

“Age and Gender Variations in Iron, Ferritin, and Hemoglobin Levels: Implications for Nutritional Guidance in Libya”

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Abstract

Iron deficiency is a major global health concern, affecting approximately two billion individuals worldwide and contributing significantly to morbidity and mortality. Dietary iron deficiency occurs when physiological requirements cannot be met through absorbed dietary iron. This study targeted individuals with low blood iron levels, low ferritin stores, or low hemoglobin concentrations. Laboratory data from 239 participants were collected from three diagnostic centers in Zliten, Libya. Iron, ferritin, and hemoglobin levels were analyzed by age and gender across three groups: children, young adults, and the elderly. Results revealed that the number of participants with normal iron, ferritin, and hemoglobin levels was 194, 129, and 145, respectively, whereas abnormal levels were recorded in 45, 110, and 45 individuals, respectively. Findings suggest that while age and gender do not directly affect iron deficiency, they influence iron storage and red blood cell counts. Nutritional recommendations include increasing iron absorption through vitamin C-rich foods, reducing tea, coffee, and calcium intake during iron-rich meals, following balanced diets with other essential nutrients, using iron supplements when necessary, and adopting appropriate food preparation techniques.

Keywords: Iron deficiency, ferritin, hemoglobin, nutrition, dietary guidance, anemia

1. Introduction

Iron deficiency remains one of the most prevalent nutritional disorders globally and a leading cause of disability and premature death. It significantly affects human health, productivity, and cognitive

development, particularly in developing countries. The bioavailability of dietary iron is often low among populations consuming predominantly plant-based diets, increasing the risk of iron deficiency anemia (IDA).

In Libya, as in many developing nations, inadequate dietary intake of iron-rich foods, limited awareness of iron deficiency screening, low socioeconomic status, and poor dietary habits contribute to this public health problem. This study aims to assess iron status among residents of Zliten city and to provide evidence-based nutritional advice to improve community awareness and dietary practices. Recent research highlights that iron metabolism and absorption are tightly regulated by liver and intestinal proteins, which respond dynamically to changes in iron status. Effective strategies to address iron deficiency include iron fortification, supplementation, and dietary modification. However, challenges such as limited bioavailability of iron compounds in fortified foods persist. Regular screening and nutritional counseling remain critical to preventing iron deficiency.

1.2. Objectives

The main objectives of this study were to:

1. Determine the prevalence of iron deficiency among males and females in Zliten city.
2. Identify age groups most affected by iron deficiency.
3. Assess the relationship between age, sex, and iron, ferritin, and hemoglobin levels.
4. Provide nutritional guidance to improve dietary iron intake and absorption.
5. Promote community awareness regarding the prevention of iron deficiency.
6. Offer practical advice on iron absorption enhancers and inhibitors in daily diets

2. Methodology

2.1. Study Design

This study employed an **analytical cross-sectional design** aimed at assessing the iron status of individuals in Zliten city, Libya. The primary objective was to determine the average iron levels in the population and evaluate the impact of dietary patterns on iron deficiency. Data were collected from selected reference laboratories in Zliten, including Alpha Medical Analysis Laboratory, Bin Haider Reference Laboratory, and Al-Resala Laboratory, to represent the general population's iron status.

2.2 Study Population

The study population included individuals who visited the selected laboratories for routine blood analysis. A total of **239 participants** were included, comprising males and females of various age groups. Only individuals without other underlying medical conditions were considered.

2.3. Study Area

The study was conducted in **Zliten city, Libya**, utilizing three reference laboratories that provide routine hematological services.

2.4 Data Collection

Data collection occurred over the first three months of 2024. Laboratory records were reviewed, and a structured data collection form was used to capture the following variables:

- Age and sex
- Hemoglobin (HGB)
- Ferritin
- Serum iron

2.5 Sample Size and Distribution

A total of **239 blood samples** were collected and distributed as follows:

- **Alpha Medical Analysis Laboratory:** 136 samples (17 male children, 9 female children, 21 men, 89 women)
- **Bin Haider Reference Laboratory:** 71 samples (21 men, 50 women)
- **Al-Resala Laboratory:** 58 samples (13 men, 45 women)

2.6 Sample Collection and Preparation

Blood samples were drawn from a vein using standard venipuncture techniques. Red-top BIO tubes without anticoagulants were used, and samples were centrifuged to obtain serum. No special preparation, such as fasting, was required prior to sample collection.

2.7 Laboratory Analysis

The following laboratory tests were analyzed:

1. **Complete Blood Count (CBC):** Used to assess overall blood health and detect conditions such as anemia. Parameters included:
 - Red blood cell count (RBC)
 - Hematocrit (HCT)
 - Mean corpuscular volume (MCV)
 - Mean corpuscular hemoglobin (MCH)
 - Mean corpuscular hemoglobin concentration (MCHC)
 - White blood cell count (WBC), including lymphocytes and neutrophils
 - Hemoglobin level
 - Erythrocyte sedimentation rate (ESR)
 - Platelet count
2. **Iron Studies:** Ferritin and serum iron levels were measured to assess iron status and identify iron deficiency anemia.

CBC and iron study results were interpreted based on established reference ranges. Abnormal results were further evaluated to identify potential anemia, polycythemia, leukopenia, thrombocytopenia, or other hematological disorders.

2.8 Study Duration

The study was conducted from **July 1 to June 3, 2024**.

2.9 Ethical Considerations

Ethical approval was obtained from the **College of Health Sciences, Al Asmarya University**, and written permission was secured from all participating laboratories to access and use the data for research purposes.

2.10 Statistical Analysis

Data were analyzed using **SPSS software (version 2.0)**. Descriptive statistics, including mean, standard deviation, frequency, and percentage, were used to summarize the data. Relationships between variables were assessed using appropriate statistical tests.

3. Results and Discussion

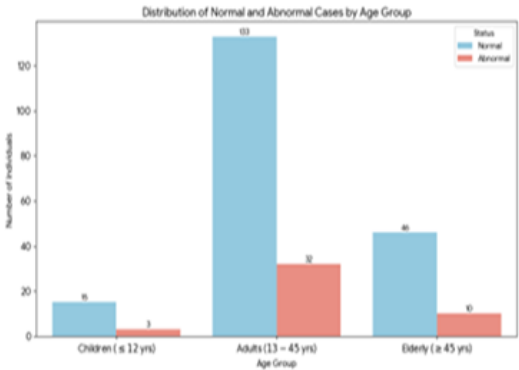
3.1 Introduction

This chapter presents the results of the study, which aimed to estimate the prevalence of iron deficiency and anemia among individuals visiting selected laboratories in Zliten city. The effects of age and gender on iron status, iron stores, and hemoglobin levels were assessed. The results were organized according to iron levels, ferritin levels, and hemoglobin (HGB) levels, stratified by age, gender, and both variables combined. Age groups were classified as children (≤ 12 years), adults (13–45 years), and elderly (≥ 45 years).

3.2 Iron Levels by Age

Table 3.1 Frequency and relative distribution of iron levels by age (n=239)

Age Group	Normal	Abnormal	Total
Children (≤ 12 yrs)	15	3	18
Adults (13–45 yrs)	133	32	165
Elderly (≥ 45 yrs)	46	10	56
Total	194	45	239



The table presents the distribution of iron levels among the study participants according to age groups. Out of a total of 239 individuals, **194 participants had normal iron levels**, while **45 participants had abnormal iron levels**. **Children (≤ 12 years):** Most children had normal iron levels (15 out of 18), with only 3 showing abnormal levels. **Adults (13–45 years):** The majority of adults also had normal iron levels (133 out of 165), whereas 32 adults exhibited abnormal iron levels. **Elderly (≥ 45 years):** Among the elderly, 46 participants had normal iron levels, while 10 participants had abnormal levels. Overall, the data indicate that normal iron levels were predominant across all age groups, while

a smaller proportion of participants in each age category experienced iron deficiency. The highest number of abnormal cases was observed in the adult group, reflecting the potential influence of lifestyle and dietary factors in this age range.

3.2 Iron Levels by Gender

Table 3.2 Iron levels by gender (n=239)

Gender	Normal	Abnormal	Total
Male	51	12	63
Female	143	33	176
Total	194	45	239

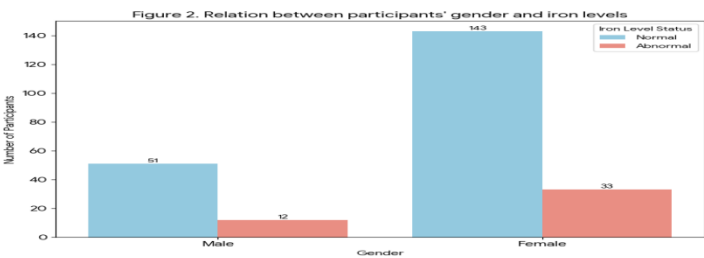
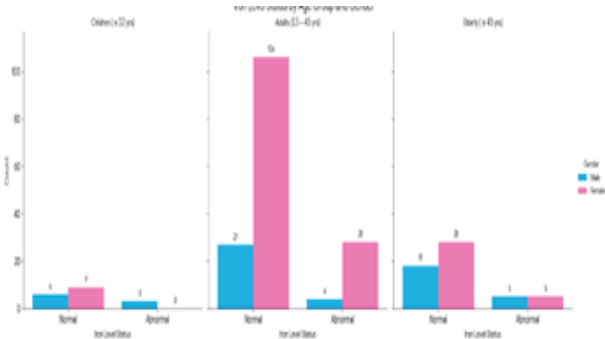


Table 3.2 shown and Figure 2 present the distribution of iron levels among the study participants according to gender. Out of the total 239 participants, **63 were male** and **176 were female**. Among males, **51 individuals (81%) had normal iron levels**, while **12 individuals (19%) had abnormal iron levels**. Among females, **143 individuals (81%) had normal iron levels**, whereas **33 individuals (19%) had abnormal iron levels**. Overall, the data indicate that the proportion of normal and abnormal iron levels was similar between males and females, with the majority of participants in both genders maintaining normal iron levels. Figure 2 visually represents this distribution, showing comparable rates of iron deficiency across genders.

3.3 Iron Levels by Age and Gender

Table 3.3. Iron levels according to age and gender (n=239)

Age Group	Normal	Abnormal	Total
Children (≤12 yrs)	M: 6, F: 9	M: 3, F: 0	18
Adults (13–45 yrs)	M: 27, F: 106	M: 4, F: 28	165
Elderly (≥45 yrs)	M: 18, F: 28	M: 5, F: 5	56
Total	194	45	239



The table3.3 presents the distribution of iron levels among study participants according to both **age group and gender**. Out of 239 participants, **194 had normal iron levels**, while **45 had abnormal iron levels**. **Children (≤12 years):** Among 18 children, 15 had normal iron levels—6 males and 9 females. Only 3 male children had abnormal iron levels, while no females were affected. **Adults (13–45 years):** Among 165 adults, 133 had normal iron levels—27 males and 106 females. Among the 32 adults with abnormal iron levels, 4 were males and 28 were females, indicating a higher prevalence of

abnormal iron levels among adult females. **Elderly (≥ 45 years):** Of 56 elderly participants, 46 had normal iron levels—18 males and 28 females. Among the 10 elderly participants with abnormal iron levels, 5 were males and 5 were females. Overall, normal iron levels were predominant across all age groups and genders. However, **adult females were the most affected by abnormal iron levels**, suggesting potential nutritional or physiological factors contributing to iron deficiency in this subgroup.

3.4. Iron Stores (Ferritin) by Age and Gender

Table 3.4. Iron stores by age

Age Group	Normal	Abnormal	Total
Children (≤ 12 yrs)	10	8	18
Adults (13–45 yrs)	76	87	163
Elderly (≥ 45 yrs)	43	15	58
Total	129	110	239



Table 3.4 presents the distribution of **iron stores (ferritin levels)** among study participants according to age groups. Out of a total of 239 participants, **129 individuals had normal ferritin levels**, while **110 individuals had abnormal ferritin levels**, indicating reduced iron stores. **Children (≤ 12 years):** Among 18 children, 10 had normal ferritin levels, while 8 exhibited abnormal iron stores, suggesting a substantial proportion of children at risk of low iron reserves. **Adults (13–45 years):** Among 163 adults, 76 had normal ferritin levels, whereas 87 adults had abnormal iron stores, indicating that adults, particularly those in this age range, had the highest prevalence of low iron stores. **Elderly (≥ 45 years):** Of 58 elderly participants, 43 had normal ferritin levels, and 15 had abnormal iron stores, showing a lower prevalence of iron depletion compared to adults. Overall, the data indicate that **iron depletion was most prominent in adults**, followed by children and elderly participants, highlighting age-specific differences in iron storage that may be influenced by dietary habits, physiological requirements, or other health factors.

3.5 Iron Stores (Ferritin) by Age and Gender

Table 3.5. Iron stores by age

Age Group	Normal	Abnormal	Total
Children (≤ 12	10	8	18

yrs)			
Adults (13–45 yrs)	76	87	163
Elderly (≥45 yrs)	43	15	58
Total	129	110	239

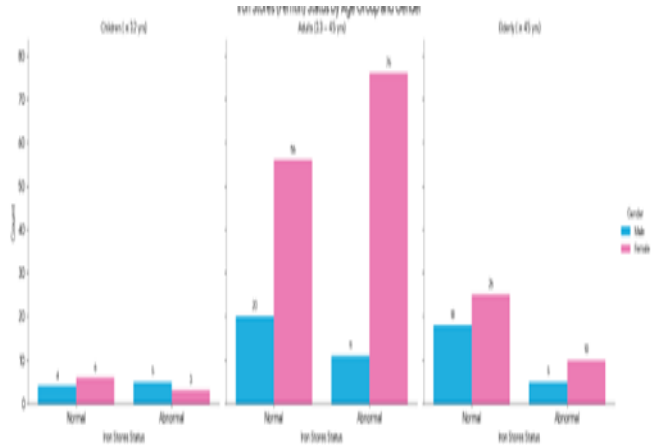


Table 3.6. Iron stores by age and gender

Age Group	Normal	Abnormal	Total
Children	M: 4, F: 6	M: 5, F: 3	18
Adults	M: 20, F: 56	M: 11, F: 76	163
Elderly	M: 18, F: 25	M: 5, F: 10	58
Total	129	110	239

Table 3.5 and 3.6 presents the distribution of **iron stores (ferritin levels)** among the study participants according to age groups. Out of 239 participants, **129 individuals had normal iron stores**, while **110 individuals had abnormal iron stores**, indicating varying levels of iron depletion across age groups. **Children (≤12 years):** Among 18 children, 10 had normal ferritin levels, while 8 had abnormal levels, suggesting that nearly half of the children showed reduced iron stores. **Adults (13–45 years):** Among 163 adults, 76 had normal iron stores, whereas 87 adults had abnormal stores, showing that adults had the **highest prevalence of iron depletion** in the study. **Elderly (≥45 years):** Among 58 elderly participants, 43 had normal iron stores, and 15 had abnormal stores, indicating a lower prevalence of iron depletion compared to adults. Overall, the results indicate that **iron deficiency is most common among adults**, followed by children, while the elderly showed relatively better iron stores. These findings highlight the importance of age-specific strategies to prevent and manage iron deficiency.

3.6 Hemoglobin (HGB) Levels by Age and Gender

Table 3.6. HGB levels by age

Age Group	Normal	Abnormal	Total
Children (≤12	18	0	18

yrs)			
Adults (13–45 yrs)	90	74	164
Elderly (≥45 yrs)	37	20	57
Total	145	94	239

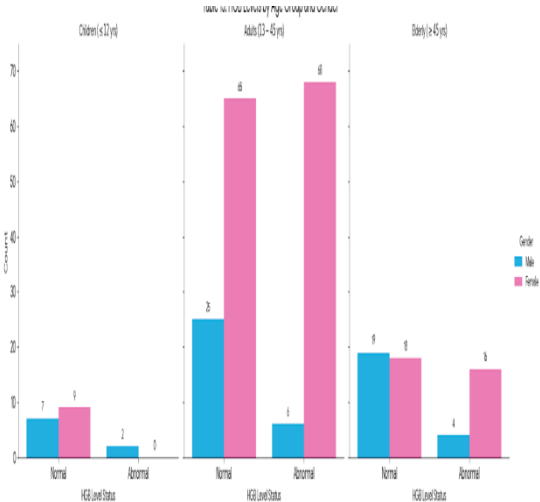


Table 3.7. HGB levels by gender

Gender	Normal	Abnormal	Total
Male	51	10	61
Female	94	84	178
Total	145	94	239

Table 3.8. HGB levels by age and gender

Age Group	Normal	Abnormal	Total
Children	M: 7, F: 9	M: 2, F: 0	18
Adults	M: 25, F: 65	M: 6, F: 68	164
Elderly	M: 19, F: 18	M: 4, F: 16	57
Total	145	94	239

Table 3.6 presents the distribution of hemoglobin levels among participants according to age groups. Out of 239 participants, **145 had normal HGB levels**, while **94 had abnormal levels**, indicating anemia. **Children (≤12 years):** All 18 children had normal HGB levels, with no cases of anemia observed **Adults (13–45 years):** Among 164 adults, 90 had normal HGB levels, while 74 exhibited anemia, representing the highest prevalence of abnormal HGB levels across age groups. **Elderly (≥45 years):** Of 57 elderly participants, 37 had normal HGB levels, and 20 had abnormal levels, showing a moderate prevalence of anemia.

Table 3.7 Shown HGB Levels by Gender

Table 3.7 shows the distribution of HGB levels according to gender. Among **61 males**, 51 had normal HGB levels and 10 had anemia. Among **178 females**, 94 had normal HGB levels, while 84 had anemia. Overall, anemia was more prevalent in females compared to males.

Table 3.8: HGB Levels by Age and Gender

Table 3.8 provides a combined distribution of HGB levels by age and gender. **Children:** Normal HGB levels were observed in 7 males and 9 females, while 2 male children had abnormal levels and no female children were anemic. **Adults:** Among adults with normal HGB levels, 25 were males and 65 were females. Among adults with abnormal HGB levels, 6 were males and 68 were females, indicating a higher rate of anemia in adult females. **Elderly:** Normal HGB levels were observed in 19 males and 18 females, whereas abnormal levels were present in 4 males and 16 females. Overall, the data indicate that **anemia is more prevalent in adults, particularly adult females**, while children generally maintained normal HGB levels, and elderly participants showed moderate anemia prevalence.

Table 3.9. Summary of Hypothesis Testing for Iron Status and Hemoglobin Levels (n = 239)

Hypothesis	Variable	Null Hypothesis	χ^2 Value	p-value	Conclusion
1	Age → Iron Deficiency	Age does not affect iron deficiency	0.124	0.940	Accept null; Age has no significant effect
2	Gender → Iron Deficiency	Gender does not affect iron deficiency	0.003	0.959	Accept null; Gender has no significant effect
3	Age → Iron Stores	Age does not affect iron stores	13.054	0.001	Reject null; Age significantly affects iron stores
4	Gender → Iron Stores	Gender does not affect iron stores	5.547	0.019	Reject null; Gender significantly affects iron stores
5	Age → HGB Levels	Age does not affect HGB levels	14.404	0.001	Reject null; Age significantly affects HGB levels
6	Gender → HGB Levels	Gender does not affect HGB levels	18.059	<0.001	Reject null; Gender significantly affects HGB levels

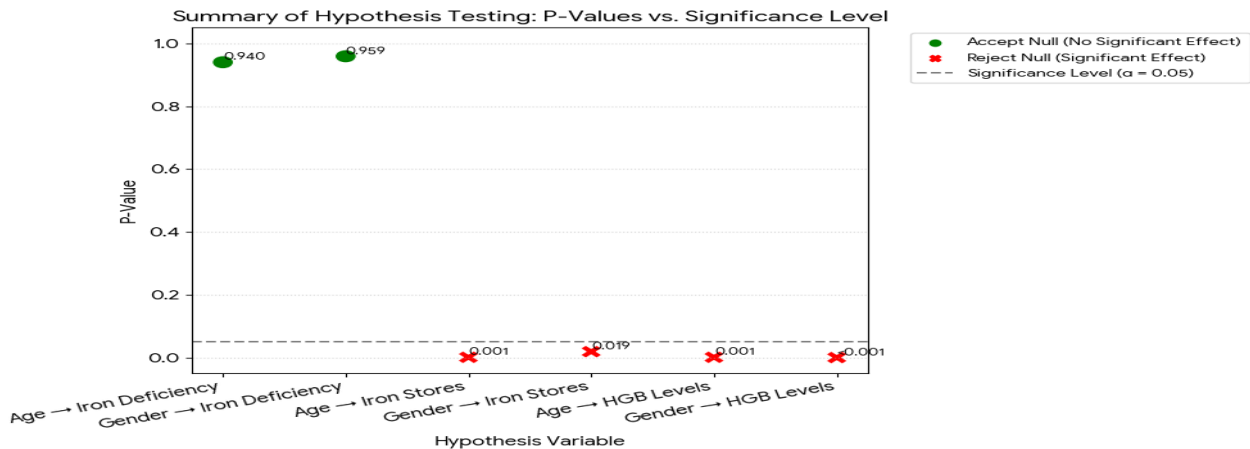


Table 3.9 summarizes the results of hypothesis testing for the effects of **age and gender** on iron status (iron deficiency and iron stores) and hemoglobin (HGB) levels among the study participants (n = 239).

- **Hypotheses 1 and 2:** Both age and gender were tested for their effect on **iron deficiency**. The chi-square results showed that age ($\chi^2 = 0.124$, $p = 0.940$) and gender ($\chi^2 = 0.003$, $p = 0.959$) had **no significant effect**, leading to acceptance of the null hypotheses. This indicates that iron deficiency prevalence is independent of age and gender in this sample.
- **Hypotheses 3 and 4:** The effect of age and gender on **iron stores (ferritin levels)** was assessed. The results revealed that both age ($\chi^2 = 13.054$, $p = 0.001$) and gender ($\chi^2 = 5.547$, $p = 0.019$) had **significant effects**, leading to rejection of the null hypotheses. This indicates that **iron stores vary by age and gender**, with adults and females showing higher prevalence of abnormal iron stores.
- **Hypotheses 5 and 6:** The effect of age and gender on **hemoglobin levels** was evaluated. The findings showed significant effects of age ($\chi^2 = 14.404$, $p = 0.001$) and gender ($\chi^2 = 18.059$, $p < 0.001$), indicating that both variables significantly influence HGB levels. Specifically, anemia prevalence was higher among **adult and female participants**.

Overall, the table highlights that while **iron deficiency itself is not influenced by age or gender**, **iron stores and hemoglobin levels are significantly affected** by these demographic factors, suggesting the need for age- and gender-specific nutritional interventions to improve iron status and prevent anemia.

4. Discussion, Conclusion, and Recommendations

4.1 Discussion

This study aimed to evaluate iron deficiency, iron stores, and hemoglobin (HGB) levels in a sample of 239 individuals visiting laboratories in Zliten city, while examining the effects of age and gender on these parameters. The study findings provide insight into the prevalence of iron-related disorders and the role of demographic factors in these conditions.

1. Iron Levels and Age/Gender Effects

The results revealed that 194 participants had normal iron levels, while 45 participants had

abnormal iron levels. Statistical analysis showed that **age and gender do not significantly affect iron deficiency**, which is consistent with several studies suggesting that iron deficiency may be influenced more by dietary habits and underlying health conditions than by age or sex alone.

2. Iron Stores (Ferritin) and Age/Gender Effects

Analysis of iron stores indicated that 129 participants had normal ferritin levels, while 110 participants had abnormal ferritin levels. **Both age and gender significantly influenced iron stores**, with younger participants and females showing higher prevalence of abnormal ferritin. This aligns with literature highlighting that females, particularly of reproductive age, are more prone to depleted iron stores due to menstruation and higher physiological requirements.

3. Hemoglobin Levels and Age/Gender Effects

The study showed that 145 participants had normal hemoglobin levels, while 94 participants had anemia. **Both age and gender significantly affected hemoglobin levels**, with older adults and females exhibiting higher prevalence of anemia. These findings support previous research demonstrating that hemoglobin concentrations can decline with age and differ between sexes due to hormonal and physiological differences.

4. Nutritional Implications

The findings indicate that iron deficiency and anemia remain significant public health issues in Zliten. Dietary habits, including low consumption of iron-rich foods, high intake of iron absorption inhibitors (tea, coffee, calcium-rich foods), and limited bioavailable iron intake, likely contribute to these conditions. Strategies to improve iron intake and bioavailability are critical for prevention and management.

4.2 Conclusion

Based on the results of the study:

1. The number of participants with normal iron, ferritin, and hemoglobin levels was 194, 129, and 145, respectively, while abnormal levels were observed in 45, 110, and 94 participants.
2. **Age and gender did not significantly affect iron deficiency.**
3. **Age and gender significantly affected iron stores (ferritin) and hemoglobin levels.**
4. Nutritional and lifestyle factors play a critical role in maintaining adequate iron status, highlighting the importance of dietary interventions and supplementation when necessary.

4.3 Recommendations

Based on the findings, the following evidence-based recommendations are proposed:

1. Dietary Enhancement of Iron Absorption

- Increase intake of vitamin C-rich foods (citrus fruits, peppers, strawberries) alongside iron-rich foods to enhance non-heme iron absorption.
- Include heme iron sources (meat, poultry, fish) to improve overall iron bioavailability.

2. Reduction of Iron Absorption Inhibitors

- Avoid drinking tea or coffee during meals.

- Limit high-calcium foods (dairy) during iron-rich meals.
- Reduce excessive dietary fiber intake that may impair iron absorption.
- 3. **Food Preparation Strategies**
 - Use iron cookware to increase dietary iron content.
 - Soak and cook legumes and grains to reduce phytates and other absorption inhibitors.
- 4. **Iron Supplementation**
 - Administer iron supplements under medical supervision for individuals with significant deficiency.
 - Monitor iron status periodically through blood tests to assess treatment efficacy.
- 5. **Balanced Nutrition and Healthy Lifestyle**
 - Ensure a well-balanced diet containing iron, folic acid, vitamin B12, and other essential micronutrients.
 - Promote regular physical activity to support overall hematologic health.
- 6. **Special Considerations for Infants and Women**
 - Breastfeeding should be supplemented with iron-rich complementary foods from six months onward.
 - Women of reproductive age should be educated about iron requirements and strategies to prevent deficiency.
- 7. **Psychological and Cognitive Implications**
 - Address early iron deficiency to prevent adverse effects on cognition, behavior, and motor development, especially in children.

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