 40% of pregnant women globally suffer from anemia, mostly due to inadequate iron intake [8].

In Yemeni pregnant women, the prevalence of IDA in Taiz Governorate was 32.9% and was higher in the third trimester and in families with low socioeconomic status (51.7% and 47.5%, respectively) [9]. In Sana'a, Yemen, among pregnant women, the prevalence of anemia was 44.2%, and it was mild in 18.8%, moderate in 25.0%, and severe in 0.4% for severity of anemia [10]. Another study in Sana'a, Yemen, reported a 40.3% rate among women aged 35 to less than 45 years, which was higher among those with low income and malnutrition [11]. Furthermore, another study in Sana'a reported that the overall prevalence of IDA was 25%, with higher rates of mild anemia (70.83%), followed by moderate anemia (28.13%), and severe anemia (1.04 %) [12]. Additionally, 55% of pregnant women in the Hodeida governorate were reported to be anemic [13].

In Yemeni pregnant women, the prevalence of IDA varies considerably. Therefore, the present study aimed to estimate its prevalence in pregnant women who attended obstetric clinics at the Al-Jomhori Teaching Hospital in Sana'a City, Yemen.

2. MATERIALS AND METHODS

2.1. STUDY AREA AND POPULATION

Between August 1, 2024, and August 30, 2025**,** a cross-sectional study was carried out on 397 pregnant women who were attended to at obstetric clinics in Al-Jomhori Teaching Hospital of Sana'a City, Yemen. Non-pregnant women and pregnant women with inherited anemia were excluded from the study.

2.2. DATA COLLECTION

A pre-designed questionnaire was employed to obtain the socioeconomic and demographic characteristics of the pregnant women, which included age at pregnancy, age at the time of marriage, gestation month, educational level, and monthly family income (low = $<$ 50,000 YER, moderate = 50,000–200,000, and high = $>$ 200,000, with 1 YER = USD 0.00185). Furthermore, the questionnaire included the obstetric history of pregnant women, such as gravidity (primigravida, multigravida, and grand multigravida), number of children (1-3 or 4-7), and inter-pregnancy space ($<$ 1 year, 1-2 years, or $>$ 2 years).

2.3. SAMPLE COLLECTION

A total of 5 mL of blood was collected from each pregnant woman: 2 mL was placed into a tube with EDTA to determine complete blood cells (CBC), and 3 mL was placed into a non-additive tube for iron profile analysis.

2.4. LABORATORY INVESTIGATIONS

2.4.1. HEMOGLOBIN AND RBC PARAMETER

Hb, red blood cell count (RBC), mean corpuscular hemoglobin concentration (MCHC), red cell distribution width (RDW), mean corpuscular volume (MCV), and mean corpuscular hemoglobin (MCH) were measured using a DH36 automated hematology analyzer (Dymind Biotechnology Limited, Shenzhen, China). For pregnant women, anemia was defined as an Hb value of less than 11 g/dl, while Hb values greater than 11 g/dl were considered normal or did not indicate anemia. Based on the WHO classification, mild anemia is defined as 9.9-10.9 g/dl, moderate anemia as 7.0-9.8 g/dl, and severe anemia as 7.0 g/dl [14]. In addition to low Hb levels, pregnant women were considered anemic if MCV $<$ 76 fl, MCH $<$ 27 pg, and RDW $>$ 15%.

2.4.2. IRON PROFILE MEASUREMENTS

Serum ferritin, unsaturated iron binding capacity (UIBC), and serum iron levels were measured automatically after calibration using a Mindray Biochemistry Analyzer (Mindray Medical International Limited, Shenzhen, China). TIBC was estimated based on the measured UIBC using a Mindray Biochemistry Analyzer (Mindray Medical International Limited, Shenzhen, China). TIBC was measured using a calculated method based on the following formula: TIBC = serum iron + serum UIBC [15]. Transferrin saturation (TSAT)was calculated using serum iron concentration and TIBC. [TSAT = (Fe/TIBC) $\times$ 100]. Pregnant women with ferritin $<$ 15 ng/dl and serum iron $<$ 37 μg/dl were diagnosed with IDA. Pregnant women with serum TIBC $>$ 400 μg/dl and TSAT less than 20% were diagnosed with iron deficiency [16, 17].

2.5. STATISTICAL ANALYSIS

All data were processed and analyzed using the Statistical Package for the Social Sciences (version 24, IBM Corp., New York, USA). Continuous variables are reported as mean $\pm$ SD) or median (range), and categorical variables as frequencies and percentages. Associations between categorical variables were evaluated using the chi-square (χ^2) test. Multivariable logistic regression analysis was performed to detect independent predictors of IDA. The strength of association was estimated, and the outcomes were expressed as Odds Ratios (OR)

with their corresponding 95% Confidence Intervals (CI). Statistical significance was defined as a P-value of < 0.05.

3. RESULTS

3.1. Sociodemographic characterization of participants

As shown in Table 1, the highest percentage of cases studied was in the 20-29 age group (57.9%), while the percentage was 38.5% in the ≥ 30 age group. The lowest percentage of pregnant women (3.5%) was in the under-20 age group. Regarding educational attainment, the highest percentage of pregnant women was among those who were illiterate (46.6%), followed by those with a primary education (23.4%). The lowest percentage was among those with a secondary education (16.1%), followed by those with a university education (13.9%). Furthermore, the percentage of women with middle incomes was 43.6%, followed by those with low incomes (40.8%) and those with high incomes (15.6%).

3.2. DISTRIBUTION OF HEMATOLOGICAL PARAMETERS

Table 2 shows the hemoglobin, MCH, MCV, MCHC, and iron profiles of the study population. The mean hemoglobin level among the study participants was 10.7 g/dl (SD 1.8), MCH was 25.3 pg (SD 3.9), MCV was 74.9 fl (SD 8.8), and MCHC was 34.2 g/dl (SD 2.1). In addition, the mean serum iron was 41.2 mcg/dl with SD 12.2, and the ferritin was 40.8 ng/ml with SD 32.3. The TIBC was 336.2 mcg/dl with SD 88.1 and the transferrin saturation was 13.6% with SD 6.5. According to the IDA, the mean hemoglobin level among the study participants was 9.4 g/dl (SD 0.95), MCH was 22.1 pg (SD 2.0), MCV was 67.5 fl (SD 5.1), and MCHC was 33.2 g/dl (SD 1.9). In addition, the mean serum iron was 31.4 mcg/dl with SD 4.8, and the ferritin was 13.8 ng/ml with SD 7.9. The TIBC was 365.2 mcg/dl with SD 87.9 and the transferrin saturation was 9.1% with SD 3.0.

3.3. DISTRIBUTION OF THE IRON DEFICIENCY AMONG PREGNANT WOMEN

Of the 397 pregnant women, the prevalence of IDA was 49.4%, followed by 42.1% for no ID, 7.0% for other anemia without ID, and 1.5% for ID without anemia (Figure 1).

3.4. IDA AND ITS SEVERITY AMONG PREGNANT WOMEN

Of the 224 anemic pregnant women, IDA was the most prevalent (87.5%), and 12.5% had other types of anemia. The highest distribution of anemia severity among pregnant women was in those with mild anemia, 112 (50.0%), followed by moderate anemia, 104 (46.5%), while the lowest distribution of anemic pregnant women was in those with severe anemia, 8 (3.5%). There was no statistically significant association between severity and IDA (χ^2 = 0.170 and p = 0.919), as summarized in Table 3. Anemia severity: mild 9.9–910.9 g/dl; moderate 7.0–9.8 g/dl; severe < 7.0 g/dl [11].

3.5. IDA AMONG PREGNANT WOMEN BY EDUCATIONAL LEVEL AND MONTH INCOME

As shown in Table 4, the distribution of IDA was more common among pregnant women with an educational level of illiteracy (67.9%), followed by primary (16.3%), whereas it was less common among those with secondary (10.7%) and university education (5.1%). IDA was more common in pregnant women with low monthly income (64.3%), followed by moderate income (33.7%), while the lowest distribution was in high family monthly income (2.0%). A highly statistically significant correlation was observed between educational status and family monthly income in relation to IDA, with χ^2 = 74.292 (p < 0.001) for educational status and χ^2 = 126.584 (p < 0.001) for family monthly income, respectively.

3.6. DISTRIBUTION OF IDA AMONG PREGNANT WOMEN BY THE HISTORY OF OBSTETRIC

Regarding age at marriage, the highest distribution of IDA was found in the 18–24 years age group (152; 77.5%), while the lowest distribution was among those ≥25 years (18; 9.2%). According to age at pregnancy, higher and lower distributions of IDA were found in the aged groups of 20–29 years (101; 51.5%) and < 20 years (4.1%), respectively, with statistical differences (P = 0.038). Regarding gestation month, a higher distribution of IDA was found among participants in the third trimester (66.9%), and a lower distribution was found among those in the first trimester (11.7%), with statistical differences (P = 0.002). Furthermore, IDA was most prevalent in pregnant women who were grand multigravida (63.8%), had an interpregnancy space of less than 1 year (75.9%), and had 4–7 children (65.4%). A significant correlation was observed between the prevalence of IDA and obstetric history, including gravidity, interpregnancy space, and number of children (P < 0.001), as listed in Table 5.

3.7. MULTIVARIATE LOGISTIC REGRESSION ANALYSIS

Multivariate logistic regression analysis in this study revealed that sociodemographic and reproductive factors

Table 1. Sociodemographic characterization of participants

Variables		No	%
Age groups	**< 20**	**14**	**3.5**
	20- 29	**230**	**57.9**
	≥ 30	**153**	**38.5**
Educational level	Illiterate	185	46.6
	Primary	93	23.4
	Secondary	64	16.1
	University	55	13.9
Monthly income	Low	162	40.8
	Moderate	173	43.6
	High	62	15.6

Table 2. Distribution of HGB, RBC indices and Iron profile among 397 pregnant women

Total (n=397)	**Hb**	**MCH**	**MCV**	**MCHC**	**Iron**	**Ferritin**	**TIBC**	**TS**
	g/dl	pg	Fl	g/dl	mcg/dl	ng/ml	mcg/dl	%
Mean	10.7	25.3	74.9	34.2	41.2	40.8	336.2	13.6
SD	1.8	3.9	8.8	2.1	12.2	32.3	88.1	6.5
Minimum	6.0	19.0	50.0	25.0	15.0	5.0	124.0	3.6
Maximum	15.7	34.3	106.0	38.9	93.0	194.0	470.0	32.8
IDA (n= 196)								
Mean	9.4	22.1	67.5	33.2	31.4	13.8	365.2	9.1
SD	0.95	2.0	5.1	1.9	4.8	7.9	87.9	3.0
Minimum	6.0	19.0	50.0	26.0	15.0	5.0	195.0	3.6
Maximum	10.8	26.0	74.7	36.6	37.0	47.0	470.0	16.8

were independent risk factors for developing IDA. The likelihood of developing IDA was 11-fold higher among illiterate pregnant women (OR = 11.5; 95% CI = 4.5–24.5; p = 0.001) and two times higher in pregnant women with primary education (OR = 2.4; 95% CI = 1.1–5.3; p = 0.037). Regarding income level, low income emerged as a 50-fold risk factor (OR = 50.8; 95% CI = 17.3–149.3; P = 0.001), while the risk of IDA was 8.9-fold higher among pregnant women with middle income (CI = 3.1–25.9; P = 0.001). Regarding reproductive history, grand multigravida was a significant risk factor for IDA, with an odds ratio of 20.6 (95% CI = 7.6–55.5; P = 0.001) and an odds ratio of 4.1 among pregnant women with multigravida pregnancies. An interpregnancy space of less than 1 year was associated with an increased risk of iron deficiency anemia, with an odds ratio of 4.9 (95% CI = 3.1–25.9; P = 0.001). Large family size was a significant risk factor for IDA among pregnant women with 4–7 children, with an odds ratio of 5.8 (95% CI = 3.2–7.9; P = 0.001), as shown in Table 6.

4. DISCUSSION

Iron deficiency anemia is a condition caused by low iron storage resulting from external and internal factors and is described as hypochromic and microcytic anemia [18]. It accounts for nearly half of all cases worldwide during pregnancy [19]. The demand for iron increases during pregnancy owing to physiological expansion of the maternal RBC mass and nutritional requirements of fetal and placental tissues [20].

Among pregnant women, our study indicated that the IDA rate was 49.4%. This result is inconsistent with studies conducted in Nepal (49%) [21], Iraq (48.6%) [22], and Egypt (52.5%) [9]. In contrast, this finding was 5% higher than that of a study conducted in Sana'a City, Yemen (44.2%) [10] and 6% lower than those of studies conducted in Dhamar City (54.5%) [23] and Hodeida City, Yemen (55%) [13]. In addition, the percentage in this study was lower than that of a study conducted in Mukalla, Yemen (81%) [24] and higher than those of studies conducted in Taiz Governorate, Yemen (32.9%) [9], Sana'a, Yemen (25.0%) [12], governmental hospitals in Sana'a, Yemen (40.3%) [11], Makkah (39%), Khamis Mushayt, Saudi Arabia (42.5%) [25, 26], Oman (41.7%) [27], Ethiopia (32%) [28], and Uganda (7.4%) [29]. The observed variations and rising prevalenceof anemia among pregnant women in Yemen are largely attributable to the sustained deterioration of healthcare services, worsening socioeconomic conditions, food consumption, lack of awareness of the importance of iron supplements, and the general economic situation that existed even before the disagreement. In addition, the variation in prevalence in this study compared to previous studies conducted in Yemen is also likely due to differences in healthcare-seeking behaviors. Our study was

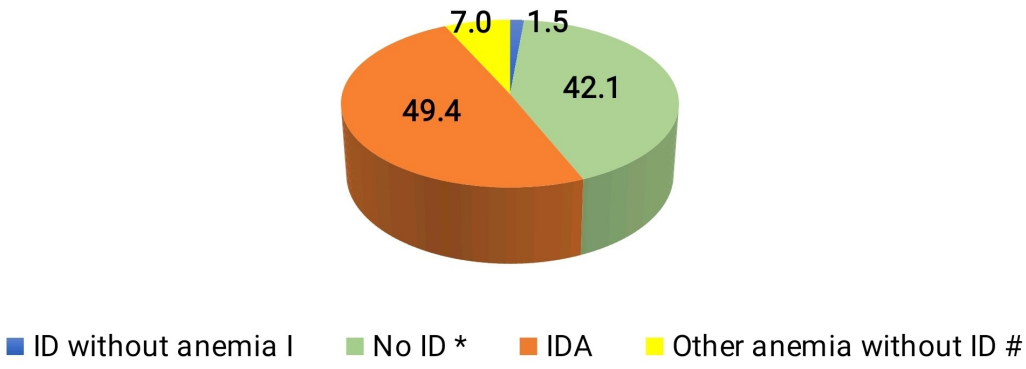

Figure 1. Distribution of the iron deficiency among 397 pregnant women
I= refers to present of iron deficiency with absent of anemia
* = refers to the normal cases
# = refers to the present of anemia (non-IDA) with absent of iron deficiency

Table 3. The rate of IDA and its severity among the 224 anemic pregnant women

Severity	Anemia						χ^2	*p*
	IDA n= **196**		Other n= **28**		Total n=**224**			
	No.	**%**	**No.**	**%**	**No.**	**%**		
Mild	97	43.3	15	6.7	112	50.0	0.170	0.919
Moderate	92	41.1	12	5.4	104	46.5		
Severe	7	3.1	1	0.4	8	3.5		
Total	**196**	**87.5**	**28**	**12.5**	**224**	**100.0**		

Chi-square (χ^2) $\geq$ 3.84 **(Significant)**
Probability value $p < 0.05$ **(Significant)**

conducted in a referral hospital where patients typically seek medical intervention to treat existing symptoms, unlike in maternal and child health centers, where attendance is mostly limited to routine follow up.

Regarding educational level, the IDA prevalence in the current study was higher among pregnant women with an educational level of illiteracy (67.9%). A highly significant relationship was observed between educational level and IDA ($p < 0.0001$). This study agrees with previous reports from Egypt (66.1%) [9] and Pakistan (65%) [30]. Comparable findings were reported in Korangi, Karachi [31] and Pakistan [32], where the prevalence of anemia was notably higher among illiterate pregnant women (55.6% and 88.0%, respectively) and among those with lower educational levels, as reported in Turkey [33]. In contrast, this result is different from the studies conducted in Sana'a, Yemen, which found no significant association between anemia and low educational levels among pregnant women [10, 12].

In the present study, the prevalence of IDA was notably higher among grand multigravida pregnant women (63.8%), and a significant correlation was established between gravidity and IDA ($P < 0.001$). These results are consistent with a study from Ethiopia, which indicated that gravidity exceeding four (63.2%) was linked to anemia [34]. In contrast, a study conducted in Qatar found that the prevalence of anemia in grand multigravida was 26.6% and reported no correlation between gravidity and anemia or iron deficiency among pregnant women [35].

Our study findings showed that IDA was highly distributed in pregnant women with interpregnancy spaces $<$ 1 year (75.9%), and a strongly significant association was found between IDA and pregnant women with interpregnancy spaces ($P < 0.001$). This finding aligns with studies from Saudi Arabia and Nigeria, indicating that short interpregnancy intervals ($<$ 1 year) are significantly associated with an increased risk of IDA [36, 37]. Moreover, studies from Yemen, Saudi Arabia, and Ethiopia have indicated a significant association between the prevalence of anemia and child spacing [11, 25, 38]. This association may be explained by the short intervals between births, which may not allow sufficient time for the restoration of maternal nutrient stores, whereas longer spacing can reduce blood loss during delivery and improve iron reserves [11, 38]. Controversial findings from Qatar indicated that extended interpregnancy intervals ($>$1-3 years and $>$3 years) are correlated with elevated risks of iron deficiency and anemia [35]. A study in Yemen reported a signifi-

Table 4. Distribution of the IDA among 397 pregnant women according to educational level and family month income

Variables	IDA						χ^2	*p*
	Yes (n= 196)		**No** (n= 201)		**Total** (n=397)			
	No.	%	No.	%	No.	%		
Educational level								
Illiterate	133	67.9	52	25.9	185	46.6	74.292	< 0.001
Primary	32	16.3	61	30.3	93	23.4		
Secondary	21	10.7	43	21.4	64	16.1		
University	10	5.1	45	22.4	55	13.9		
Total	**196**	**49.4**	**201**	**50.6**	**397**	**100.0**		
Monthly income								
Low	126	64.3	36	17.9	162	40.8	126.584	< 0.001
Moderate	66	33.7	107	53.2	173	43.6		
High	4	2.0	58	28.9	62	15.6		
Total	**196**	**49.4**	**201**	**50.6**	**397**	**100.0**		

Chi-square (χ^2) $\geq$ 3.84 **(Significant),** Probability value $p < 0.05$ **(Significant),** Low income = < 50,000 YER (YER1 = USD 0.00185), Moderate income = 50,000-200,000, High income = > 200,000

cant correlation between anemia prevalence and short spacing between pregnancies (1–2years or 3–4years) [12].

The highest prevalence of IDA was found in pregnant women with 4–7 children (63.8%), and a highly significant association was identified between IDA and pregnant women with 4–7 children (P < 0.001). The results of the present study are consistent with those of studies from Saudi Arabia [39] and Pakistan [40]. Women with four to seven children are more likely to have iron-deficiency anemia because they have had multiple pregnancies and lost blood during childbirth, particularly if the pregnancies are close together. This makes them more likely to develop anemia. Therefore, health education programs should be implemented to raise awareness among women who give birth to twins about the importance of spacing pregnancies and to provide therapeutic interventions, such as nutritional supplements, to women at a higher risk of developing anemia.

According to monthly family income, the highest distribution of IDA was found in pregnant women with low family income (64.3%). A highly significant relationship was observed between family monthly income and IDA (P = 0.001). This study is consistent with a previous study that reported that IDA was higher in low-income Egyptian (68.1%) and Yemeni (47.5%) pregnant women [9]. This association can be explained by the fact that poverty may contribute to the development of IDA, as families with low socioeconomic status may have inadequate intake of iron-rich foods [9]. In contrast, a study in Pakistan reported no relationship between the economic status of pregnant women and IDA (*P* = 0.5) [41]. The differences in the results of this study could be explained by differences in the characteristics of the study population or sample size.

The multivariate logistic regression analysis in the current study revealed that sociodemographic and reproductive factors are independent risk factors for IDA. Moreover, a strong association was observed between lower education levels and an increased likelihood of developing IDA, with an 11-fold higher risk than that associated with higher education levels. Furthermore, income was a strong predictor, with the likelihood of developing IDA being significantly higher among women with low incomes (OR = 50.8) than among women with higher incomes. Regarding reproductive history, multiple births (odds ratio [OR]: 20.6) and short intervals between pregnancies (less than one year) (OR = 4.9) constituted a physiological burden that doubled the risk of developing IDA. Furthermore, this study was inconsistent with the findings of previous studies in Yemen, China, and Bangladesh, which reported that women with low monthly income were significantly more susceptible to anemia than those with middle monthly income [10, 12, 42, 43]. In contrast, our findings were contradicted by a study conducted in Qatar, which reported that educational level, family income, and inter-pregnancy space had no significant association with anemia [35].

4.1. SIGNIFICANCE AND LIMITATION OF THIS STUDY

This study is one of the few that sheds light on one of the most prominent health problems facing pregnant women in Yemeni society, particularly given Yemen's current circumstances. The results of this study will contribute to providing up-to-date and accurate data on the prevalence of iron deficiency anemia among pregnant women and identifying the most vulnerable groups. Furthermore, the findings will contribute to the development of health poli-

Table 5. Distribution of IDA among pregnant women according to the history of obstetric

Variables	IDA						χ^2	*p*
	Yes n=196		No n= 201		Total n= 397			
	No	%	No	%	No	%		
Age at the marriage								
< 18	26	13.3	18	8.9	44	11.1	2.215	0.330
18- 24	152	77.5	167	83.1	319	80.4		
≥ 25	18	9.2	16	8.0	34	8.6		
Total	**196**	**49.4**	**201**	**50.6**	**397**	**100.0**		
Age at pregnant								
< 20	8	4.1	6	3.0	14	3.5	6.515	0.038
20- 29	101	51.5	129	64.2	230	57.9		
≥ 30	87	44.4	66	32.8	153	38.5		
Total	**196**	**49.4**	**201**	**50.6**	**397**	**100.0**		
Gestation month								
First trimester	23	11.7	50	24.9	73	18.4	12.150	0.002
Second trimester	42	21.4	43	21.4	85	21.4		
Third trimester	131	66.9	108	53.7	239	60.2		
Total	**196**	**49.4**	**201**	**50.6**	**397**	**100.0**		
Gravidity (n=397)								
Primigravida (1)	5	2.5	37	18.4	42	10.6	77.161	< 0.001
Multigravida (2-3)	66	33.7	119	59.2	185	46.1		
Grand multigravida (≥ 4)	125	63.8	45	22.4	170	43.3		
Total	**196**	**49.4**	**201**	**50.6**	**397**	**100.0**		
Interpregnancy space (n=355)								
<1 year	145	75.9	48	29.3	193	54.3	85.035	< 0.001
1-2	34	17.8	55	33.5	89	25.1		
>2 year	12	6.3	61	37.2	73	20.6		
Total	**191**	**53.8**	**164**	**46.2**	**355**	**100.0**		
Number of children (n=355)								
1-3	66	34.6	119	72.6	185	52.1	51.073	< 0.001
4-7	125	65.4	45	27.4	170	47.9		
Total	**191**	**53.8**	**164**	**46.2**	**355**	**100.0**		

Chi-square (χ^2) ≥ 3.84 **(Significant), Probability** value $p < 0.05$ **(Significant)**

Table 6. Predictors of IDA among pregnant women according to the logistic regression analysis

Variables	IDA		OR	95% CI	P. value
	No	%			
Educational level (n=397)					
Illiterate (n= 185)	133	71.9	11.5	5.4-24.5	**<0.001**
Primary (n= 93)	32	34.4	2.4	1.1-5.3	0.037
Secondary (n=64)	21	32.8	2.1	0.9-5.2	0.073
University (n=55)	10	5.1	1(Ref.)		
Income (n=397)					
Low (n= 162)	126	77.8	50.8	17.3-149.3	**<0.001**
Moderate (n= 173)	66	38.2	8.9	3.1-25.9	**<0.001**
High (n=62)	4	2.0	1(Ref.)		
Gravidity (n=397)					
Primigravida (1) (n= 42)	5	11.9	1(Ref.)		
Multigravida (2-3) (n= 185)	66	35.7	4.1	1.5-10.9	0.005
Grand multigravida ($\geq$ 4) (n= 170)	125	73.5	20.6	7.6-55.5	**<0.001**
Interpregnancy space (n= 355)					
<1 year (n=193)	145	75.1	4.9	2.8-8.4	**<0.001**
1-2 (n=89)	34	38.2	0.3	0.2-0.7	0.578
>2 year (n=73)	12	16.4	1(Ref.)		
Number of children (n=355)					
1-3 (n= 185)	66	35.7	1(Ref.)		
4-7 (n= 170)	125	73.5	5.8	3.2-7.9	**<0.001**

OR = Odds Ratio, **95% CI** = 95% Confidence Interval, Probability value $p < 0.05$ **(Significant),** Low income = < 50,000 YER, Moderate income = 50,000-200,000, High income = > 200,000

cies that direct available resources toward implementing awareness programs among the most vulnerable groups regarding the importance of birth spacing in protecting mothers. In addition, they will strengthen essential intervention programs that effectively contribute to reducing maternal and fetal morbidity. One of the limitations of this study is that it was conducted at a single center, which limits the generalizability of our results. Furthermore, the absence of C-reactive protein (CRP) analysis did not rule out inflammation and may have obscured the diagnosis of iron deficiency anemia in many women in this study. The study did not address several factors associated with iron deficiency anemia, including place of residence, folic acid/iron supplementation, khat use, smoking, thalassemia trait, and other causes such as bleeding, particularly hemorrhoids, which are common during pregnancy.

5. CONCLUSIONS

The current study concluded that iron deficiency anemia is more common among pregnant women in Sana'a, Yemen than previously reported. Pregnant women with short intervals between pregnancies (less than one year), those with four to seven children, and those with low monthly incomes were more susceptible to iron deficiency anemia. Iron deficiency anemia (IDA) is a significant public health problem in Yemen. Therefore, we recommend raising awareness of the risks of iron deficiency anemia during pregnancy among women, their families, and communities. Furthermore, it is important to improve and tailor health education programs related to iron deficiency anemia during pregnancy to meet individual needs and utilize media to promote awareness in the region.

The current study concluded that iron deficiency anemia is more common among pregnant women in Sana'a, Yemen, compared to previous studies. Pregnant women with short intervals between pregnancies (less than one year), those with four to seven children, and those with low monthly incomes were more susceptible to iron deficiency anemia. Iron deficiency anemia (IDA) is a significant public health problem in Yemen. Therefore, we recommend raising awareness of the risks of iron deficiency anemia during pregnancy among women, their families, and communities. Furthermore, it is important to improve and tailor health education programs related to iron deficiency anemia during pregnancy to meet individual needs and utilize media to promote awareness in the region. Additionally, a larger sample size that includes pregnant women from all areas of Sana'a city is needed for further investigation, along with the use of

more diagnostic tests to obtain more accurate results.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

ACKNOWLEDGEMENTS

We wish to thank the administrators, doctors in obstetric clinics, nurses, and laboratory technicians of Al-Jomhori Teaching Hospital in Sana'a City, Yemen, for their assistance in completing this work.

ABBREVIATION

CBC: Complete Blood Count
Hb: Hemoglobin
ID: Iron Deficiency
IDA: Iron Deficiency Anemia
LMICs: Low- Middle-Income Countries
EDTA: Ethylene Diamine Tetraacetic Acid
MCH: Mean Corpuscular Haemoglobin
MCHC: Mean Corpuscular Haemoglobin Concentration
MCV: Mean Corpuscular Volume
P: Probability value
RBC: Red Blood Cell
RDW: Red cell Distribution Width
SD: Standard Deviation
SPSS: Statistical Package for the Social Sciences
TIBC: Total Iron Binding Capacity
TSAT: Transferrin Saturation
UIBC: Unsaturated Iron-Binding Capacity
WHO: World Health Organization
(χ^2): Chi-square.
CI: 95% Confidence Intervals.
OR: Odds Ratios.

REFERENCES

[1] M. Ali et al. "FETO/Maternal complications in iron deficiency anemia during pregnancy and Labor". In: *JHRR* 4.1 (2024), pp. 1204–1208. DOI: 10.61919/jhrr.v4i1.623.

[2] R. A. Annan, L. A. Gyimah, C. Apprey, et al. "Factors associated with iron deficiency anaemia among pregnant teenagers in Ashanti Region, Ghana: A hospital-based prospective cohort study". In: *PLoS ONE* 16.4 (2021), e0250246. DOI: 10.1371/journal.pone.0250246.

[3] N. Al-Bayyari et al. "Dietary diversity and iron deficiency anemia among a cohort of singleton pregnancies: a cross-sectional study". In: *BMC Public Health* (2024), p. 1840. DOI: 10.1186/s12889-024-19294-z.

[4] G. U. Obeagu and E. I. Obeagu. "Iron Deficiency Anaemia in pregnancy: A threat to maternal and fetal wellbeing". In: *Lifeline Nursing Health Sciences* 2.1 (2024), pp. 1–14.

[5] R. Ataide et al. "Iron deficiency, pregnancy, and neonatal development". In: *International Journal Gynecology & Obstetrics* 162.2 (2023), pp. 14–22. DOI: 10.1002/ijgo.14944.

[6] O. Dewidar, J. John, A. Baqar, et al. "Effectiveness of nutrition counseling for pregnant women in low- and middle income countries to improve maternal and infant behavioral, nutritional, and health outcomes: A systematic review". In: *Campbell Systematic Reviews* 19.4 (2023), e1361. DOI: 10.1002/cl2.1361.

[7] F. Yang, X. Liu, and P. Zha. "Trends in socioeconomic inequalities and prevalence of anemia among children and non-pregnant women in Low-and Middle Income Countries". In: *JAMA Network Open* 1.5 (2018), e182899. DOI: 10.1001/jamanetworkopen.2018.2899.

[8] World Health Organization. *Anaemia*. 2023. URL: https://www.who.int.

[9] M. E. Abu Salem et al. "Epidemiology of iron-deficiency anemia among pregnant women in menoufia governorate, Egypt and Taiz Governorate, Yemen: A comparative study". In: *Menoufia Medical Journal* 29 (2016), pp. 1005–1011.

[10] M. A. Al-Nuzaili, M. A. Hajar, and A. K. Allow. "Prevalence of anemia and associated risk factors among pregnant women in Sana'a, Yemen". In: *Sana'a University Journal Medical Health Sciences* 2.1 (2023), pp. 48–55. DOI: 10.59628/jchm.v2i1.107.

[11] Y. M. Alflah et al. "Prevalence and determinants of anemia in pregnancy, Sana'a, Yemen". In: *International Journal Public Health Science (IJPHS)* 6.3 (2017), pp. 213–220. DOI: 10.11591/ijphs.v6i3.7931.

[12] S. Al-Aini, C. P. Senan, and M. Azzani. "Prevalence and associated factors of anemia among pregnant women in Sana'a, Yemen". In: *Indian Journal Medical Sciences* (2020). DOI: 10.25259/IJMS_5_2020.

[13] N. M. H. Gonaid, S. El-Sanousi, and H. Kadi. "Prevalence and determinants of anemia during pregnancy at Hodeida city, (Yemen) during the year 2021". In: *International Journal Health Sciences Research* 12.3 (2022), pp. 23–31. DOI: 10.52403/ijhsr.20220304.

[14] World Health Organization. *Guideline on haemoglobin cut-offs to define anaemia in individuals and populations*. 2024. URL: https://www.who.int.

[15] H. Mahant et al. "Appropriate method of TIBC estimation in reference to serum transferrin levels". In: *Journal Laboratory Physicians* 15 (2022), pp. 25–30. DOI: 10.1055/s-0042-1750065.

[16] T. Eleftheriadis et al. "Which is the best way for estimating transferrin saturation?" In: *Renal Failure* 32.8 (2010), pp. 1022–1023. DOI: 10.3109/0886022x.2010.502609.

[17] R. Miniero, V. Talarico, M. C. Galati, et al. "Iron deficiency and iron deficiency anemia in children". In: *IntechOpen eBooks*. 2018, pp. 23–38. DOI: 10.5772/intechopen.79790.

[18] S. A. E. H. Aboud, H. A. E. El Sayed, and H. A. F. Ibrahim. "Knowledge, attitude and practice regarding prevention of iron deficiency anemia among pregnant women in Tabuk Region". In: *International Journal Pharmaceutical Research & Allied Sciences* 8.2 (2019), pp. 87–97.

[19] F. Armin et al. "Awareness and preventive practice of iron deficiency anemia among pregnant women in Bangladesh". In: *IJCSMCR* 36.2 (2024), pp. 1–6. DOI: 10.46998/IJCMCR.2023.36.000881.

[20] A. Oumer and A. Hussein. "Knowledge, attitude and practice of pregnant mothers towards preventions of iron deficiency anemia in Ethiopia". In: *Health Care Current Reviews* 7.1 (2019), pp. 2381–2387. DOI: 10.11591/ijphs.v8i2.19476.

[21] J. Margwe. "Prevalence, knowledge, and attitude of pregnant women on control measures of anaemia in Mbulu District, Tanzania". In: *NJE* 4.4 (2015), pp. 386–392.

[22] A. M. Hussain, Q. I. Kadhem, and N. A. Hussain. "Prevalence of anaemia in a sample of pregnant women in Babylon Governorate, Iraq". In: *Revista Latinoamericana de Hipertensi'on* 15.4 (2020), pp. 275–279. DOI: 10.5281/zenodo.4442769.

[23] F. Y. Mogahed, A. Y. Al-Qudari, and A. G. Akydy. "Iron deficiency anemia and associated risk factors among pregnant women in Dhamar city, Yemen". In: *Al-Saeeda Journal Medical Sciences* 1.1 (2019), pp. 1–11.

[24] A. A. Sayad et al. "Determinants and knowledge of iron deficiency anemia and its impact among pregnant women attending university hospital in Mukalla, Yemen". In: *Hadhramout University Journal Natural & Applied Sciences* 19.1 (2020), pp. 23–30.

[25] A. M. Abdelhafez and S. S. El Soadaa. "Prevalence and risk factors of anemia among a sample of pregnant females attending primary health care centers in Makkah, Saudi Arabia". In: *Pakistan Journal Nutrition* 11.12 (2012), pp. 1113–1120.

[26] A. Enas. "Descriptive study for pregnant women's knowledge attitude and practices regarding iron deficiency anemia and iron supplements in the southern region of KSA". In: *Asian Journal Clinical Nutrition* 12 (2020), pp. 21–33. DOI: 10.3923/ajcn.2020.21.33.

[27] S. Vidya et al. "Can gestational anemia be alleviated with increased awareness of its causes and management strategies". In: *Oman Medical Journal* 133.4 (2018). DOI: 10.5001/omj.2018.59.

[28] M. L. Serbesa and M. T. Iffa. "Knowledge, attitude and practice on prevention of iron deficiency anemia among pregnant women attending antenatal care unit at public hospitals of Harar Town, Eastern Ethiopia". In: *International Journal Pregnancy Child Birth* 5.2 (2019), pp. 48–55.

[29] C. C. Okia, B. Aine, R. Kiiza, et al. "Prevalence, morphological classification, and factors associated with anemia among pregnant women accessing antenatal clinic at Itojo hospital, south western Uganda". In: *Journal Blood Medicine* 10 (2019), pp. 351–357. DOI: 10.2147/jbm.s216613.

[30] Z. Shams, Z. Ahmad, and A. Wadood. "Prevalence of iron deficiency anemia in pregnant women of district mardan, Pakistan". In: *Journal Pregnancy Child Health* 4 (2017), p. 356. DOI: 10.4172/2376-127X.1000356.

[31] S. A. Karim et al. "Anaemia in pregnancy its cause in the underprivileged class of Karachi". In: *Journal Pakistan Medical Association* 44 (1994), pp. 90–92.

[32] U. Irfan et al. "Prevalence of anaemia in pregnant women in district Karak, Khyber Pakhtunkhwa, Pakistan". In: *International Journal Biosciences* 3 (2013), pp. 77–83.

[33] C. E. Taner, A. Ekin, U. Solmaz, et al. "Prevalence and risk factors of anemia among pregnant women attending a high-volume tertiary care center for delivery". In: *Journal Turkish-German Gynecological Association* 16 (2015), pp. 231–236. DOI: 10.5152/jtgga.2015.15071.

[34] R. S. Gibson, Y. Abebe, S. Stabler, et al. "Zinc, Gravida, Infection, and Iron, but Not Vitamin B-12 or Folate Status, Predict Hemoglobin during Pregnancy in Southern Ethiopia". In: *The Journal Nutrition* 138 (2008), pp. 581–586. DOI: 10.1093/jn/138.3.581.

[35] N. A. A. Selim et al. "Assessment of Anemia, IDA and ID among Pregnant in Qatar: Cross Sectional Survey". In: *SM Journal Public Health Epidemiology* 2.3 (2016), p. 1035.

[36] A. A. Mahfouz, M. M. El-Said, W. Alakija, et al. "Anemia among pregnant women in the Asir Region, Saudi Arabia: An epidemiologic study". In: *The Southeast Asian Journal Tropical Medicine Public Health* 25 (1994), pp. 84–87.

[37] G. N. Okwu and I. I. Ukoha. "Studies on the predisposing factors of iron deficiency anaemia among pregnant women in a Nigerian Community". In: *Pakistan Journal Nutrition* 7 (2008), pp. 151–156. DOI: 10.3923/pjn.2008.151.156.

[38] N. Obse et al. "Magnitude of anemia and associated risk factors among pregnant women attending antenatal care in Shalla Woreda, West Arsi Zone, Oromia Region, Ethiopia". In: *Ethiopian Journal Health Sciences* 23.2 (2013), pp. 165–173.

[39] G. Z. R. Alruwaili et al. "Knowledge, attitude, and practices of general female population toward iron deficiency anemia in Al-Jouf, Saudi Arabia". In: *International Journal Medicine Developing Countries* 7.1 (2023), pp. 113–122. DOI: 10.24911/IJMDC.51-1669114059.

[40] A. F. Khan, S. Khan, and H. Ahmad. "Prevalence of iron deficiency anemia (IDA) in pregnant women and its associated risk factors: a novel study from Pakistan". In: *THE STETHO* 1.2 (2020), pp. 29–34.

[41] H. Zulfiqar, I. U. Shah, M. N. Sheas, et al. "Dietary association of iron deficiency anemia and related pregnancy outcomes". In: *Food Science & Nutrition* 9 (2021), pp. 4127–4133. DOI: 10.1002/fsn3.2373.

[42] B. S. Azhar, M. S. Islam, and M. R. Karim. "Prevalence of anemia and associated risk factors among pregnant women attending antenatal care in Bangladesh: a cross-sectional study". In: *Primary Health Care Research & Development* 2.e61 (2021), pp. 1–10. DOI: 10.1017/s146342362100061x.

[43] L. Lin, Y. Wei, W. Zhu, et al. "Prevalence, risk factors and associated adverse pregnancy outcomes of anaemia in Chinese pregnant women: A multicentre retrospective study". In: *BMC Pregnancy Childbirth* 18 (2018), p. 111. DOI: 10.1186/s12884-018-1739-8.