Sirte University Scientific Journal Vol. 16, No. 1 (2026) 160-165
Sirte University Scientific Journal (SUSJ)
Journal home page: http://journal.su.edu.ly/index.php/susj

Prevalence and Association of *Helicobacter pylori* Infection and Iron Deficiency Anemia in Sirte, Libya: A Cross-Sectional Study.

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DOI: https://doi.org/10.37375/susj.v16i1.4171

ARTICLE INFO:

Received 16 May 2026.
Accepted 10 June 2026.
Available online 24 June 2026.

Keywords: *Helicobacter pylori*, Iron Deficiency Anemia (IDA), Ferritin, Sirte .

A B S T R A C T

This population-based cross-sectional study investigated the association between *Helicobacter pylori* (*H. pylori*) infection and Iron Deficiency Anemia (IDA)among 200 participants in Sirte, Libya. Laboratory analysis revealed a high prevalence of *H. pylori* infection (67.5%) and iron deficiency (87.5%), with a statically significant correlation between the two variables ($p<0.05$). Notably, 92.6% of infected group. Gender and age-stratified data showed a 100% deficiency rate among infected males and participants aged 10-30 years. Furthermore, a significant tendency toward latent iron deficiency was observed, as many participants even those within normal clinical ranges exhibited ferritin levels at the lowest thresholds (Females:20ng/ml; Males: 30ng/ml), inditing a systemic risk for future IDA. These findings identify *H. pylori* as a critical risk factor for refractory anemia in the Sirte population and strongly support the integration of bacterial eradication into clinical management protocols for anemia.

انتشار عدوى *Helicobacter pylori* وعلاقتها بفقر الدم الناجم عن نقص الحديد في مدينة سرت، ليبيا: دراسة مقطعية.

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الـمُخلص

بحثت هذه الدراسة المقطعية القائمة على السكان العلاقة بين الاصابة ببكتيريا (*H. pylori*) وفقر الدم الناجم عن نقص الحديد بين (200) مشارك في مدينة سرت، كشفت التحاليل المختبرية عن ارتفاع معدل انتشار عدوى الملوية البوابية (67.5%) ونقص الحديد (87.5%) ، مع وجود ارتباط ذي دلالة إحصائية بين المتغيرين ($p < 0.05$) و الجدير بالذكر أن (92.6%) من المجموعة المصابة. وأظهرت البيانات المصنفة حسب الجنس و العمر معدل نقص بنسبة 100% بين الذكور المصابين و المشاركين الذين تتراوح أعمارهم بين 10 و 30 عاماً، علاوة على ذلك لوحظ اتجاه ملحوظ نحو نقص مخزون الحديد، حيث أظهر العديد من المشاركين، حتى أولئك الذين يقعون ضمن النطاقات السريرة الطبيعية مستويات فيريتين عند أدنى الحدود (الإناث: 20 نانو غرام/مل ؛ الذكور: 30 نانو غرام/مل)، مما يشير إلى خطر جهازي للإصابة بفقر الدم الناجم عن نقص الحديد في المستقبل. تحدد هذه النتائج بكتيريا *H. pylori* كعامل خطر حاسم لفقر الدم المقاوم للعلاج لدى سكان مدينة سرت، وتدعم بقوة دمج اعلاج بكتيرا في بروتوكولات الإدارة السرية لفقر الدم.

الكلمات المفتاحية: بكتيريا ***Helicobacter pylori***، فقر الدم الناتج عن نقص الحديد، فيريتن، سرت.

1. Introduction

Helicobacter pylori (*H. pylori*) infection and iron deficiency anemia (IDA) represent significant public health challenges in Libya. While investigations in various global populations have established a robust link between *H. pylori* and IDA, population-based evidence from Libya remains scarce (Pu et al., 2025; Said et al., 2025). The present study seeks to bridge this knowledge gap by examining the association between *H. pylori* infection and the risk of iron deficiency anemia in Sirte, Libya (Abdallah et al., 2021).

Currently, more than half of the world's population is infected with *H. pylori*, which predominantly colonizes the gastric mucosa (Hooi et al., 2017). Although the infection is often asymptomatic, persistent colonization can provoke a systemic inflammatory response, leading to hematological abnormalities, most notably IDA (Pu et al., 2025). IDA is clinically characterized by depleted iron stores, subnormal serum iron, and impaired hemoglobin production. Furthermore, *H. pylori* infection has been shown to influence other nutrition-dependent conditions, such as vitamin B12 deficiency. In the Libyan context, both *H. pylori* and IDA impose considerable economic and health burdens; however, their association remains under-examined in this specific population (Wang et al., 2025).

The bacterium's ability to persist in the diverse and harsh conditions of the gastric habitat generates chronic inflammatory responses and stimulates various host immune cell populations. This leads to a wide spectrum of clinical manifestations, ranging from chronic gastritis to gastric carcinoma. Efficient colonization depends on metabolic adaptability, immune evasion, and

sophisticated adherence mechanisms mediated by outer membrane proteins, which facilitate attachment to the gastric epithelium (Boren et al., 1993).

The interplay between the organism's genetic makeup, geographic distribution, and host-specific risk factors significantly defines disease outcomes. Serologic evidence suggests that approximately 50% of the global population has a prior or active infection, with prevalence rates reaching as high as 90% in socioeconomically deprived settings (Hooi et al., 2017). Consequently, this study evaluates this association in a population-based cross-sectional cohort from Sirte to provide relevant insights for public health and intervention strategies.

2. Literature Review and Overview

2.1. Helicobacter pylori: Pathogenesis and Virulence Factors

Helicobacter pylori is a helical-shaped, microaerophilic, Gram-negative bacterium that primarily colonizes the human gastric mucosa and duodenum. While its primary niche is the stomach, extra-gastrointestinal manifestations have been increasingly documented (Figura et al., 2010). The International Agency for Research on Cancer (IARC) has classified *H. pylori* as a definitive Group 1 carcinogen due to its established role in the etiology of gastric carcinoma (IARC, 2021).

The pathogenicity of *H. pylori* is largely determined by its virulence factors. Strains are typically categorizes strains based on the presence of vacuolating cytotoxin A (VacA) and cytotoxin-associated gene A (CagA). Efficient colonization and persistence depend on metabolic adaptability and adherence mechanisms mediated by outer membrane proteins (OMPs). Specifically, the blood group antigen-binding adhesin (BabA) facilitates attachment to Lewis b (Le^b) blood group antigens in the gastric mucosa (Boren et al., 1993). The presence of the BabA2 gene is significantly correlated with increased gastric inflammation and the development of precancerous lesions. Furthermore, the phosphorylation of the CagA protein via Glu-Pro-Ile-Tyr-Ala (EPIYA) motifs has been implicated in the development of refractory iron deficiency anemia (R-IDA) (Paliwal et al., 2022).

2.2. Iron Deficiency Anemia(IDA) Overview

Iron deficiency anemia is a global public health crisis characterized by reduced hemoglobin concentrations resulting from insufficient iron supply or impaired absorption. According to the World Health Organization (WHO), anemia affects approximately one-third of the global population, or roughly 2 billion people (WHO, 2025).

The prevalence of IDA is disproportionately higher in women due to physiological demands associated with the childbearing cycle, including menstruation, pregnancy, and lactation. Other etiologies include malnutrition, chronic hemorrhage, hookworm infestation, and gastrointestinal diseases that disrupt the balance between iron requirement and absorption (WHO, 2025).

2.3. The Link Between *H. pylori* and Iron Homeostasis

The association between *H. pylori* infection and unexplained IDA is well-documented, though the precise mechanisms remain a subject of academic debate. The most widely accepted hypothesis involves the development of atrophic gastritis during the early stages of infection. This condition leads to diminished hydrochloric acid (HCl) secretion (hypochlorhydria), which is essential for the dissolution of non-heme iron and the reduction of ferric (Fe^{3+}) iron into the absorbable ferrous (Fe^{2+}) form within the duodenum (Figura et al., 2010; Paliwal et al., 2022).

While gastrointestinal bleeding was historically considered a cause, it has been largely dismissed due to the rarity of endoscopic evidence of active bleeding in IDA patients with *H. pylori*. Instead, researchers focus on the bacteria's competition with the host for iron and the disruption of host iron trafficking. Refractory IDA (R-IDA), which accounts for 10–15% of IDA cases, is particularly noted for its failure to respond to oral iron supplementation unless the *H. pylori* infection is eradicated (Paliwal et al., 2022). Given the high global endemicity of the bacterium and the limited published data regarding the Libyan population, this study provides critical evidence from Sirte to enhance clinical management strategies.

3. Study Objectives

The primary objective of this study is to investigate the association between Helicobacter pylori infection and iron deficiency anemia (IDA) among the population of Sirte, Libya. Understanding the link between *H. pylori* and IDA is crucial, especially in developing countries such as Libya, where the bacterium reportedly infects approximately 68% of the population by the age of 30 (Abdallah et al., 2021)This research constitutes the first population-based cross-sectional study in Sirte aimed at providing empirical evidence to inform clinical interventions and healthcare strategies for managing refractory anemia.

4. Methodology

4.1. Study Design and Population

A population-based cross-sectional study was conducted in Sirte, Libya, to evaluate the association between *Helicobacter pylori* infection and iron deficiency. The study involved a total of 200 participants selected through a simple random sampling technique.

4.2. Data Collection and Variables

Data collection was streamlined to capture specific demographic and clinical variables essential for the correlation analysis:

- **Demographic Data:** Information regarding Age and Gender was collected for all participants through direct interviews.
- **Laboratory Investigations:** Professional medical laboratory personnel obtained venous blood samples from each participant to perform the following:

1. ***H. pylori* Screening**: Detection of the bacterium using established laboratory assays to determine infection status.
2. **Iron Status Assessment**: Measurement of Serum Ferritin and Hemoglobin levels to identify cases of iron deficiency.

4.3. Procedures and Standards

All diagnostic procedures and blood sample processing were carried out in strict accordance with the **World Health Organization (WHO) Manual (2017).** This ensured methodological consistency, accuracy in measuring iron stores, and reliability in detecting *H. pylori* colonization across all age groups and genders.

4.4. Laboratory analysis

To determine the levels of serum ferritin, Enzyme-Linked Immunosorbent Assay (ELISA) was utilized. The ferritin test is considered the most accurate primary indicator for iron deficiency, even before clinical symptoms manifest. Regarding H> pylori, the infection was detected by identifying specific antibodies in the blood serum using the ELISA technique (Li & Zhang, 2024).

4.5. Statistical Analysis

The collected data were analyzed using SPSS version 20.0 (IBM Corp, Armonk, NY, USA). Descriptive statistics were used to summarize the demographic characteristics of the participants. The Chi-square test was employed to examine the prevalence of *H. pylori* infection between the anemic and non-anemic subgroups and to determine the strength of the association between the variables. All statistical tests were two-sided, and a P-value < 0.05 was considered the threshold for statistical significance.

5. Results and Discussion

5.1. Demographic Characteristics of the Study Sample

The study population consisted of 200 participants from Sirte, Libya. Demographic analysis showed a higher representation of females (60%, n=120) compared to males (40%, n=80), (Table 1) . This distribution is particularly relevant for analyzing iron deficiency, which is physiologically more prevalent in females due to the childbearing cycle and menstruation.

Table 1: Demographic characteristics of the study population (N=200)

Gender	Frequency	Percentage (%)
Male	80	40%
Female	120	60%
Total	200	100%

Age-wise, nearly half of the participants (47.5%) fell within the 30–40 age bracket (Table 2). This concentration in young adulthood is critical, as nutritional demands and the cumulative risk of chronic infections like *H. pylori* are often more pronounced during this period.

Table 2: Distribution of the Sample by Age Group

Age Group (Years)	Frequency	Percentage (%)
5 – 10	25	12.50%
10 – 20	30	15%
20 – 30	50	25%
30 – 40	95	47.50%

5.2. Prevalence of *H. pylori* and Iron Deficiency

Laboratory investigations revealed a high prevalence of *H. pylori* infection (67.5%) and an alarming rate of iron deficiency (87.5%) within the sample (Table 3 & 4). The high infection rate is likely associated with environmental and socioeconomic factors prevalent in developing regions.

Table 3: Prevalence of *H. pylori* Infection

H. pylori Infection Status	Percentage (%)	Frequency
Positive (Infected)	67.50%	135
Negative (non-infected)	33%	65

Prevalence of *H. pylori* Infection

Commentary: The results indicate a high prevalence of *H. pylori* (67.5%) within the study sample. Such high rates are often associated with environmental factors, hygiene, and socioeconomic conditions, necessitating further investigation into its systemic impacts.

Table 4: Prevalence of Iron Deficiency (Based on Serum Ferritin)

Iron Status (Ferritin Levels)	Percentage (%)	Frequency
Iron Deficiency	87.50%	175
Normal Iron Stores	13%	25

Commentary: An overwhelming majority of the sample (87.5%) suffers from iron deficiency (defined as Ferritin <20 ng/ml for females and <30 ng/ml for males). This critical level of depletion highlights a significant public health concern in the studied population.

5.3. Correlation Analysis

A significant statistical association was observed between *H. pylori* and iron status. Among those infected, 92.6% suffered from iron deficiency, compared to 76.9% in the non-infected group (Table 5). This suggests that while iron deficiency is common in the region, *H. pylori* significantly exacerbate the risk of depletion.

Table 5: Association Between *H. Pylori* Status and Iron Stores

H. pylori Status	Normal Iron Stores	Iron Deficiency	Total
Positive (Infected)	10	125	135
Negative (non-infected)	15	50	65

Data stratified by gender and age (Tables 6 & 7) revealed that 100% of infected males and 100% of infected individuals in the 10–30 age groups presented with iron deficiency. This implies that the bacterium's interference with iron absorption—possibly through gastric atrophy or host-iron competition—is particularly damaging during periods of rapid growth and peak physiological activity.

Table 6: *H. pylori* and Iron Status Categorized by Gender

Gender	*H. pylori* Status	Normal Iron Stores	, Iron Deficiency
Male	Positive	0	65
	Negative	5	10
Female	Positive	10	60
	Negative	10	40

Commentary: Interestingly, 100% of the infected males in this sample showed iron deficiency. In females, while the numbers are high, the presence of deficiency in the negative group (40 out of 50) suggests that other factors—such as menstrual blood loss or nutritional habits—also play a major role in women's iron status.

Table 7: *H. pylori* and Iron Status Categorized by Age Group

Age Group	*H. pylori* Status	Iron Deficiency	Normal Iron Stores
5–10 Years	Positive	20	5
	Negative	5	5
10–20 Years	Positive	30	0
	Negative	0	5
20–30 Years	Positive	35	0
	Negative	20	5
30–40 Years	Positive	40	5
	Negative	25	0

Commentary: The age-specific data shows that in the 10–20 and 20–30 age groups, every single individual infected with *H. pylori* also presented with iron deficiency. This suggests that during years of rapid growth or peak activity, the bacteria's interference with iron absorption (through gastric atrophy or iron sequestration) is particularly damaging.

Table 8: Comparison of Iron Deficiency Prevalence (Infected vs. Non-Infected)

Group	Total Sample	Iron Deficiency Cases	Prevalence (%)
Infected (Patients)	135	125	92.6%
Non-Infected (Healthy)	65	50	76.9%

Final Conclusion for Research: The data demonstrates a strong statistical association between *H. pylori* infection and reduced iron stores. The prevalence of

deficiency is nearly 16% higher in infected individuals compared to the non-infected group. This supports the clinical hypothesis that *H. pylori* is a significant risk factor for iron-refractory iron deficiency anemia.

5.4. Comparison with Previous Studies

The results of this study add significant population-based evidence from Libya, a developing country context. The high prevalence of *H. pylori* (67.5%) observed here is higher than the 52.4% reported by John et al. (2018) in a similar Libyan cohort, though both studies found a strong positive association ($p = 0.001$) between the infection and IDA.

Our findings also align with historical data from Benghazi, where iron deficiency was noted in 37% of high-parity women. However, the higher rates in our study (87.5% overall deficiency) suggest an escalating public health concern. While some global studies in countries like Sweden or Iran have failed to find a significant link, our results support the "probable" causal relationship suggested by El Demerdash et al. (2018). The disparity in global results may be attributed to differences in study designs, geographic areas, or host genetic factors (Queiroz et al., 2013).

5.5. Clinical Significance of Ferritin Levels and Future Risk

In this study, iron deficiency was defined according to standardized clinical ranges (20–250 ng/ml for females and 30–350 ng/ml for males). A critical observation in our results is that even among participants whose ferritin levels fell within the "normal" range, the majority concentrated at the lower threshold of these limits.

From a clinical perspective, this suggests a state of "latent iron deficiency." Although these individuals are not yet classified as anemic, their depleted iron stores indicate a high vulnerability to developing overt IDA in the near future. This trend was consistent across both genders, implying that the population in Sirte is at a systemic risk. The coexistence of *H. pylori* in such cases may act as a catalyst, rapidly depleting these minimal reserves and accelerating the transition from latent deficiency to clinical anemia.

6. Conclusion

The data demonstrates a robust statistical association between *H. pylori* infection and reduced iron stores in Sirte. The prevalence of deficiency is approximately 16% higher in infected individuals. This supports the clinical hypothesis that *H. pylori* is a significant risk factor for iron-refractory IDA, necessitating targeted eradication programs to improve hematological outcomes in the Libyan population.

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