Original Article

Microbial Biosystems 10(2) (2025) 2025.362072
10.21608/mb.2025.362072.1259

Contents lists available at Egyptian Knowledge Bank
Microbial Biosystems
Journal homepage: http://mb.journals.ekb.eg/

Molecular evaluation of *Helicobacter pylori* glmM gene in patients with gastric cancer

Jihad N. Abid[1*], Lamees A. Abdul-Lateef[1], Mohend A. N. Al-Shalah[2]

[1] *Department of Microbiology, College of Medicine, University of Babylon, Iraq.*
[2] *Department of Surgery, College of Medicine, University of Babylon, Iraq.*

ARTICLE INFO

Article history
Received 20 February 2025
Received revised 12 March 2025
Accepted 5 April 2025
Available online 1 June 2025

Corresponding Editors
Mohammed, T. K.
Hadi, A. M.

Keywords
Babylon Province,
cancer screening programs,
demographic factors,
gastric carcinogenesis,
glmM gene detection,
Polymerase Chain Reaction (PCR)

ABSTRACT

Helicobacter pylori (*H. pylori*) is a major etiological factor in gastric cancer (GC), which poses a significant global health burden. Chronic *H. pylori* infection contributes to gastric carcinogenesis through inflammation, genetic, and epigenetic changes. This study aimed to investigate the prevalence of *H. pylori* infection among gastric and duodenal cancer patients in Babylon province, Iraq, corresponding to demographic factors such as age, gender, and residency. It further sought to explore the role of *H. pylori* in gastric cancer development and inform targeted screening and eradication programs. Gastroduodenal biopsies were collected from 36 patients diagnosed with gastric and duodenal cancers at the Gastroenterology and Hepatology Center in Babylon Province between October 2023 and October 2024. The presence of *H. pylori* was determined using polymerase chain reaction (PCR) targeting the glmM gene. Statistical analyses were performed to evaluate the *H. pylori* infection and demographic variables, with significance set at $p < 0.05$. The study reported a 19.4% prevalence of *H. pylori* infection among cancer patients, with all positive cases detected exclusively within the cancer group ($p < 0.05$). Male patients accounted for 57.1% of infections, and the highest prevalence was observed among individuals aged >60 years. Significant gender- and age-based disparities were identified. Furthermore, 100% of *H. pylori*-positive cases were linked to gastric malignancies, underscoring the bacterium's oncogenic potential. Therefore, the findings highlight the critical role of *H. pylori* in gastric carcinogenesis, particularly in older male patients. The study underscores the importance of integrating targeted *H. pylori* screening and eradication programs with public health initiatives to reduce gastric cancer incidence.

Published by Arab Society for Fungal Conservation

Introduction

Helicobacter pylori (*H. pylori*) has been classified as a class I carcinogen by the World Health Organization. The long-term colonization of *H. pylori* in the gastric mucosa contributes to the development of various gastric diseases, such as persistent inflammation, chronic gastritis, gastric mucosal atrophy and intestinal metaplasia, with its different genes encoding virulence factors. Approximately 75% of the global burden of gastric cancer and 5.5% of malignancies worldwide are due to inflammation and injury caused by *H. pylori* (Mladenova, 2021; Nassir Faisal et al., 2023).

***Corresponding author Email address**: med125.jihad.nadhim@student.uobabylon.edu.iq (Jihad N. Abid)

Chronic *H. pylori* infection also induces epigenetic and genetic changes in gastric epithelial cells, which suggests the genetic instability of these cells. Therefore, *H. pylori* infection is etiologically related to GC, and the duration also predisposes individuals toward GC later in life (Machado et al., 2009).

According to the Global Cancer Observatory (IARC 2024), gastric cancer remains a considerable public health issue in Iraq. The age-standardized incidence and mortality rates of cancer among the Iraqi population in 2018, as displayed in the Global Cancer Observatory, are 105.5 and 64.7, respectively (Qasim & Mohammed, 2024). The latest Iraqi Cancer Registry (ICR) has illustrated that the total number of new cancer cases during 2018 was 31,502, with an incidence rate of 82.6/100,000 population; 43% occurred in males and 57% in females (Bray et al., 2018). Accurate detection of the organism is essential for patient management. Abdominal sepsis might also be caused by this bacterial infection (Hawez et al., 2022; Sein et al., 2023). *H. pylori* eradication results in a marked reduction in the rate of recurrence of peptic ulcer and prevention of gastric cancer (Lee et al., 2022). In addition, *H. pylori* treatment can potentially prevent gastric cancer by reducing the progress of precancerous lesions defined as atrophy, intestinal metaplasia or dysplasia to invasive cancer. Therefore, methods that accurately detect *H. pylori* infection in patients with dyspepsia symptoms are of major importance. The ideal diagnostic method for detection of *H. pylori* does not exist at this moment, although there are various methodologies presenting advantages and limitations. Thus, clinical indication, costs and the available resources should be considered when choosing the type and number of specimens, and the method to be used.

The complex relationship between infectious agents and their hosts has intrigued researchers in gastroenterology and oncology, especially regarding the role of *H. pylori* infection in gastric cancer. Being a widespread chronic bacterial infection globally, *H. pylori* is a significant contributor to gastric cancer, prompting essential questions about its demographic and epidemiological characteristics in various populations.

This study directed to investigate the prevalence of *H. pylori* infection among patients with gastric and duodenal cancers in Babylon Province, Iraq, and to assess its association with demographic factors such as age, gender, and residency. The study seeks to determine the potential role of *H. pylori* in gastric cancer development and explore gender- and age-specific differences in infection rates to inform targeted screening and eradication strategies.

Materials and Methods

Patients and specimens

The samples for this research were collected over a one-year period from October 2023 to October 2024 at the Endoscopy Unit of the Gastroenterology and Hepatology Center in Babylon Province. The patients were suffering from tumors in the stomach and duodenum. Biopsies were obtained directly from the tumors and preserved in physiological saline solution for subsequent analysis. These tumors were later histopathological diagnosed as gastric and duodenal cancers by a specialized pathologist in collaboration with the attending physician. Patients who had received prior treatments for *H. pylori* were excluded from sample collection, also patients with residual gastric cancer or Barrett's esophageal adenocarcinoma were excluded.

Ethical approval statement

The research protocol was reviewed and approved by the Ethical Review Committee of the College of Medicine, University of Babylon, Iraq (certificate No. 28-20230628). Informed consent was obtained from all participants prior to sample collection. Participants were provided with comprehensive information about the study's objectives, procedures, potential risks, and benefits, ensuring voluntary participation. Confidentiality and anonymity of all patient data were strictly maintained throughout the study. All collected samples were used solely for the purpose of this research and were handled with utmost care to adhere to ethical and scientific standards.

Molecular detection

The molecular identification of *H. pylori* was done according to previous study (Aziz & Abdul-Lateef, 2023), where glmM specific primers (Table 1) were used to produce 140bp product. PCR amplification of DNA was performed by thermal cycler in final mixture volume of 25 µl (GoTaq® G2 Green Master Mix, Promega, USA).

The conditions achieved optimum for amplification glmM gene were consisting of an initial denaturation of target DNA at 95 °C for 3 min (stage 1), followed by 35 cycles of denaturation at 95 °C for 30 s, annealing at (57) °C for 1 min and extension at 72 °C for 30 s (stage 2). The final stage included only one cycle for extension 8 min at 72 °C. Eight microliters from PCR products were subjected to electrophoresis on 2% (wt/vol) agarose gel with 80 voltages for 90 min using horizontal electrophoresis apparatus and 1X TAE as a running buffer. The gel was stained with RedSafe DNA staining dye (INTRON© – Korea) and PCR bands were

visualized gel documentation instrument under ultraviolet light.

Statistical analysis

Statistical analyses were carried out using IBM SPSS Statistics 23 (IBM Corp., Armonk, NY, USA). Categorical variables were presented as frequencies (percentages). Group differences were evaluated using the student's t-test or Mann–Whitney U test for normally and non-normally distributed continuous variables, respectively. Differences in categorical variables were assessed using Chi-square or Fisher's exact tests. Statistical significance was set at $P < 0.05$.

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Table 1 Specific primers used for detection of the *glmM* gene.

Gene	Oligo Name	5` - Oligo Seq - 3`	PCR product (bp)
glmM	glmM _F	GGTCTTGCTGTCACTTATAGATGG	140
	glmM _R	CGGAAGATTCCCTACTGCTG	

Results

Among the 36 patients, 20 were male (55.6%) and 16 were female (44.4%). Patients were categorized into three age groups: <50 years (G1), 50–60 years (G2), and >60 years (G3). Most cancer cases were observed in the 50–60 age group (76.9%). The study aimed to detect *H. pylori* among 36 patients using a glmM-specific primer, a molecular diagnostic tool known for its high specificity to *H. pylori.* Out of the total patient population, 7 patients tested positive, indicating the presence of *H. pylori* DNA in their samples, while 29 patients tested negative, suggesting an absence of detectable *H. pylori* DNA. These results are showed in figure 1 and table 2.

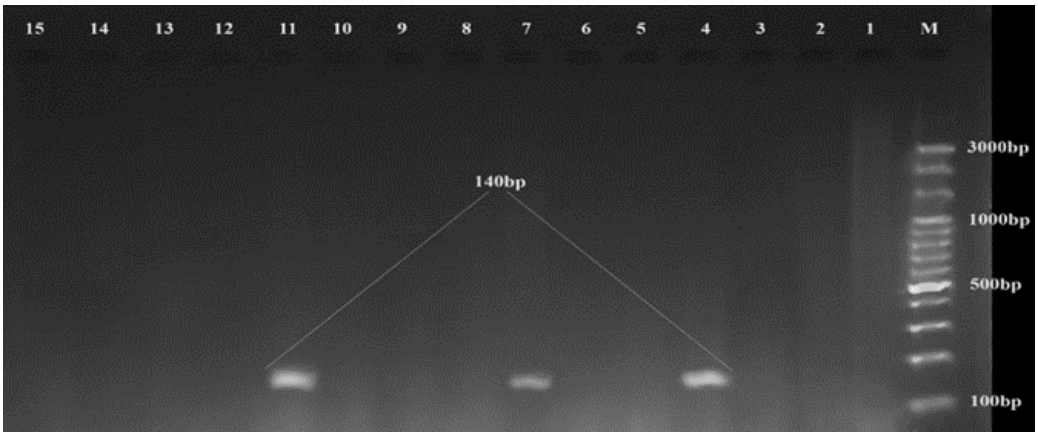

Fig 1. Identification of *H. pylori* isolates by specific glmM gene amplification. Lanes 4, 7, and 11 show the identified 140 bp gene products. Lane M represents the 100 bp DNA ladder.

Table 2 Identification of *H. pylori* among patients using glmM-specific primers.

Results	No	Percentage	P value
Positive	7	19.44%	<0.001*
Negative	29	80.56%	
Total	36	100%	

* Represent a significant difference at $p<0.05$.

According to gender distribution, males constituted most of the sample with 55.6% (20/36), while females made up 44.4% (16/36). Among age Group, age group G1 (<50 years) included 10 individuals (27.8%), age group G2 (50-60 years) had 13 individuals (36.1%), while age group G3 (>60 years) also comprised 13 individuals (36.1%). Males are slightly more represented overall and across most age groups, except for G3 (>60 years), where females more than males (53.8% vs. 46.2%). Age groups G2 (50-60 years) and G3 (>60 years) have an equal proportion of individuals, each accounting for 36.1% of the total sample, while G1 (<50 years) constitutes a smaller portion (27.8%). These results are showed in table 3.

Sex distribution across age groups: In G1 (<50 years): 6 males (60%) and 4 females (40%), in G2 (50-60 years): 8 males (61.5%) and 5 females (38.5%), while in G3 (>60 years): 6 males (46.2%) and 7 females (53.8%) as showed in table 4.

Significant variations were noted when analyzing age and condition together ($p<0.05$). The highest incidence of gastric cancer was observed in the G2 group, with 76.9% of individuals affected. This was followed by the G3 group at 61.5%, indicating a peak in cancer cases within the 50–60 age (table 5).

Among the 36 samples tested, 19.4% (7/36) tested positive for *H. pylori* using PCR, while 80.6% (29/36) tested negative. All 7 positive samples (100%) were found within the cancer group. Most cancer cases (24 samples, 82.8%) tested negative. The total for the cancer group accounted for 86.1% (31/36) of the study population. None of the control cases tested positive (0% positivity rate). The remaining 5 samples (17.2%) were negative for *H. pylori* in the control group. The control group made up 13.9% (5/36) of the total samples. Statistical Significance: P value (a = 0.236): No statistically significant difference between cancer and control groups in overall *H. pylori* status. P value (b = 0.002*): A highly significant association between *H. pylori* positivity and the cancer group, as no positive cases were observed in the control group ($P < 0.05$) (table 6).

The identification of *Helicobacter pylori* using PCR in gastric cancer patients reveals significant findings regarding infection rates, gender differences, and age-related patterns. Out of the 36 samples analyzed, 7 samples (19.4%) tested positive for *H. pylori*, while 29 samples (80.6%) tested negative. Age Group G1 (<50 years): Positive: 2 cases (28.6%) tested positive. Negative: 8 cases (27.6%) tested negative. Total: G1 represented 10 individuals (27.8%) of the cohort. Age Group G2 (50-60 years): Positive: 2 cases (28.6%) tested positive. Negative: 11 cases (37.9%) tested negative. Total: G2 represented 13 individuals (36.1%) of the cohort. Age Group G3 (>60 years): Positive: 3 cases (42.9%) tested positive. Negative: 10 cases (34.5%) tested negative. Total: G3 also represented 13 individuals (36.1%) of the cohort.
Statistical Significance: a (0.883): No significant difference between positive and negative results across age groups. b (0.058): No significant difference among positive results in different age groups (close to significance threshold). c (0.013): * Significant difference among negative results in different age groups, suggesting an age-dependent variation in *H. pylori*-negative cases. d (0.052): Overall comparison across age groups approaches significance, indicating potential age-related trends. These results are showed in table 7.

Male and female groups were almost evenly distributed in the sample population, with males making up 55.6% (20/36) and females 44.4% (16/36). Male Group: Positive: 4 cases (57.1%) tested positive. Negative: 16 cases (55.2%) tested negative. Total: Male participants constituted 55.6% of the total sample. Female Group: Positive: 3 cases (42.9%) tested positive. Negative: 13 cases (44.8%) tested negative. Total: Female participants constituted 44.4% of the total sample.

Statistical Significance: a (0.925): No significant difference in *H. pylori* positivity and negativity between genders. *b (0.007):* * Significant difference in positive results between males and females, suggesting a gender-associated variation in *H. pylori* positivity. *c (0.012):* * Significant overall comparison across gender groups, indicating gender may play a role in *H. pylori* infection dynamics (table 8).

Discussion

Since *H. pylori* infection has been related to gastritis, peptic ulcers, and gastric cancer (Almashhadany et al., 2023). Therefore, epidemiological surveillance of *H. pylori* helps in establishing public health counter measures that could reduce and control the transmission and acquisition of infection. In addition, accurate detection of the organism is essential for patient management. *H. pylori* eradication results in a marked reduction in the rate of recurrence of peptic ulcer and prevention of gastric cancer (Salman et al., 2020).

H. pylori identification was done via PCR, we find that *H. pylori* was identified in 19.4% of samples (7/36), with 80.6% testing negative. All *H.*

Table 3 Frequency distribution of sex and age among all samples.

Gender	G1	G2	G3	Total	P value*
Male	6 (60)	8 (61.5)	6 (46.2)	20 (55.6)	a- 0.693 b- 0.779
Female	4 (40)	5 (38.5)	7 (53.8)	16 (44.4)	c- 0.505
Total	10 (27.8)	13 (36.1)	13 (36.1)	36 (100)	

*Letters represent type of statistical analysis (P<0.05), a. between sex and age groups; b. among Age groups; c. among sex groups. Age groups (G1=<50 years, G2=50-60 years, G3=>60 years).

Table 4 Frequency of study groups according to sex group.

Condition	Male	Female	Total	P value[a]	P value[b]
Cancer	14 (70)	10 (62.5)	24 (66.7)	0.404	0.751
Cancer with Hp	4 (20)	3 (18.8)	7 (19.4)	0.705	
Control	2 (10)	3 (18.8)	5 (13.9)	0.655	
Total	20 (55.6)	16 (44.4)	36 (100)	0.376	
P value[c]	0.002*	0.047*	<0.0001*		

* Represent a significant difference at p<0.05. Letters represent type of statistical analysis (P<0.05), a. between sex groups (male and female) for each condition group and for total of sex groups.; b. between sex and condition groups in general.; c. among condition groups (Cancer, Cancer with Hp and Control) for each sex group and for total of condition groups.

Table 5 Frequency of study groups according to age categories.

Condition	G1	G2	G3	Total	P value[a]	P value[b]
Cancer	6 (60)	10 (76.9)	8 (61.5)	24 (66.7)	0.607	0.883
Cancer with Hp	2 (20)	2 (15.4)	3 (23.1)	7 (19.4)	0.867	
Control	2 (20)	1 (7.7)	2 (15.4)	5 (13.9)	0.819	
Total	10 (27.8)	13 (36.1)	13 (36.1)	36 (100)	0.779	
P value[c]	0.202	0.004*	0.092	<0.001*		

* Represents a significant difference at p<0.05. Letters represent type of statistical analysis (P<0.05), **a.** between Age groups (G1, G2 and G3) for each condition group and for total of Age groups.; b. between Age and condition groups in general.; **c**. among condition groups (Cancer, Cancer with Hp and Control) for each Age group and for total of condition groups. Age groups (G1=<50 years, G2=50-60 years, G3=>60 years).

Table 6 Frequency of *H. pylori* PCR identification results according to cancer and control groups (36 samples).

Cases	Positive	Negative	Total	P value
Cancer	7 (100)	24 (82.8)	31 (86.1)	0.236[a] 0.002*[b]
Control	0 (0)	5 (17.2)	5 (13.9)	
Total	7 (19.4)	29 (80.6)	36 (100)	

* Represents a significant difference at p<0.05. Letters represent type of statistical analysis (P<0.05), **a**. between PCR results and Cancer-Control group in general. **b**. between PCR results and cancer group.

pylori positive cases were from the cancer group (100% detection rate within cancer patients), whereas the control group had no positive detections. This result underscores the utility of glmM-specific primers as a reliable molecular diagnostic tool for detecting *H. pylori*. The detection of *H. pylori* in nearly one-fifth (19.44%) of the

patients highlights the burden of infection within this group.

Most patients (80.56%) did not show evidence of *H. pylori* DNA, which could be due to: true absence of infection, effective prior treatment in some patients, or variations in sampling or bacterial load below the detection threshold. The reported p-value of <0.001 indicates a highly significant difference in the observed distribution of positive vs. negative results. This statistical significance suggests that the glmM-specific primer is robust in distinguishing between infected and uninfected patients. A positivity rate of 19.44% suggests that while *H. pylori* is present, its prevalence might be lower in this cohort compared to global or regional averages. The findings underscore a significant association between *H. pylori* infection and gastric cancer, with a prevalence of 19.4%. This rate is relatively lower compared to other regional study (Kalaf, 2018), who reported 38.8% using broader detection methods. This disparity highlights the need to standardize diagnostic techniques. Epidemiological factors, such as dietary habits, sanitation, and antibiotic use, may contribute to the observed rates. While the primer is highly specific, false negatives could arise due to low bacterial loads or mutations in the glmM gene region. Combining glmM-PCR with additional diagnostic tests (e.g., stool antigen tests or endoscopy) can enhance accuracy.

Table 7. Frequency of *H. pylori* PCR identification results according to Age groups.

Age	Positive	Negative	Total	P value
G1	2 (28.6)	8 (27.6)	10 (27.8)	a. 0.883
G2	2 (28.6)	11 (37.9)	13 (36.1)	b. 0.058
G3	3 (42.9)	10 (34.5)	13 (36.1)	c. 0.013*
Total	7 (19.4)	29 (80.6)	36 (100)	d. 0.052

* Represents a significant difference at p<0.05. Letters represent a type of statistical analysis (P<0.05), **a**. between PCR results and age group in general. **b.** between PCR results and G1 group (G1=<50 years); **c.** between PCR results and G2 group (G2=50-60 years); **d.** between PCR results and G3 group (G3=>60 years).

Table 8 Frequency of ***H. pylori*** PCR identification results according to gender groups.

Gender	Positive	Negative	Total	P value
Male	4 (57.1)	16 (55.2)	20 (55.6)	a. 0.925
Female	3 (42.9)	13 (44.8)	16 (44.4)	b. 0.007*
Total	7 (19.4)	29 (80.6)	36 (100)	c. 0.012*

* Represents a significant difference at p<0.05. Letters represent a type of statistical analysis (P<0.05), **a**. between PCR results and Gender group in general. **b.** between PCR results and Male group; **c.** between PCR results and Female group.

All patients testing positive should be considered for eradication therapy to mitigate risks of complications such as peptic ulcers and gastric cancer. On the other hand, negative results in symptomatic patients might warrant further testing to rule out false negatives.

The lowest sensitivity (80.56%) is reported for the molecular detection of the glmM gene, and this result could be due to sequence polymorphisms in the glmM loci and variations between strains. This outcome is in high agreement with other studies, where they also noticed high polymorphism within this gene (Kalaf, 2018). In Iraq, different genes were detected, with the glmM gene included, in *H. pylori* samples in their study. Another Iraqi study conducted by AlNaji et al. (2017) identified the glmM gene in 19 out of 49 positive samples (38.8%) (Omran, 2018). In Iran, the detection results for glmM-positive samples showed very low sensitivity (26%) (Bezmin Abadi, 2018).

Understanding *H. pylori* infection and its link to gastric cancer requires a close look at findings showing differences based on gender and age, especially in Iraq's Babylon Governorate. This study found a higher occurrence of *H. pylori* in male gastric cancer patients, with older people showing a strong connection, similar to earlier studies stating that men usually face a higher risk for both the infection and the development of gastric

cancer due to lifestyle and biological factors (Liaquat Memon et al., 2024).

On the other hand, fewer women had the infection, and the age breakdown showed higher rates in older adults, matching results from other areas indicating older individuals are more at risk due to long-term exposure and weaker immune responses (Zahid Irfan Marwat et al., 2021). Examining regional differences reveals that high *H. pylori* rates often relate to socioeconomic factors, which affect healthcare access and dietary habits, marking an important area for intervention (Li et al., 2024).

These findings are significant as they highlight the need for gender- and age-specific screening and preventive health actions targeting at-risk groups. The theoretical considerations around *H. pylori* also point to a complex approach to understanding its role in disease and the link to gastric cancer, stressing the influence of environmental, genetic, and lifestyle factors that may explain the observed differences (Mülder et al., 2025). Practically, these insights can shape healthcare policies in Iraq, pushing for localized prevention strategies suited to the population's demographic traits (Abboud et al., 2024). Including demographic factors in research designs can improve the quality and relevance of future studies looking at the risk factors connected to *H. pylori* infection and gastric cancer (Zandian et al., 2023).

Thus, this research adds to current knowledge and establishes a foundation for future studies that can further explore the relationship between *H. pylori* infection and gastric cancer across different demographic groups, while also addressing the urgent need for effective public health measures. In the end, understanding how gender and age affect *H. pylori* infection trends can guide clinical practices, influence future research directions, and lead to better health outcomes for populations facing significant gastric cancer challenges.

Gender-based findings: Males accounted for 57.1% of positive cases, while females comprised 42.9%. Significant differences were noted in PCR results between male and female groups ($p<0.05$), suggesting potential gender-based disparities in *H. pylori* infection rates.

Age-based findings: Among positive cases, G3 contributed the highest proportion (42.9%), followed by G1 and G2 equally (28.6% each). Statistical tests revealed significant differences ($p<0.05$), particularly between G1 and G3 groups, indicating an age-associated risk gradient. Investigating the underlying causes of gender differences in *H. pylori* positivity may include biological factors such as hormone-mediated immunity and behavioural factors like dietary habits or smoking prevalence. Gender-specific differences suggest males are at higher risk, potentially due to lifestyle factors or hormonal influences, consistent with previous findings by Xing et al. (2024).

The age distribution reveals a peak in cancer incidence within the 50–60 age group, suggesting the need for targeted screening in this demographic. All cancer patients showed a statistically significant association with *H. pylori* positivity ($p<0.05$), while the control group had no detections. This strong association implies a critical role for *H. pylori* as a co-factor in oncogenesis or cancer progression. The absence of *H. pylori* in controls suggests the organism may act more aggressively in a predisposed environment. The strong association of *H. pylori* with cancer in this cohort supports its role as a critical co-factor in gastric oncogenesis. Genomic studies on local strains and longitudinal research are imperative to understand infection dynamics and inform eradication strategies. Public health initiatives, including gender- and age-specific screenings, could mitigate the burden of *H. pylori*-associated diseases.

In this study, gender-specific differences were examined across three conditions: Cancer, Cancer with *H. pylori*, and Control. Males formed the majority across the cancer-related conditions (70% in Cancer, 20% in Cancer with *H. pylori*), while females represented 62.5% in Cancer and 18.8% in Cancer with *H. pylori*. The control group had a balanced gender distribution. Significant differences were observed when conditions were analyzed collectively for gender ($p<0.05$). This suggests that gender may influence susceptibility or detection rates in certain conditions. These findings warrant a deeper exploration of gender as a risk modifier or biological determinant in cancer and *H. pylori*-associated pathology.

A study conducted by Xing et al. (2024) showed that the incidence of gastric cancer was higher for males than for females. Results obtained by Qiao et al. (2024) indicated that older women had higher infection rates, lower eradication success, and higher recurrence rates compared to men. Age is one of the main risk factors for *H. pylori* infection (Qiao et al., 2024).

In age group patterns: Three age groups (G1: <50 years, G2: 50–60 years, G3: >60 years) were assessed for their condition distributions. Cancer predominantly affected individuals in G2 (76.9%), followed by G3 (61.5%), indicating a peak cancer incidence within the 50–60 age bracket. On the other hand, Cancer with *H. pylori* distributed relatively evenly across age groups, with G3 showing slightly higher representation (23.1%). Meanwhile, Control was least prevalent in G2 (7.7%), suggesting this age group may have other underlying pathologies or reduced representation in the non-disease

cohort. Significant variations among groups were observed ($p<0.05$) when age and condition were analyzed together, highlighting an interaction between age and pathological outcomes. These trends support theories of age-related immune response decline or chronic exposure accumulation influencing *H. pylori* detection and cancer prevalence.

Some studies indicate no significant difference in *H. pylori* infection rates between genders ($p=0.37$) (Vianna et al., 2019). However, other research by Borka Balas et al. (2022) highlights a higher prevalence in males, particularly in certain populations where lifestyle factors may contribute to this disparity.

The statistical outputs (e.g., p-values) underline the robustness of the study findings showed as comparison: Gender showed disparities in *H. pylori* detection and its association with cancer conditions, while age demonstrated a stepwise increase in risk, particularly in older age groups. Condition-specific analyses reiterated the role of *H. pylori* in malignancy versus benign or control states (Borka Balas et al., 2022).

Conclusion

This study elucidates the complex interplay between demographic factors (*H. pylori* detection, cancer association, and control comparisons). Practically, the findings highlight the need for focused screening and intervention programs targeting high-risk groups, which could improve preventive measures against gastric cancer. Future Directions: further studies are needed to explore causative relationships. Genomic analysis to investigate gender and age susceptibility. Interventional trials focusing on early eradication of *H. pylori*. Future studies should include genomic profiling of local *H. pylori* strains to identify unique virulence factors. Longitudinal studies can establish causative links between infection and gastric cancer progression, while interventional trials can assess the efficacy of eradication programs.

Acknowledgments

We thank Endoscopy Unit of the Gastroenterology and Hepatology Center in Babylon Province. We also thank Department of Microbiology and Surgery, College of Medicine, University of Babylon, Iraq.

Conflict of interest

No conflicts of interest, as the authors declared.

Funding source:

No governmental, commercial, or nonprofit funding agencies provided any funds for this project.

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