ORIGINAL RESEARCH

Eradication Rate and Factors Influencing *Helicobacter pylori* Infection Clearance Using Standard Triple Therapy at a Single Centre in Jazan Region, Saudi Arabia: A Retrospective Study

Majid Ahmed Darraj[1–3]

[1]Department of Internal Medicine, Faculty of Medicine, Jazan University, Jazan, Saudi Arabia; [2]Department of internal medicine, King Fahad Central Hospital, Jazan, Saudi Arabia; [3]Department of Internal Medicine, Al-Hayat Jazan Hospital, Jazan, Saudi Arabia

Correspondence: Majid Ahmed Darraj, Email mdarraj@jazanu.edu.sa

Introduction: *Helicobacter pylori* infection is a common gastrointestinal infection that affects around 50% of the global population. This infection can lead to various health conditions such as peptic ulcer disease, dyspepsia, gastric carcinoma, and mucosa-associated lymphoid tissue lymphoma. The triple therapy which consists of proton-pump inhibitors, clarithromycin, and amoxicillin or metronidazole for 14 days is considered the first-line treatment for *H. pylori* and its eradication, especially in areas where clarithromycin sensitivity is still high. However, recent research shows that the efficacy of this treatment is decreasing due to antibiotic resistance.

Methods: This was a retrospective study that took place at Al-Hayat Jazan Hospital in Jazan, Saudi Arabia. The study analyzed the medical records of 186 patients with *H. pylori* who had undergone the standard triple therapy. The objectives of this study were to determine the eradication rate of H. pylori by using the standard triple therapy, and to highlight the influence of some demographic characteristics such as age, gender, diabetes mellitus, and smoking on the eradication rate, in Jazan region, Saudi Arabia.

Results: The medical records of 186 patients were included in the study. The overall rate of successful eradication was found to be 77.4%. The results of the study showed that the decline in the eradication rate was significantly associated with the presence of diabetes and smoking status (with p-values of <0.001 and <0.004, respectively).

Conclusion: This study finds that the standard triple therapy for *H. pylori* eradication is less effective than optimal standards, as per literature and guidelines. Given its declining efficacy globally, alternative first-line treatments may be necessary. Further research is needed to assess its effectiveness in various regional contexts.

Keywords: *Helicobacter pylori*, *H. pylori*, triple therapy, eradication rates, Jazan region

Introduction

Helicobacter pylori (*H. pylori*) is a Gram-negative bacillus that causes gastrointestinal diseases, such as peptic ulcer and carcinoma of the stomach. It is also linked with mucosa-associated lymphoid tissue (MALT) lymphoma, vitamin B_{12} deficiency, iron deficiency anemia, and idiopathic thrombocytopenic purpura (ITP).[1] *H. pylori* infection is considered one of the most common infections worldwide, and contaminated water is considered the main source of infection, especially in developing countries.[2] Other risk factors include individuals with low socioeconomic status and a family history of the infection.[2]

H. pylori prevalence differs throughout the world with a prevalence of 30% in the United States in contrast to 70 to 80% in South America.[3] The data from Arab countries reported higher prevalence, which approaches for example 78% in the United Arab Emirates.[4] *H. pylori* frequency is higher (approaching 80%) in developing countries rather than in developed ones.[1] In Saudi Arabia, the prevalence of *H. pylori* infection has notable variation rates ranging from 10.2% to 96% in the various geographical locations of the country.[5,6] One study reported a prevalence of 46.5% in Jazan province.[7] A study conducted in

Jazan by Akeel et al reported that *H. pylori* virulence genes are extremely common and diversified in patients with dyspepsia in southwest Saudi Arabia.[6]

It is important for patients with a history of peptic ulcers, especially those with MALT lymphoma, and those who have undergone endoscopic resection for early gastric cancer, to be screened for *H. pylori*.[8] *H. pylori* screening is also recommended for patients with atypical presentation of GERD, long-term aspirin and NSAID use, uninvestigated and functional dyspepsia, unexplained iron deficiency anemia, and ITP.[9] If the result of screening is positive, treatment for the eradication of *H. pylori* should be initiated. Prior use of antibiotics should also be taken into consideration when selecting a management strategy.[2,10] Gastric and duodenal ulcers are mainly caused by *H. pylori*, NSAIDs, or a combination of both, and treating *H. pylori* is an effective way to decrease the recurrence risk of ulcers, prevent the onset of stomach cancer, and treat dyspepsia, peptic ulcers, and MALT lymphoma.[11]

Triple therapy with proton-pump inhibitors (PPIs), clarithromycin, and amoxicillin or metronidazole for 14 days is recommended as standard therapy for *H. pylori* treatment and eradication, particularly in areas where clarithromycin resistance is less than 15%.[1,2]

The combination of PPIs, bismuth, tetracycline, and metronidazole (bismuth quadruple therapy) for a duration of 10 to 14 days is considered first-line therapy, as per the Maastricht guidelines, in areas where the rate of resistance to metronidazole and clarithromycin is greater than 15%.[8] Other treatment options include sequential therapy with 5 days of PPIs and amoxicillin, followed by PPIs plus clarithromycin and metronidazole for another 5 days; concomitant therapy for 3 to 10 days of PPIs, amoxicillin, clarithromycin, and metronidazole; or hybrid treatment with 7 days of PPIs, amoxicillin, clarithromycin, and metronidazole followed by PPIs and amoxicillin for 7 days. Levofloxacin can be used with standard triple therapy, quadruple therapy, or sequential therapy.[9,10]

According to previous reports, the population of Saudi Arabia has an *H. pylori* eradication rate of 62.3% with sequential therapy and 67.6% with standard triple therapy.[12]

It is important to evaluate the effectiveness of H. pylori eradication therapy in Jazan region because this will provide valuable insights for managing *H. pylori* infection at the level of local practice in the Jazan region, and Saudi Arabia.

Objective

The objective of this study was to determine the eradication rate of *H. pylori* in patients newly diagnosed and initially treated with standard triple therapy in the Jazan region, Saudi Arabia. Moreover, this study aimed to determine the correlation between the eradication rate and some demographic characteristics such as age, gender, DM, and smoking, that influence the eradication rate.

Methods
Study Design and Study Area
This study was a retrospective analysis that took place in an outpatient internal medicine clinic at Al-Hayat Jazan Hospital, Jazan region, Saudi Arabia. The study involved 186 patients each diagnosed as a new case of *H. pylori* infection. The study was conducted over a period of one year, starting from March 2022.

Study Population and Sample Size
The study included the review of the medical records of patients who visited the outpatient internal medicine clinic at Al-Hayat Jazan Hospital during the study period with symptoms of dyspepsia and who were newly diagnosed with *H. pylori* via the ¹³C urea breath test (UBT). The inclusion criteria for this study were individuals of both genders who are 18 years of age or above and have recently had a confirmed diagnosis of *H. pylori* infection. These individuals had undergone standard triple therapy for 14 days and had strictly adhered to the follow-up visits 4 weeks after the completion of the treatment.[13] However, the exclusion criteria included patients who were less than 18 years of age, those who had a history of *H. pylori* recurrence, those who had previously undergone *H. pylori* eradication therapy or taken antibiotics in the last 4 weeks before the test, and those who had acute or chronic renal impairment, and individuals who had missed the follow-up visits.

Data Collection

A data sheet was used to collect data by reviewing the medical records of the patients who were included in the study. Each patient's medical data were examined separately to establish their level of eradication and associated risk factors. Data collected included background characteristics, such as age and gender, as well as risk factors, such as smoking and DM.

Statistical Analysis and Data Management

Data was entered and analyzed using Statistical Package for Social Sciences software version 26.0 (SPSS, Chicago, IL, USA). Descriptive statistics and correlations using the Chi-square test and logistic regression analysis were performed. A $P < 0.05$ was considered statistically significant.

Ethical Considerations

The study was conducted in accordance with the principles of the Declaration of Helsinki. Ethical approval was obtained from the Jazan Hospital's research ethics committee (H-10-Z-068). As this was a retrospective review of existing medical records, individual informed consent was not required. However, patient information was de-identified to ensure confidentiality.

The process of collecting and managing data was carried out using coded identifiers, ensuring that no direct personal information was involved in any way. This was done to maintain the privacy and confidentiality of individuals whose data was being collected and managed. The use of coded identifiers allowed for the effective tracking and organization of data, without compromising the anonymity of the data subjects.

Results

After reviewing the medical records, the study considered 197 patients with confirmed *H. pylori* infection for participation. Nine patients were excluded after the initial screening, either because they failed to comply with the follow-up schedule (5 patients) or because they received another treatment as first-line therapy (4 patients). In contrast, 186 patients who met the inclusion criteria were enrolled, and their mean age was 54.4±14.8 years, indicating a wide age range of participants. In terms of gender, there was a nearly equal distribution with 48.4% being male and 51.6% being female. However, around a third of the participants had a smoking history, which is an important risk factor for *H. pylori* infection. When looking at common comorbidities, slightly over half (55.9%) were not diabetics. Regarding treatment outcomes, the study examined the eradication rates of *H. pylori* using standard triple therapy as the initial treatment regimen. The results showed that the treatment was effective in eradicating the infection in 77.4% of participants, which is considered a relatively low sensitivity to this first-line therapy (Table 1).

Table 1 Socio-Demographic and Clinical Characteristics of All Participants

Socio-Demographic and Clinical Characteristics		Frequency (n=186)	Percent (100%)
Age		Mean age: 54.4±14.8 years	
Age Group	<50years	57	30.6%
	≥ 50 years	129	69.4%
Gender	Male	90	48.4%
	Female	96	51.6%
Smoking status	Nonsmoker	131	70.4%
	Smokers	55	29.6%
Diabetes mellitus	Absent	104	55.9%
	Present	82	44.1%
Treatment outcome with Triple therapy	Sensitive	144	77.4%
	Resistant	42	22.6%

Table 2 presents the association between the treatment outcome of *H. pylori* with socio-demographic and clinical characteristics using the Chi-Square test. The eradication rate was higher in patients aged 50 years or older (80.6%) than in those aged less than 50 years (70.2%), while there was no significant difference between males and females (p-value: 0.910). Nonsmokers had a higher eradication rate (83.2%) than smokers (63.6%). Patients with diabetes mellitus (DM) had a lower eradication rate (65.9%) than those without DM (86.5%). The odds ratio (OR) of eradication for patients aged <50 years was 0.553 (95% confidence interval (CI): 0.259–1.179), suggesting a potential negative association, although the CI includes 1, indicating the result is not statistically significant at the 0.05 level. Similarly, the OR for patients with DM present was 0.297 (95% CI: 0.134–0.657), indicating a negative association and the CI does not include 1, suggesting a statistically significant result (p = 0.001). On the other hand, the OR for nonsmokers was 3.276 (95% CI: 1.481–7.247), indicating a positive association, and the CI does not include 1, suggesting a statistically significant result (p = 0.004).

Table 3 shows the logistic regression analysis of the association between patient characteristics and treatment outcome. Age group, gender, history of diabetes mellitus, and history of smoking were significantly associated with the treatment outcome. Patients aged less than 50 years had lower odds of eradication (OR=0.180, 95% CI: 0.033–0.995) than those aged 50 years or older. Female patients had a lower OR of eradication (OR=0.195, 95% CI: 0.045–0.854) than male patients. Patients with a history of diabetes mellitus had a lower OR of eradication (OR=0.033, 95% CI: 0.007–0.163) than those without diabetes mellitus. Patients with a history of smoking had a lower OR of eradication (OR=0.334, 95% CI: 0.113–0.990) than those without a history of smoking.

Table 2 Association Between Treatment Outcome of *H. pylori* with Socio-Demographic and Clinical Characteristics Using Chi-Square Test

		Successful Eradication (n=144)	Failed Eradication (n=42)	OR	95% CI	p-value
Age Groups	<50 years	40 (70.2%)	17 (29.8%)	0.553	(0.259–1.179)	0.116
	≥ 50 years	104 (80.6%)	25 (19.4%)			
Gender	Male	70 (77.8%)	20 (22.2%)	0392	(0.124–1.234)	0.910
	Female	74 (77.1%)	22 (22.9%)			
Smoking status	Nonsmoker	109 (83.2%)	22 (16.8%)	3.276	(1.481–7.247)	0.004
	Smokers	35 (63.6%)	20 (36.4%)			
Diabetes mellitus	Absent	90 (86.5%)	14 (13.5%)	0.297	(0.134–0.657)	0.001
	Present	54 (65.9%)	28 (34.1%)			

Abbreviations: OR, odd ratio; CI, confidence interval.

Table 3 Logistic Regression Analysis of the Association Between Patient Characteristics and Treatment Outcome

Variables	SE	P-value	OR with 95% CI
Age group	0.871	0.049	0.180 (0.033–0.995)
Gender	0.753	0.030	0.195 (0.045–0.854)
Diabetes Mellitus	0.809	0.000	0.033 (0.007–0.163)
Smoking Status	0.555	0.048	0.334 (0.113–0.990)

Abbreviations: SE, standard error, CI, confidence interval, OR, odd ratio.

Discussion

H. pylori infection is a common gastrointestinal infection affecting 50% of the global population. It leads to different gastric complications.[2] Several research studies have shown that eradicating *H. pylori* decreases long-term gastrointestinal complications and improves the prognosis.[14–16] Current research around the world has reported a reduction in the eradication rate by standard triple therapy to less than 80% due to growing resistance to antibiotics.[17] The finding in this research is consistent with the above statement with an eradication rate of less than 80%.[1,5]

The overall eradication rate in this study was 77.4%, which is better than geographically nearby studies from Lebanon, Iran, Kuwait, and Saudi Arabia, where the eradication rate was 63.5%, 60.0%, 68.6%, and 67.6%, respectively.[14,15] This discordancy in the eradication rate may be due to patient-related factors such as cytochrome P450system, genetic factors, alcohol consumption, smoking, and DM.

Studies indicate that metronidazole and clarithromycin resistance rates have increased in Saudi Arabia and around the world, resulting in a decline in the effectiveness of standard triple therapy and being considered as the root cause.[17–20]

The resistance of *H. pylori* to metronidazole has grown over time and become more prevalent in Saudi Arabia. A prior Saudi Arabian study found that 80% of those with infection had *H. pylori* resistance to metronidazole and 4% had clarithromycin resistance.[21] An analysis of 368 Saudi patients' clinical isolates of *H. pylori* revealed a similar trend of drug resistance. Metronidazole was shown to have the greatest resistance (48.2%) followed by clarithromycin (27.7%).[22]

The importance of eradicating *H. pylori* has been proven in numerous research studies.[8] Although several therapeutic protocols for *H. pylori* have been developed, an optimum therapeutic approach has yet to be established.[15] The most prevalent regimen adopted is the standard triple therapy. A recent systematic review reported a global *H. pylori* eradication rate of 98% with standard triple therapy (98% in Asia, 94% in Europe and Africa, 93% in South America, and 84% in North America).[10]

The explanations for the disparity in eradication rates across different geographic areas include differences in causative strains of *H. pylori*, anti-microbial susceptibility patterns, therapeutic regimens used, and differences in pharmacological drug metabolism.[16] The European Registry on *H. pylori* Management (Hp-EuReg) reported an eradication rate of 91% in patients with high clarithromycin sensitivity, which indicates that it is a major predictor of the efficacy of the standard triple therapy.[23,24]

Although age was not found a significant factor as a predictor of eradication rate, but it was found that patients over 50 years old had a higher eradication rate in comparison to those under 50 years, (80.6% versus 70.2%, *p*-value 0.116). This is consistent with a study conducted in France, which reported a 22.2% failure in patients over 60.[25] This higher response rate among older patients can be explained by the higher presence of intestinal metaplasia with chronic atrophic gastritis in these patients. Intestinal metaplasia creates an unfavorable environment for *H. pylori*, resulting in a lower bacterial burden and possibly better eradication. Furthermore, hypochlorhydria and intestinal-type mucosa both play a role in the higher eradication rate for the elderly.[26] However, one study conducted in Turkey reported old age as a predictor for eradication failure, but this study addressed the importance of antibiotic resistance as well as the grade of *H. pylori* density as a contributor to unsuccessful eradication.[27]

Smoking is considered a well-defined risk factor for peptic ulcer disease.[28] The study showed significant differences in failure rates between smokers and nonsmokers (33.7% vs 16.8%). This aligns with several meta-analyses that reported a decrease in the eradication rate for smokers.[29–31] Smoking has been reported to impair gastric mucosal blood supply and the release of mucus, which may impede the transport of antibiotics to the gastric mucosa. This is one of the potential processes involved in treatment failure. Additionally, smoking raises gastric acid output, which reduces the effectiveness of some antibiotics that are acid-labile, including amoxicillin and clarithromycin. A new large trial that indicates an increase in the eradication rate in smokers (but not in non-smokers) that administered larger dosages of clarithromycin appears to support both of these results.[29]

Diabetes-related metabolic abnormalities may affect the immune system, including cellular and humoral immunity; therefore, patients with diabetes mellitus are more prone to several infections.[32] It has been hypothesized that changes in glucose homeostasis may enhance the growth of *H. pylori* through the reduction in gastric motility, or chemical alterations in the gastric mucosa brought on by non-enzymatic mucin glycosylation or increased sialic acid which may function as a receptor for *H. pylori* on the cell surface by facilitating *H. pylori* adhesion to gastric mucosa cells.[33,34]

The current study found that the prevalence of *H. pylori* is slightly higher in patients without DM than in those with DM (44.1% and 55.9%, respectively). The occurrence of *H. pylori* infection in Chinese patients with DM was estimated to be approximately 50%,[35] which is comparable to that of the normal control. Infection was somewhat more common in patients with DM than in patients without DM (37.3% versus 35%, respectively) in Athens, Greece,[36] but the variation was not statistically significant.

According to Xia et al, 2001, and Oluyemi et al in Nigeria,[37,38] there was no discernible difference between patients with DM and patients without DM in the seroprevalence of *H. pylori* infection. Another study reported that infection with *H. pylori* affects about 25% of patients with DM and patients without DM in Jeddah City in Saudi Arabia and reported no correlation between *H. pylori* infection and diabetes.[39] The significant heterogeneity of findings observed among research may be a result of methodological variations or pure chance.

Bener et al stated that the epidemiological pattern of *H. pylori* may account for the variation in the prevalence of the infection.[40]

There is a considerable association between DM and failure of eradication in this current study. Patients with DM had eradication rate of 65.9 in comparison to patients without DM who had 86.5 eradication rate (*p*-value 0.001). This is in contrast with a retrospective study with standard triple therapy for 7 to 14 days which found that patient with DM and patients without DM obtained equal eradication rates.[41] However, it was consistent with a clinical trial that showed reduced eradication rates in patients DM.[42]

Appropriate eradication for *H. pylori* should attain an intention-to-treat (ITT) eradication rate of over 80%, which is presently inadequate in DM patients according to the Maastricht III Consensus.[43]

Limitations and Strengths of the Current Study

The present study provided valuable and significant data on the efficacy of the conventional triple therapy approach for the eradication of *H. pylori* and the influencing factors in the Jazan Region. However, it is not free of limitations. One of the main drawbacks of this study is the research design (retrospective), which can result in missed data as well as potential biases in data collection. Furthermore, this study was conducted using data from a single center; therefore, its sample size is not representative of the whole population in the Jazan region. However, the robust results and conclusion of this study represent an excellent addition to the existing literature and provide a baseline for future research.

Conclusion

The results of this study show that the standard triple therapy for eradication of *H. pylori* infection as a first-line approach is lower than the optimum rate, which is consistent with many worldwide outcomes, according to the literature and guidelines and as recommended by *H. pylori* consensus. A comparable shift in the first-line treatments maybe needed to properly eradicate this infection. Additional research is required to determine the scope of the triple therapy's declining effectiveness in several areas in the region.

DM, and smoking status were the main predictors of the decline in the eradication rate in this study. Therefore, DM optimum control and smoking cessation may play a crucial role in the eradication of *H. pylori* infection. Finally, it is important to continuously monitor the growing antibiotic resistance and bacterial susceptibility pattern for *H. pylori* as more studies are required in the future.

Disclosure

The author reports no conflicts of interest in this work.

References

1. Goderska K, Agudo Pena S, Alarcon T. Helicobacter pylori treatment: antibiotics or probiotics. *Appl Microbiol Biotechnol*. 2018;102:1–7. doi:10.1007/s00253-017-8535-7
2. Chey WD, Leontiadis GI, Howden CW, Moss SF. ACG clinical guideline: treatment of Helicobacter pylori infection. *Off J Am Coll Gastroenterol*. 2017;112(2):212–239. doi:10.1038/ajg.2016.563
3. Jung HK, Kang SJ, Lee YC, et al. Evidence-based guidelines for the treatment of Helicobacter pylori infection in Korea 2020. *Gut Liver*. 2021;15 (2):168. doi:10.5009/gnl20288

4. Hassan M, Noureddine M, Assi F, Houmani Z. Eradication rate of Helicobacter pylori by classic triple therapy in Lebanon: is it still effective? *Endoscopy*. 2018;5:3. doi:10.15761/ICM.1000129

5. Alharbi RH, Ghoraba M. Prevalence and patient characteristics of Helicobacter pylori among adults in primary health care of security forces hospital Riyadh, Saudi Arabia, 2018. *J Family Med Prim Care*. 2019;8(7):2202. doi:10.4103/jfmpc.jfmpc_398_19

6. Akeel M, Shehata A, Elhafey A, et al. Helicobacter pylori vacA, cagA and iceA genotypes in dyspeptic patients from southwestern region, Saudi Arabia: distribution and association with clinical outcomes and histopathological changes. *BMC Gastroenterol*. 2019;19(1):1–11. doi:10.1186/s12876-019-0934-z

7. Akeel M, Elmakki E, Shehata A, et al. Prevalence and factors associated with H. pylori infection in Saudi patients with dyspepsia. *Elect Phys*. 2018;10(9):7279. doi:10.19082/7279

8. Malfertheiner P, Megraud F, O'Morain C, et al. Current concepts in the management of Helicobacter pylori infection: the Maastricht III Consensus Report. *Gut*. 2007;56(6):772–781. doi:10.1136/gut.2006.101634

9. Chey WD, Wong BC; Practice Parameters Committee of the American College of Gastroenterology. American College of Gastroenterology guideline on the management of Helicobacter pylori infection. *Off J Am Coll Gastroenterol*. 2007;102(8):1808–1825. doi:10.1111/j.1572-0241.2007.01393.x

10. Zamani M, Alizadeh-Tabari S, Zamani V, Shokri-Shirvani J, Derakhshan MH. Worldwide and regional efficacy estimates of first-line Helicobacter pylori treatments: a systematic review and network meta-analysis. *J Clin Gastroenterol*. 2022;56(2):114–124. doi:10.1097/MCG.0000000000001641

11. Bayerdörffer E, Rudolph B, Neubauer A, et al. Regression of primary gastric lymphoma of mucosa-associated lymphoid tissue type after cure of Helicobacter pylori infection. *Lancet*. 1995;345(8965):1591–1594. doi:10.1016/S0140-6736(95)90113-2

12. Losurdo G, Iannone A, Giorgio F, Ierardi E, Di Leo A, Principi M. A prospective trial in Saudi Arabia comparing the 14-day standard triple therapy with the 10-day sequential therapy for treatment of Helicobacter pylori infection: a further confirmation of "Geographic Weight". *Saudi J Gastroenterol*. 2016;22(1):77–78. doi:10.4103/1319-3767.173763

13. Cardos AI, Maghiar A, Zaha DC, et al. Evolution of diagnostic methods for Helicobacter pylori infections: from traditional tests to high technology, advanced sensitivity and discrimination tools. *Diagnostics*. 2022;12(2):508. doi:10.3390/diagnostics12020508

14. Erkut M, Uzun DY, Kaklıkkaya N, et al. Sociodemographic characteristics and clinical risk factors of Helicobacter pylori infection and antibiotic resistance in the Eastern Black Sea region of Turkey. *Turk J Gastroenterol*. 2020;31(3):221. doi:10.5152/tjg.2020.18631

15. Mokhtare M, Hosseini V, Fakheri HT, et al. Comparison of quadruple and triple Furazolidone containing regimens on eradication of helicobacter pylori. *Med J Islamic Republic Iran*. 2015;29:195.

16. Vakil N. Are there geographic/regional differences in Helicobacter pylori eradication? *Helicobacter Pylori*. 2003;439–443. doi:10.1155/2003/903494

17. Smith S, Jolaiya T, Fowora M, et al. Clinical and socio-demographic risk factors for acquisition of Helicobacter pylori infection in Nigeria. *Asian Pac J Cancer Prev*. 2018;19(7):1851. doi:10.22034/APJCP.2018.19.7.1851

18. Alsohaibani F, Al Ashgar H, Al Kahtani K, et al. Prospective trial in Saudi Arabia comparing the 14-day standard triple therapy with the 10-day sequential therapy for treatment of Helicobacter pylori infection. *Saudi J Gastroenterol*. 2015;21(4):220. doi:10.4103/1319-3767.161647

19. Alsohaibani F, Peedikayil M, Alshahrani A, et al. Practice guidelines for the management of Helicobacter pylori infection: the Saudi H. pylori Working Group recommendations. *Saudi J Gastroenterol*. 2023;29(6):326–346. doi:10.4103/sjg.sjg_288_22

20. Bakri MM. Prevalence of Helicobacter pylori infection and the incidence of ureA and clarithromycin resistance gene 23S rRNA genotypes status in Saudi Arabia. *Saudi J Biol Sci*. 2013;20(1):75–78. doi:10.1016/j.sjbs.2012.10.006

21. Eltahawy AT. Prevalence of primary Helicobacter pylori resistance to several antimicrobials in a Saudi Teaching Hospital. *Med Princ Pract*. 2002;11(2):65–68. doi:10.1159/000058009

22. Momenah AM, Asghar AH. Prevalence and antibiotic resistance among Helicobacter pylori clinical isolates from main Hospitals in the Western Region of Saudi Arabia. *Pakistan J Med Sci*. 2008;24(1):100.

23. Bujanda L, Nyssen OP, Cosme A, et al. Impact of Helicobacter pylori clarithromycin resistance on the treatment effectiveness: data of the European Registry on H. pylori Management (Hp-EuReg). In: Helicobacter: Special Issue: The Year in Helicobacter. EHMSG–33rd International Workshop on Helicobacter & Microbiota in Inflammation & Cancer: Virtual Conference September 10–12, 2020, Glasgow, United Kingdom: Accepted Abstracts/European Helicobacter and Microbiota Study Group; Guest editors: Francis Mégraud & Peter Malfertheiner. Vol. 25. Oxford: Wiley-Blackwell; 2020. doi:10.1111/hel.12745.

24. Houben, Beek DV, Hensen, Craen AD, Rauws, Tytgat. A systematic review of Helicobacter pylori eradication therapy—the impact of antimicrobial resistance on eradication rates. *Aliment Pharmacol Ther*. 1999;13(8):1047–1055. doi:10.1046/j.1365-2036.1999.00555.x

25. Broutet N, Tchamgoue S, Pereira E, Lamouliatte H, Salamon R, Megraud F. Risk factors for failure of Helicobacter pylori therapy — results of an individual data analysis of 2751 patients. *Aliment Pharmacol Ther*. 2003;17(1):99–109. doi:10.1046/j.1365-2036.2003.01396.x

26. Shin K, Fogg VC, Margolis B. Tight junctions and cell polarity. *Annu Rev Cell DevBiol*. 2006;22(1):207–235. doi:10.1146/annurev.cellbio.22.010305.104219

27. Gumurdulu Y, Serin E, Özer B, et al. Low eradication rate of Helicobacter pylori with triple 7–14 days and quadriple therapy in Turkey. *World J Gastroenterol*. 2004;10(5):668. doi:10.3748/wjg.v10.i5.668

28. Ogihara A, Kikuchi S, Hasegawa A, et al. Relationship between Helicobacter pylori infection and smoking and drinking habits. *J Gastroenterol Hepatol*. 2000;15(3):271–276. doi:10.1046/j.1440-1746.2000.02077.x

29. Suzuki T, Matsuo K, Ito H, et al. Smoking increases the treatment failure for Helicobacter pylori eradication. *Am J Med*. 2006;119(3):217–224. doi:10.1016/j.amjmed.2005.10.003

30. Yu J, Yang P, Qin X, Li C, Lv Y, Wang X. Impact of smoking on the eradication of Helicobacter pylori. *Helicobacter*. 2022;27(1):e12860. doi:10.1111/hel.12860

31. Itskoviz D, Boltin D, Leibovitzh H, et al. Smoking increases the likelihood of Helicobacter pylori treatment failure. *Digestive Liver Dis*. 2017;49(7):764–768. doi:10.1016/j.dld.2017.03.010

32. Devrajani BR, Shah SZA, Soomro AA, Devrajani T. Type 2 diabetes mellitus: a risk factor for Helicobacter pylori infection: a hospital based case-control study. *Int J Diabetes Dev Countries*. 2010;30(1):22. doi:10.4103/0973-3930.60008

33. Perdichizzi G, Bottari M, Pallio S, Fera MT, Carbone M, Barresi G. Gastric infection by Helicobacter pylori and antral gastritis in hyperglycemic obese and in diabetic subjects. *New Microbiol*. 1996;19(2):149–154.

34. Valkonen KH, Ringner M, Ljungh Ã, Wadström T. High-affinity binding of laminin by Helicobacter pylori: evidence for a lectin-like interaction. *FEMS Immunol Med Microbiol*. 1993;7(1):29–37. doi:10.1111/j.1574-695X.1993.tb00378.x

35. Małecki M, Bień AI, Galicka-Latała D, Stachura J, Sieradzki J. The prevalence of Helicobacter pylori infection and types of gastritis in diabetic patients. The Krakow study. *Exp Clin Endocrinol Diabetes*. 1996;104(05):365–369. doi:10.1055/s-0029-1211469

36. Anastasios R, Goritsas C, Papamihail C, Trigidou R, Garzonis P, Ferti A. Helicobacter pylori infection in diabetic patients: prevalence and endoscopic findings. *Eur J Internal Med*. 2002;13(6):376–379. doi:10.1016/S0953-6205(02)00094-8

37. Xia HHX, Talley NJ, Kam EP, Young LJ, Hammer J, Horowitz M. Helicobacter pylori infection is not associated with diabetes mellitus, nor with upper gastrointestinal symptoms in diabetes mellitus. *Am J Gastroenterol*. 2001;96(4):1039–1046. doi:10.1111/j.1572-0241.2001.03604.x

38. Oluyemi A, Anomneze E, Smith S, Fasanmade O. Prevalence of a marker of active Helicobacter pylori infection among patients with type 2 diabetes mellitus in Lagos, Nigeria. *BMC Res Notes*. 2012;5(1):1–4. doi:10.1186/1756-0500-5-284

39. Alzahrani AM, Al Zaidi AA, Alzahrani SM, Binmahfouz SA, Farahat FM. Association between type 2 diabetes mellitus and Helicobacter pylori infection among Saudi patients attending National Guard Primary Health Care Centers in the Western Region, 2018. *J Fam Commun Med*. 2020;27 (1):8. doi:10.4103/jfcm.JFCM_142_19

40. Bener A, Micallef R, Afifi M, Derbala M, Al-Mulla HM, Usmani MA. Association between type 2 diabetes mellitus and Helicobacter pylori infection. *Turk J Gastroenterol*. 2007;18(4):225–229.

41. Yoo J, Yu YJ, Cho G, et al. Helicobacter pylori eradication rate in patients with diabetes. *Korean J Helicobacter Up Gastrointest Res*. 2017;17 (2):83–87. doi:10.7704/kjhugr.2017.17.2.83

42. Demir M, Gokturk HS, Ozturk NA, Arslan H, Serin E, Yilmaz U. Clarithromycin resistance and efficacy of clarithromycin-containing triple eradication therapy for Helicobacter pylori infection in type 2 diabetes mellitus patients. *South Med J*. 2009;102(11):1116–1120. doi:10.1097/SMJ.0b013e3181bca538

43. Malfertheiner P, Megraud F, O'Morain CA, Atherton J, Axon AT, Bazzoli F; European Helicobacter Study Group. Management of Helicobacter pylori infection—the Maastricht IV/Florence consensus report. *Gut*. 2012;61(5):646–664. doi:10.1136/gutjnl-2012-302084