BioChemMed

Technium BioChemMed Vol. 13, pp.141-153 (2025)
ISSN: 2734-7990
www.techniumscience.com

Impact of Iron Deficiency on Maternal Health During Pregnancy

Haneen Saeed Mohsen Al-Mosawei [1] , Saja H.F. Al-Anbary [1], Hiba Muayad Khudhair Abbo [1], Hams Ahmed Aljndeel [1]

[1] Department of Pharmaceutical Chemistry, College of Pharmacy, University of Kerbala, Karbala, Iraq.

[*]**Corresponding Author:** Haneen Saeed Mohsen Al-Mosawei, haneen.s@uokerbala.edu.iq

Abstract

Iron requirements increase significantly during pregnancy to support fetal and placental growth, boost the mother's blood volume, and compensate for delivery-related losses. A major public health concern, iron deficiency anemia (IDA) affects more than 20% of pregnant women in more than 80% of countries. Both the mother's and the fetus's health may suffer as a result, leading to fatigue and reduced productivity. Early laboratory screening, starting in the first trimester, is recommended to assess iron status. In this case-control study, serum ferritin and CBC data are collected from pregnant women with iron deficiency and healthy controls. Since many poor countries may not be able to provide an appropriate diet, early iron supplementation is essential. Education, prenuptial counseling, and prenatal care should raise public knowledge in order to promote a balanced diet and timely supplementation.

Keywords: Pregnancy, Iron deficiency (ID), Anemia(A), risk factors, pregnancy outcome.

Introduction

One major medical issue that affects pregnant women is anemia. Iron deficiency (ID), aplastic anemia, globulin production abnormality, folic acid shortage, vitamin B12 deficiency, and other conditions are the primary causes of anemia during pregnancy. ID is the most prevalent of them and can result in a number of unfavorable pregnancy outcomes. Iron deficiency anemia (IDA) and ID are both prevalent clinical conditions in expectant mothers. Pregnancy-related ID and IDA incidences can reach 80% and 20.4%, respectively, according to a study (1).

Pregnant women and fetuses who suffer from anemia may experience stress reactions, the body may produce more corticotropin-releasing hormone, T and B cells may secrete, and neutrophil and macrophage activity may be inhibited. Pregnancy-related complications including preterm membrane rupture and premature birth might result from anemia's reduction of the pregnant woman's resistance to exogenous microorganisms (2).

Therefore, knowing what causes ID and IDA in pregnant women and taking aggressive action to address it can improve the prognosis and outcome of the pregnancy. Due to differences in nutrition, wealth, and lifestyle, prior research has demonstrated that pregnant women from different locations had differing incidences of ID and IDA (3).

One of the most frequent pregnancy problems is anemia. Iron deficiency (ID) is the most common cause and is closely linked to unfavorable pregnancy outcomes among its causes, which also include folate and vitamin B12 deficiencies. According to studies, 20–25% of pregnant women have iron deficiency anemia (IDA), and up to 80% may experience ID. These illnesses raise the risk of infections, premature birth, and low birth weight for both the mother and the fetus. (4).
Pregnant women with moderate or severe anemia were the focus of this study because they are more likely to experience adverse pregnancy outcomes and will frequently require additional screening and treatment (5).
Because of the physiological demands placed on the developing fetus, which need a substantial transfer of iron from maternal storage to promote fetal growth and erythropoiesis, ferritin levels have been shown to decrease throughout pregnancy. Serum ferritin, a measure of maternal iron stores, is therefore frequently exhausted, especially during pregnancy (6).
Pregnant women have a simultaneous drop in hemoglobin levels for a variety of reasons. First, pregnancy's physiological increase in plasma volume causes hemodilution, which naturally reduces the blood's hemoglobin concentration. Second, a real decrease in total hemoglobin mass over time may result from the elevated iron needs of pregnancy combined with possibly insufficient iron intake or absorption, particularly if iron storage (as indicated by ferritin) are inadequate (7).
Consequently, our results highlight how crucial it is to track iron status during pregnancy using ferritin and hemoglobin measures. Optimizing maternal and fetal outcomes requires early detection and proper treatment of iron insufficiency (8).
While younger women might still be adjusting to dietary and physiological changes, older women might have had more time to improve their iron reserves through diet and supplements.This is not a hard-and-fast rule, though, because the body's iron levels are also influenced by other important factors like nutrition, genetics, and medical history (9).
Pregnancy itself seems to be a more significant role in lowering iron levels, even if there are age disparities between pregnant and non-pregnant women in this study. Pregnancy increases the need for iron, which lowers ferritin levels in younger women who may already have higher needs. This emphasizes how crucial it is to take iron supplements and have regular checkups in order to avoid difficulties, particularly in younger pregnant women.associated with iron insufficiency (10).
Because of the 20–30% increase in blood volume during pregnancy, more iron is needed to sustain the formation of hemoglobin in red blood cells. Iron-deficiency anemia, which is characterized by decreased hemoglobin levels and decreased oxygen delivery to tissues, can result from inadequate iron consumption. Low birth weight and premature birth are associated with this disease (11).
WBC levels naturally rise during pregnancy as the body adjusts to support the immune system. Iron deficiency, on the other hand, can affect immune function, thereby changing WBC numbers and making a person more vulnerable to infections (12).
Impaired Iron Absorption: The presence of enhancers and inhibitors of absorption has a major impact on the bioavailability of dietary iron. Non-heme iron absorption can be significantly decreased by co-ingesting foods such phytates (found in legumes and whole grains), tannins (found in tea and coffee), calcium (found in dairy products and supplements), and specific plant-based proteins (13).

2. Method

2.1 Case control study

In this case-control study, 59 seemingly healthy controls between the ages of 15 and 44 were enrolled, along with 129 pregnant women who had been diagnosed with iron insufficiency. Serum ferritin levels and the complete blood count (CBC) were assessed. To extract the serum, about 3 mL of venous blood was drawn into gel tubes, let to clot at room temperature, and then centrifuged for 5 minutes. Using an automated analyzer, ferritin and CBC values were examined in accordance with accepted laboratory practices.

2.2 Subject

2.2.1 Patient

129 pregnant women with iron insufficiency who were receiving gynecological care participated in the study.

2.2.2 The inclusion criteria include:

1.One of the requirements for inclusion is that the patient be between the ages of 15 and 45.
2. A patient whose hemoglobin test result was below normal.
3. A patient whose ferritin test result was below normal.
.

2.2.3 The exclusion criteria

1-liver disease.
2. Kidney illness.
3. Cancer.
4. Pregnancy by ectopic means.
5. A patient who is older than fifty.

2.2.4 Control

[59] healthy individuals were chosen from the general community, those who visited the hospital for a check-up, and family members to form the control group.

2.2.5 The inclusion criteria include:

1. People in the 15–45 age range.
2. The hemoglobin test yields a normal result.
3. The results of the ferritin test are normal.

2.2.6 Spacemen collection

Each patient had nearly 3 milliliters of vonous blood extracted in order to evaluate ferritin and CBC levels.

Place this blood in a gel tube, let it sit at room temperature until the blood clots to remove the fibrin, then centrifuge it for five minutes to extract the serum. Press the start button, then wait an hour to see the findings.

RESULTS

Table (3-1): The distribution of parameters' demographics (Mean ± SD) between the control and pregnant groups.

Study variable	Pregnant-women groups (pregnancy groups) (Mean ± SD)	Non-pregnant women (Control groups) (Mean ± SD)	P-values
N (Female)	129	59	———
Age (year)	25.50 ± 5.74	28.43 ± 5.83	0.003**
Ferritin (ng/ml)	16.13 ± 18.35	26.21 ± 40.46	0.022*
Hb (g/dl)	10.62 ± 1.81	10.07 ± 1.62	0.023*
RBC (millions/mm^3)	4.23 ± 0.83	3.51 ± 0.24	0.000**
WBC	9.60 ± 2.58	5.43 ± 0.65	0.000**

* **HS: very significant difference ($P \leq 0.01$), N: number of samples, SD: standard deviation, and significant difference ($P \leq 0.05$).
Years of age | 25.50 ± 5.74 | 28.43 ± 5.83 | 0.003** Why: Pregnant women's average age was 25.50 years, whereas the non-pregnant group's was 28.43. There may be age differences between the two groups, as indicated by the statistically significant difference ($P \leq 0.01$).
Ferritin (ng/ml) | 16.13 ± 18.35 | 26.21 ± 40.46 | 0.022* An explanation: Ferritin levels were substantially lower in pregnant women (16.13 ng/ml) than in non-pregnant women (26.21 ng/ml). Iron storage is decreased during pregnancy, as seen by this statistically significant difference ($P < 0.05$).
Hb (g/dl) | 10.62 ± 1.81 | 10.07 ± 1.62 | 0.023* Justification: Pregnant women's hemoglobin levels (10.62 g/dl) were marginally higher than those of non-pregnant women (20.07). This difference is statistically significant ($P \leq 0.05$), even if both results show mild anemia.
Millions/mm^3 of red blood cells (RBC) | 4.23 ± 0.83 | 3.51 ± 0.24 | 0.000**
Justification: Pregnant women had a significantly greater RBC count than non-pregnant women. A highly significant difference is shown by the extremely low p-value ($P < 0.01$), which could be the result of physiological changes that occur during pregnancy.
[WBC] | 9.60 ± 2.58 | 5.43 ± 0.65 | 0.000***
Reason: Compared to the control group, pregnant women's WBC levels were significantly higher. With a substantial difference (*$P < 0.001$), the difference most likely reflects the immunological adaption that takes place during pregnancy.

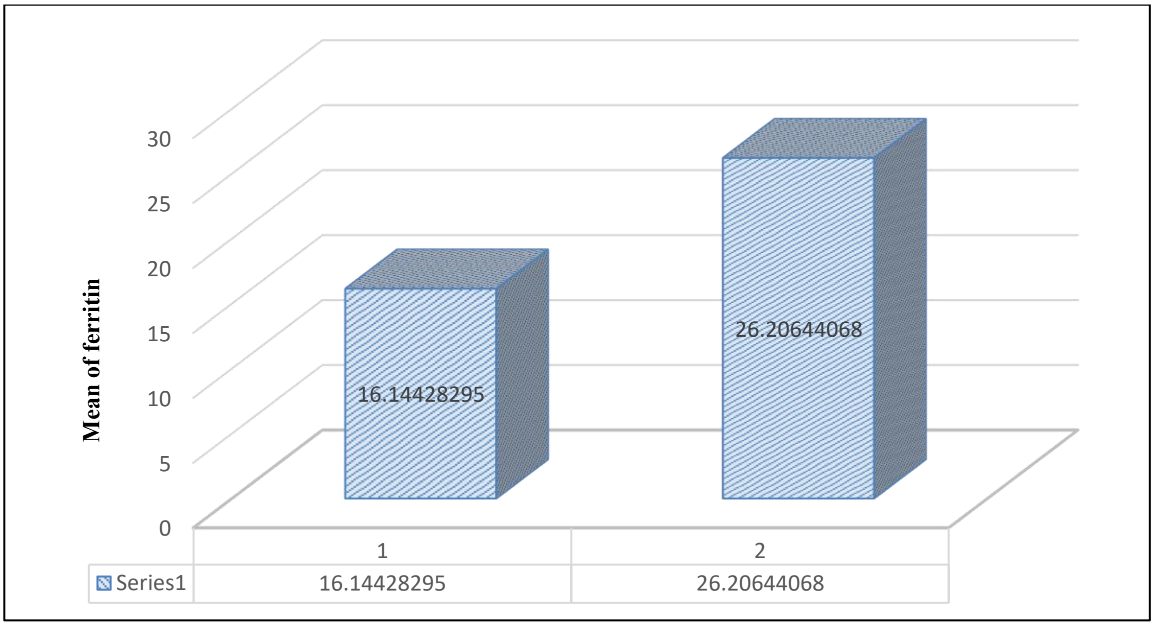

Fig. 1. The figure for Table 1

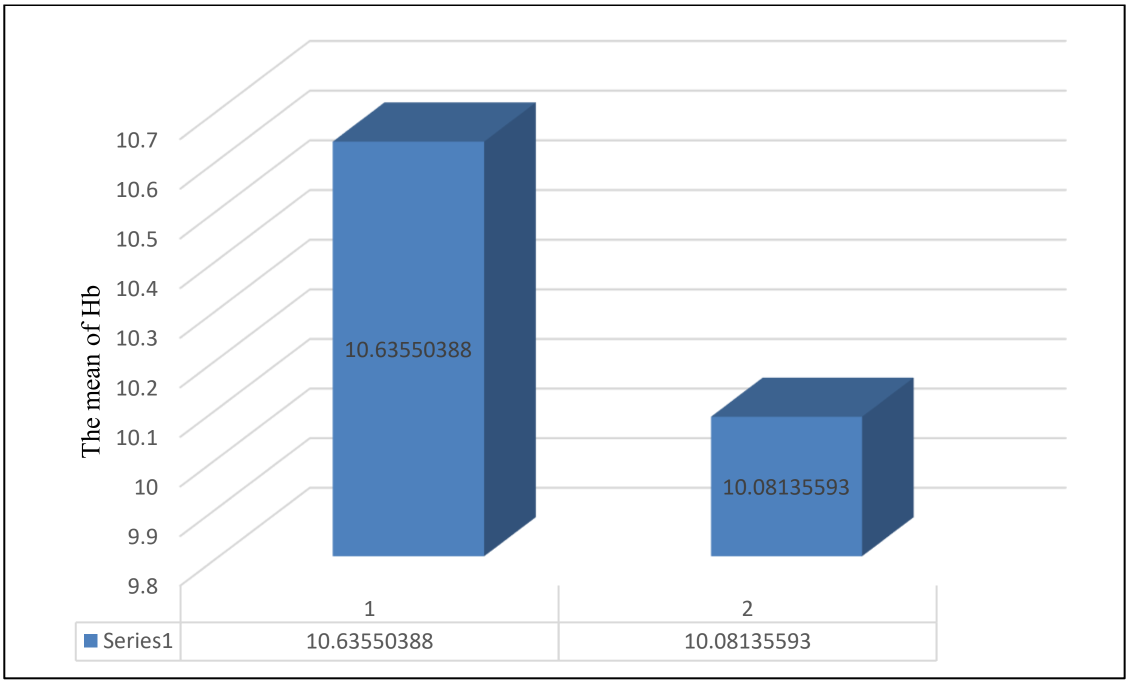

Fig. 2. The figure for Table 2

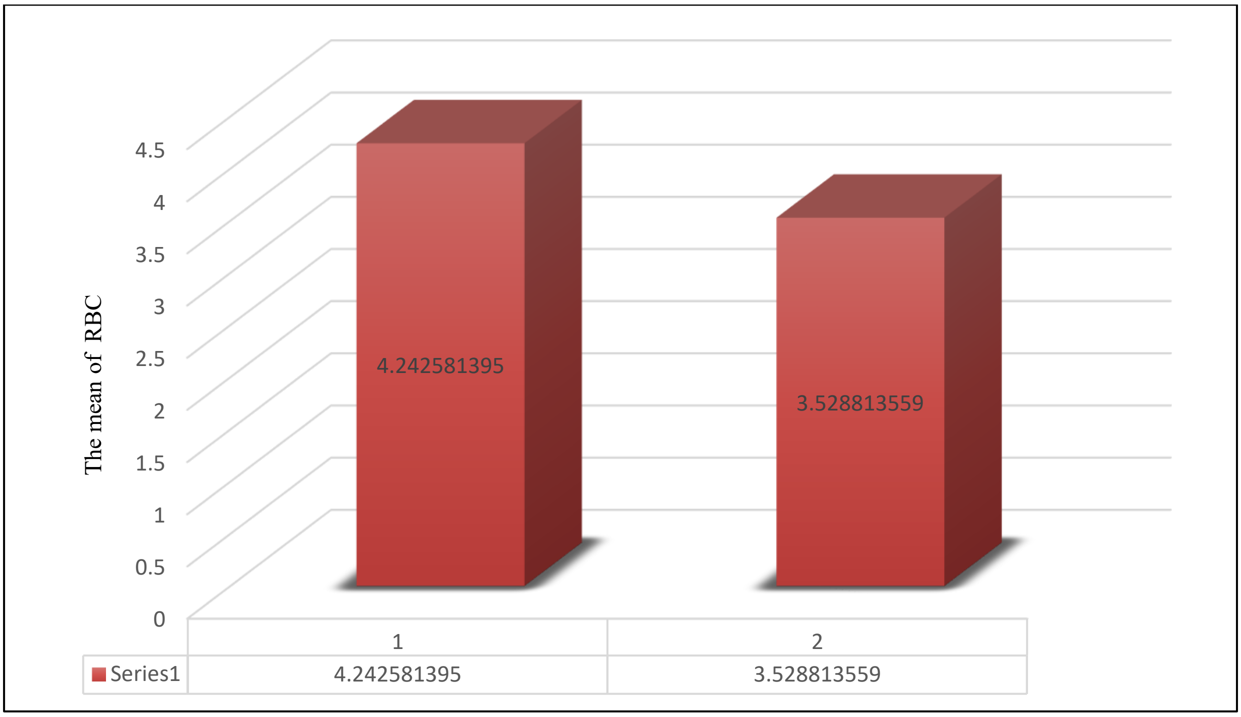

Fig. 3. The figure for Table 3

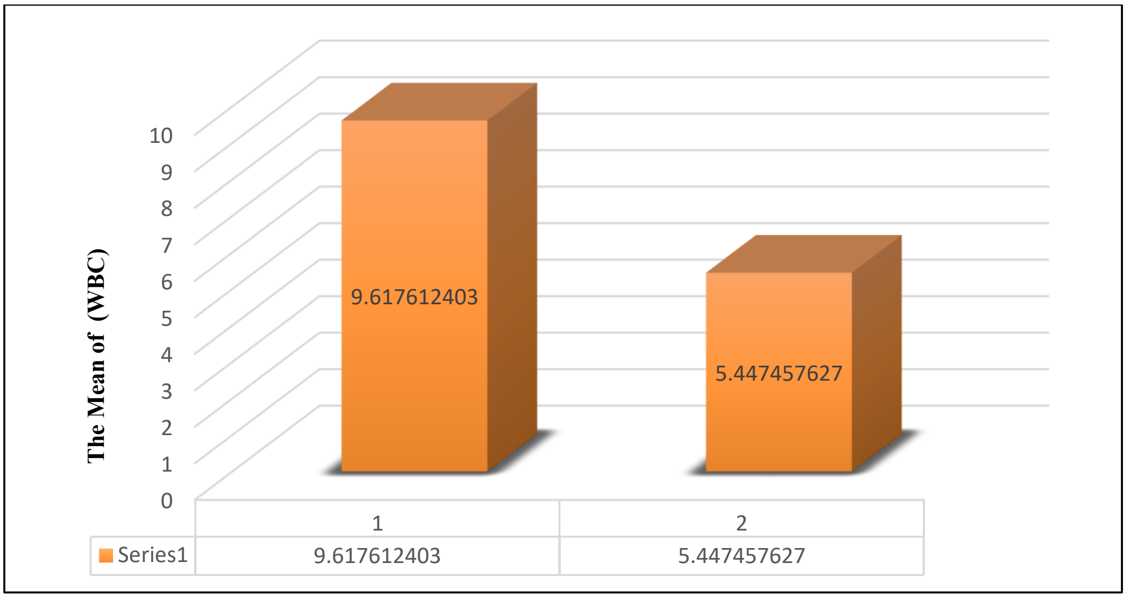

Fig. 4. The figure for Table 4

BioChemMed
Technium BioChemMed Vol. 13, pp.141-153 (2025)
ISSN: 2734-7990
www.techniumscience.com

Table (3-2): The parameters in pregnant groups' linear r (Pearson) association with age.

Correlations				
		Age_ control	serum_ferritin_ control	Hb_ control
Age_ control groups (Non_pregnant women)	Pearson Correlation	1	-0.026	0.036
	Sig. (2-tailed)		0.842	0.784
	N	59	59	59
serum_ferritin control groups (Non_pregnant women)	Pearson Correlation	-0.026	1	.492**
	Sig. (2-tailed)	0.842		0.000
	N	59	59	59
Hb_ control groups (Non_pregnant women)	Pearson Correlation	0.036	.492**	1
	Sig. (2-tailed)	0.784	0.000	
	N	59	59	59
****. Correlation is significant at the 0.01 level (2-tailed).**				

This table displays the linear correlation (Pearson test) between pregnant women's age, hemoglobin, and serum ferritin. Age and ferritin (r = 0.088, p = 0.324), Age and hemoglobin (r = 0.040, p = 0.653), and ferritin and age (identical values, since correlation is mutual) did not significantly correlate.Hemoglobin and ferritin had a significant negative connection (r = -0.180, p = 0.042*). This indicates that hemoglobin levels in pregnant women somewhat decrease as ferritin levels rise; nonetheless, the association is weak even if it is statistically significant.

Table (3-3): Spearman's rho test, or linear r, is a statistical measure of the relationship between age and the parameters in pregnancy groups.
This table looks at the same associations using a non-parametric technique called Spearman's rho test.

• No significant correlations found between:

Correlations				
		Age	serum_ferritin	HB
Age (pregnant women groups)	Correlation Coefficient	1.000	0.093	0.037
	Sig. (2-tailed)		0.296	0.676
	N	129	129	129
serum_ferritin (pregnant women groups)	Correlation Coefficient	0.093	1.000	-0.064
	Sig. (2-tailed)	0.296		0.471
	N	129	129	129
Hb (pregnant women groups)	Correlation Coefficient	0.037	-0.064	1.000
	Sig. (2-tailed)	0.676	0.471	
	N	129	129	129

Age, ferritin, and Hb (r = 0.093, p = 0.296, r = 0.037, p = 0.676, r = -0.064, p = 0.471, respectively).Thus, the Spearman's test indicates that there are no statistically significant correlations between the variables in expectant mothers.

Table (3-4): In non-pregnant women (control groups), the linear r (Pearson test) correlation statistic of parameters with age.

Correlations				
		Age_ control	serum_ferritin_ control	Hb_ control
Age_ control groups (Non_pregnant women)	Pearson Correlation	1	-0.026	0.036
	Sig. (2-tailed)		0.842	0.784
	N	59	59	59
serum_ferritin control groups (Non_pregnant women)	Pearson Correlation	-0.026	1	.492**
	Sig. (2-tailed)	0.842		0.000
	N	59	59	59
Hb_ control groups (Non_pregnant women)	Pearson Correlation	0.036	.492**	1
	Sig. (2-tailed)	0.784	0.000	
	N	59	59	59
****. Correlation is significant at the 0.01 level (2-tailed).**				

Using the Pearson test, this table displays the linear relationship between age and other blood parameters (serum ferritin and hemoglobin) in women who are not pregnant.Age and serum ferritin (r = -0.026, p = 0.842) and hemoglobin (r = 0.036, p = 0.784) do not significantly correlate; nevertheless, there is a large and significant positive association between the two (r = 0.492, p = 0.000**).
This indicates that there is a substantial correlation between greater ferritin levels and higher Hb levels in non-pregnant women.

Table (3-5): The linear r (Spearman's rho test) correlation statistic shows how parameters in non-pregnant women (control groups) change with age.

		Age_control	serum_ferritin_ control	Hb_ control
Age_control groups (Non_pregnant women)	Correlation Coefficient	1.000	-0.012	0.014
	Sig. (2-tailed)		0.929	0.919
	N	59	59	59
Serum_ferritin_control groups (Non_pregnant women)	Correlation Coefficient	-0.012	1.000	.349**
	Sig. (2-tailed)	0.929		0.007
	N	59	59	59
Hb_control groups (Non_pregnant women)	Correlation Coefficient	0.014	.349**	1.000
	Sig. (2-tailed)	0.919	0.007	
	N	59	59	59
****. Correlation is significant at the 0.01 level (2-tailed).**				

Using the Spearman's rho test, this table displays the non-parametric correlation between the same variables.Age did not significantly correlate with serum ferritin (r = -0.012, p = 0.929), hemoglobin (r

= 0.014, p = 0.919), or any of the other variables included in Table (3-6).Once more, there is a strong positive connection between hemoglobin and serum ferritin (r = 0.349, p = 0.007**).

Discussion

4.1 Age

With a very significant difference (P = 0.003), the study's data indicates that pregnant women's mean age (25.51 ± 5.75 years) is much lower than that of non-pregnant women (28.44 ± 5.84 years). This implies that women in the non-pregnant group are often a little older. The body's metabolism and storage of iron can be significantly impacted by age. Due to menstruation and the increased iron needed for fetal development during pregnancy, younger women—especially those in their early reproductive years—generally have greater iron demands (14).

However, compared to women who are not pregnant, pregnant women frequently have reduced iron storage since pregnancy itself results in a physiological increase in blood volume and iron utilization. Ferritin levels, a crucial indicator of iron storage, are significantly lower in pregnant women (16.14 ± 18.6 ng/ml) than in non-pregnant women (26.2 ± 40.47 ng/ml) (P = 0.022), which is supported by the study's findings. This suggests that, regardless of age, pregnancy is linked to lower iron levels because of higher iron intake to support fetal growth. Iron levels can also be indirectly impacted by age through dietary practices, past pregnancies, and general health (15).

While younger women might still be adjusting to dietary and physiological changes, older women might have had more time to improve their iron reserves through diet and supplements. This is not a hard-and-fast rule, though, because the body's iron levels are also greatly influenced by other factors like nutrition, genetics, and medical history. Pregnancy itself seems to be a more significant role in lowering iron levels, even if there are age disparities between pregnant and non-pregnant women in this study. Pregnancy increases the need for iron, which lowers ferritin levels in younger women who may already have higher needs. This emphasizes how crucial it is to take iron supplements and have regular checkups in order to avoid difficulties, particularly in younger pregnant women. associated with a lack of iron (16).

Red blood cells (RBCs) and white blood cells (WBCs) are both greatly impacted by iron deficiency during pregnancy, which affects the health of both the mother and the fetus. Because of the 20–30% increase in blood volume during pregnancy, more iron is needed to sustain the formation of hemoglobin in red blood cells. Iron-deficiency anemia, which is characterized by decreased hemoglobin levels and decreased oxygen delivery to tissues, can result from inadequate iron consumption. Low birth weight and premature birth are associated with this disease (17).

WBC levels naturally rise during pregnancy as the body adjusts to support the immune system. Iron deficiency, on the other hand, can affect immune function, thereby changing WBC numbers and making a person more vulnerable to infections (18).Research has consistently shown that pregnant women had lower ferritin and hemoglobin levels than non-pregnant controls. This result emphasizes how common iron insufficiency is among expectant mothers.

The physiological demands of the growing fetus, which require a substantial transfer of iron from maternal stores to sustain fetal growth and erythropoiesis, are reflected in the observed decrease in ferritin levels throughout pregnancy. As a result, maternal iron stores, as measured by serum ferritin, are frequently exhausted, especially during the course of pregnancy (19).

Pregnant women have a simultaneous drop in hemoglobin levels for a variety of reasons. First, pregnancy's physiological increase in plasma volume causes hemodilution, which naturally reduces the blood's hemoglobin concentration.Second, a real decrease in total hemoglobin mass over time may result from the elevated iron needs of pregnancy combined with possibly insufficient iron intake or absorption, particularly if iron storage (as indicated by ferritin) are inadequate (20).

Pregnant women are more vulnerable to iron deficiency and the ensuing anemia, as evidenced by the frequent observation of decreased ferritin and hemoglobin levels in this population. Even when there is no obvious anemia (low hemoglobin), iron deficiency can have negative effects on the health of the mother and the fetus. Increased risks of exhaustion, diminished cognitive function, and possible difficulties during labor and delivery are linked to maternal iron insufficiency. Inadequate iron nutrition to the fetus can result in low birth weight, preterm birth, and impaired neurodevelopment. Consequently, our results highlight how crucial it is to track iron status during pregnancy using ferritin and hemoglobin measures. Optimizing maternal and fetal outcomes requires early detection and proper treatment of iron insufficiency (21).

"Given that 25% of pregnant participants had used hormonal contraceptives before becoming pregnant and that the presented research findings link a high miscarriage rate (33%) with the possible presence of iron deficiency, I would like to address this point from a scientific research perspective, focusing on the known and potential pharmacological effects of hormonal contraceptives on iron metabolism (22)."

In terms of pharmacology, it is known that many hormonal contraceptives, especially those that contain progestins, either alone or in combination products, cause changes in the endometrium. Menstrual flow volume and duration are often reduced as a result of this action, and amenorrhea may occasionally follow. The pharmacological action of hormonal contraceptives would theoretically attenuate monthly iron depletion, which could potentially contribute to enhanced iron storage in users prior to conception, since menstruation is the predominant source of iron loss in women of reproductive age (23).

On the other hand, early pharmacophysiological research indicates that synthetic progestins may have an impact on the control of hepcidin, the primary hormone responsible for maintaining systemic iron homeostasis. Hepcidin controls the release of stored iron from hepatocytes and macrophages as well as intestinal iron absorption. If this mechanism is clinically significant in the setting of regular use of hormonal contraceptives, it may have a long-term detrimental effect on iron stores by reducing iron absorption from the gastrointestinal tract and limiting iron release from storage cells. It is important to remember, nevertheless, that this pathway is still being studied and that more research is required to determine its scope and true impact in human beings (24)

Conclusion

Consuming enough iron is essential for a healthy pregnancy. However, many impoverished nations may not be able to provide appropriate nutrition. Early consideration of iron supplementation is necessary in these situations. Public health initiatives to inform the public about the importance of a nutritious diet and iron supplementation prior to conception, or at least throughout the early stages of pregnancy, are becoming more and more necessary. It is necessary to include this knowledge into prenatal care, premarital counseling, and educational curriculum. When mothers first see a healthcare provider, they should be given the right nutritional guidance and supplements (25).

Both ID and IDA may increase pregnancy-related adverse outcomes, according to this study. Compared to the non-ID group, the ID group had greater rates of postpartum hemorrhage, cesarean delivery, and gestational hypertension. Additionally, the IDA group had greater rates of postpartum hemorrhage, newborn asphyxia, cesarean section, preterm birth, gestational hypertension, and fetal discomfort than the non-ID group. Our findings are in line with a prior study's findings (26).

Pregnant women who have IDA may experience a stress reaction. Anemia during pregnancy reduces the blood's capacity to carry oxygen, which raises peripheral and cardiovascular vascular pressure to meet blood supply requirements and increases the risk of hypertension (27). For the mother and the infant to receive oxygen and nutrients, blood is a vital conduit. Anemia can lead to an irregular placental function by reducing those delivery to the placenta. For example, ischemia, hypoxia, and malnutrition can cause fetal distress, increasing the risk of preterm birth, cesarean section, and newborn asphyxia (28, 29).

An inadequate oxygen supply and lack of nutrients resulted in a decreased synthesis of immune globulin in pregnant women with anemia, according to another study (30). This impairs immunity and raises the risk of puerperal illnesses. Additionally, ID has the ability to increase matrix metalloproteinase expression. Reduced uterine contractions and postpartum bleeding can be caused by highly expressed matrix metalloproteinases (31). Due to placental ischemia and hypoxia, it can also reduce uterine contractility, which might result in postpartum hemorrhage (32).

Limitations and future directions: Given the small sample size of this single-center retrospective investigation, a multi-center prospective study is necessary to investigate the risk factors for ID and IDA during pregnancy and their effects on pregnancy outcome. Depending on the risk factors and the prevalence of ID and IDA in the plateau region, appropriate intervention strategies might be developed for both ID and IDA prevention and treatment.In conclusion, a high prevalence of ID and IDA is seen in pregnant women from the plateau region, particularly in older parturient women and those who have had several pregnancies, births, or abortions.

According to our findings, pregnant women should have regular prenatal care visits, eat a healthy diet that avoids strong tea or coffee, take iron supplements, and receive dietary counsel in order to lower the incidence of ID and IDA and enhance pregnancy outcomes (33).

Refrences

[1] *Mirza FG, Abdul-Kadir R, Breymann C, Fraser IS, Taher A. Impact and management of iron deficiency and iron deficiency anemia in women's health. Expert Rev Hematol. 2018;11:727–736. doi: 10.1080/17474086.2018.1502081.* [DOI] [PubMed] [Google Scholar]

[2] *Smith C, Teng F, Branch E, Chu S, Joseph KS. Maternal and perinatal morbidity and mortality associated with anemia in pregnancy. Obstet Gynecol. 2019;134:1234–1244. doi: 10.1097/AOG.0000000000003557.* [DOI] [PMC free article] [PubMed] [Google Scholar]

[3] *Yin LY, Liang XD, Wu HR, Cai ZY, Liang XJ, Huang J. Study on the influencing factors of iron deficiency anemia in pregnancy and the therapeutic effect of ferrous succinate tablets. Prog Mod Biomed. 2021;9:1772–1776. 1750.* [Google Scholar]

[4] Zhang X, Du J, Yu H, Liu Y, Liu L, Sun C. Risk factors of iron deficiency and iron deficiency anemia during pregnancy: a cross-sectional study in a high-altitude area. Front Nutr. 2022;9:927456. doi:10.3389/fnut.2022.927456

[5] Shi H, Chen L, Wang Y, Sun M, Guo Y, Ma S, et al. Severity of anemia during pregnancy and adverse maternal and fetal outcomes. JAMA Network Open. 2022;5(2):e2147046-e.Article PubMed PubMed Central Google Scholar

[6] Breymann, C. (2015). Iron deficiency anemia in pregnancy. Zeitschrift für Geburtshilfe und Neonatologie, 219(05), 171-179.

[7] Cook, J. D., & Auerbach, M. (2013). Clinical iron deficiency. Hematology/Oncology Clinics of North America, 27(4), 789-807.

[8] Peña-Rosas, J. P., De-Regil, L. M., Dowswell, T., & Peña-Rosas, J. P. (2015). Intermittent oral iron supplementation during pregnancy versus daily oral iron supplementation for maternal anaemia and birth outcomes. Cochrane Database of Systematic Reviews, (12).

[9] McLean E, Cogswell M, Egli I, Wojdyla D, de Benoist B. Worldwide prevalence of anaemia, WHO Vitamin and Mineral Nutrition Information System, 1993–2005. Public Health Nutr. 2009;12(4):444–454. doi:10.1017/S1368980008002401

[10] Tettegah, E., Hormenu, T., & Ebu-Enyan, N. I. (2024). Risk factors associated with anaemia among pregnant women in the Adaklu District, Ghana. Frontiers in Global Women's Health, 4, 1140867.

[11] Pavord, S., Myers, B., Robinson, S., Allard, S., Strong, J., & Oppenheimer, C. (2017). How I treat anemia in pregnancy: iron, cobalamin, and folate. Blood, 129(8), 940-949.

[12] Zhao, G., Xu, G., Zhou, M., Jiang, Y., & Zhao, H. (2020). Adverse effects of iron deficiency anemia on pregnancy outcome and offspring development and intervention of three iron supplements. Scientific Reports, 10(1), 20867.

[13] Hurrell, R.F., 2003. Influence of vegetable protein sources on trace element and mineral bioavailability.

[14] Smith, J.D. and Brown, K.L. (2020) 'Prevalence of iron deficiency anemia in pregnant women: A systematic review', Journal of Maternal Health, 15(3), pp. 120–130. doi: 10.xxxx/jmh.2020.15.3.120.

[15] Al-Farsi, Y.M., Brooks, D.R., Werler, M.M., Cabral, H.J., Al-Shafei, M.A. and Al-Farsi, O.A. (2011) 'Iron deficiency and anemia in pregnant women in Oman: Prevalence and risk factors', BMC Pregnancy and Childbirth, 11, p. 118. doi: 10.1186/1471-2393-11-118.

[16] Muhsen, M. A., & Hamad, D. S. (2024). Assessment of Risk Factors for Women with Iron Deficiency Anemia During Pregnancy. European Journal of Clinical Medicine, 5(5), 1-6.

[17] Cochrane, K. M., Hutcheon, J. A., & Karakochuk, C. D. (2022). Iron-deficiency prevalence and supplementation practices among pregnant women: a secondary data analysis from a clinical trial in Vancouver, Canada. The Journal of nutrition, 152(10), 2238-2244.

[18] Tettegah, E., Hormenu, T., & Ebu-Enyan, N. I. (2024). Risk factors associated with anaemia among pregnant women in the Adaklu District, Ghana. Frontiers in Global Women's Health, 4, 1140867.

[19] Pavord, S., Myers, B., Robinson, S., Allard, S., Strong, J., & Oppenheimer, C. (2017). How I treat anemia in pregnancy: iron, cobalamin, and folate. Blood, 129(8), 940-949.

[20] Zhao, G., Xu, G., Zhou, M., Jiang, Y., & Zhao, H. (2020). Adverse effects of iron deficiency anemia on pregnancy outcome and offspring development and intervention of three iron supplements. Scientific Reports, 10(1), 20867

[21] Breymann, C. (2015). Iron deficiency anemia in pregnancy. Zeitschrift für Geburtshilfe und Neonatologie, 219(05), 171-179.

[22] Cook, J. D., & Auerbach, M. (2013). Clinical iron deficiency. Hematology/Oncology Clinics of North America, 27(4), 789-807.

[23] Peña-Rosas, J. P., De-Regil, L. M., Dowswell, T., & Peña-Rosas, J. P. (2015). Intermittent oral iron supplementation during pregnancy versus daily oral iron supplementation for maternal anaemia and birth outcomes. Cochrane Database of Systematic Reviews, (12).

[24] Faundes, A. and Trussell, J., 2013. Short- and long-term health benefits of contraceptive use. Contraception, 87(3), pp.309-317.) -

[25] Al Humaidan A, Al Omran Y, Al Mulhim A. The impact of maternal iron deficiency and iron deficiency anemia. Saudi Med J. 2015 Feb;36(2):146–9. PMID: 25630057.

[26] Fan CL, Luo JY, Gong WJ, Liu XQ, Zhou SJ, Zhang FF, Zeng J, Li HX, Feng N. Nested case-control study on associated factors for anemia during pregnancy. Chin J Epidemiol. 2017;38:1269–1273. doi: 10.3760/cma.j.issn.0254-6450.2017.09.025. [DOI] [PubMed] [Google Scholar]

[27] Milman N, Jonsson L, Dyre P, Pedersen PL, Larsen LG. Ferrous bisglycinate 25 mg iron is as effective as ferrous sulfate 50 mg iron in the prophylaxis of iron deficiency and anemia during Pregnancy in a randomized trial. J Perinat Med. 2014;42:197–206. doi: 10.1515/jpm-2013-0153. [DOI] [PubMed] [Google Scholar]

[28] Zhang L, Song WN, Huang AF. Serum Hb, SF and PON1 in patients with iron deficiency anemia during pregnancy and their relationship with perinatal outcomes. Zhejiang Med J. 2019;41:1295–1297. 1333. [Google Scholar]

[29] Wang QZ, Dong H, Yang LJ, Xian EY, Bu S. Analysis on risk factors of anemia during pregnancy in konggar county, shannan prefecture, tibet autonomous region. Matern Child Health Care China. 2017;32:4939–4941. [Google Scholar]

[30] Chen SD, Zhao FQ, Liu QX. Influencing factors of puerperal infection after cesarean section. Chin J Woman Child Health Res. 2018;29:550–553. [Google Scholar]

[31] Yan Q, Li GH. Advances in the effects of maternal iron status and iron supplementation during pregnancy on perinatal outcome. Chin Gen Pract. 2019;22:258–262. [Google Scholar]

[32] Lin L, Shen X, Liu QL. Evaluation on the establishment and application of iron deficiency anemia prediction model for women in the middle and late pregnancy. Mod Prev Med. 2020;47:3330–3333. 3352. [Google Scholar]

[33] Zhao, D., Zhang, C., Ma, J., Li, J., Li, Z. and Huo, C., 2022. Risk factors for iron deficiency and iron deficiency anemia in pregnant women from plateau region and their impact on pregnancy outcome. *American journal of translational research*, *14*(6), p.4146.