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Original Research Article

Prevalence of Helicobacter Pylori Infection in Acid Peptic Disease and its Association with Demographic and Lifestyle Determinants: A Prospective Study from a Tertiary Care Centre in South India

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Abstract

Background and Objectives: Helicobacter pylori is the dominant modifiable cause of acid peptic disease, but region-specific data are needed to guide testing and eradication policy in India. This study determined its prevalence in acid peptic disease at a tertiary care centre in Mysore and its association with demographic, lifestyle and disease variables.

Methods: A prospective observational study was conducted at K.R. Hospital, Mysore Medical College and Research Institute, from February 2024 to February 2026. One hundred and fifty consecutive patients aged over 18 years with clinically diagnosed acid peptic disease undergoing upper gastrointestinal endoscopy were enrolled. Gastric biopsies were stained by the Warthin-Starry method, and gastritis was graded by the updated Sydney System. The chi-square test and independent samples t-test were applied, with $p < 0.05$ taken as significant.

Results: H. pylori was demonstrated in 136 of 150 patients, a prevalence of 90.7% (95% CI 86.0-95.3). Infected patients were older than uninfected patients (44.73 ± 9.94 versus 26.93 ± 6.02 years; $t = 6.563$, $p < 0.0001$). Prevalence was higher in rural than urban residents (98.5% versus 84.7%; $p = 0.0097$). All patients with duodenal ulcer, gastric ulcer, chronic gastritis and erosive gastritis were infected, against 22.2% with gastro-oesophageal reflux disease ($p < 0.0001$). Smoking ($p = 0.0014$) and alcohol use ($p = 0.0035$) were significantly associated; sex ($p = 0.6061$) and NSAID use ($p = 0.1168$) were not. Antral-predominant gastritis occurred in 79.4% and chronic active gastritis in 79.3%; atrophy and intestinal metaplasia were present in 7.3% and 4.0%.

Conclusion: Prevalence was very high and effectively universal in ulcer disease but low in reflux disease. Older age, rural residence, smoking and alcohol use marked the highest-risk group. Routine biopsy-based testing and eradication are justified in endoscopically proven peptic ulceration.

Keywords: Helicobacter pylori; Acid peptic disease; Peptic ulcer; Warthin-Starry stain; Gastritis; Prevalence; India.

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Introduction

Acid peptic disease is a collective term for a group of disorders of the upper gastrointestinal tract in which mucosal injury results from the action of gastric acid and pepsin on a mucosa whose defensive capacity has been overwhelmed. The spectrum includes chronic and erosive gastritis, duodenal ulcer, gastric ulcer and gastro-oesophageal reflux disease. Although these entities differ in their anatomical distribution, natural history and complication profile, they share a common pathophysiological theme, namely a disturbance in the equilibrium between aggressive luminal factors such as acid secretion, pepsin activity and bile reflux, and protective mucosal mechanisms including the surface mucus-bicarbonate layer, epithelial restitution, prostaglandin synthesis and mucosal blood flow. When this equilibrium is disturbed for a sufficient

period, epithelial breach occurs and the clinical syndromes of dyspepsia, epigastric pain, heartburn and, in a minority, haemorrhage or perforation follow.

The single most important discovery in this field was the recognition that a bacterium colonising the gastric mucosa is responsible for the majority of peptic ulceration. Helicobacter pylori is a Gram-negative, spiral, microaerophilic, flagellated organism that has co-evolved with humans and colonises the gastric epithelium of a large fraction of the world population.[1] Its persistence in an environment lethal to most bacteria depends on an unusually well-adapted set of survival mechanisms. Abundant cytoplasmic and surface-associated urease hydrolyses urea to ammonia and carbon dioxide, buffering the periplasm and creating a locally neutral micro-environment. Sheathed unipolar flagella provide the corkscrew motility required to traverse viscous gastric mucus, and a chemotactic apparatus directs the organism towards the near-neutral pH at the epithelial surface. Adhesins including BabA, SabA and OipA anchor the bacterium to Lewis blood group antigens and sialylated glycans on the foveolar epithelium, converting a transient colonisation into a lifelong infection.[2]

Once established, H. pylori initiates a chronic inflammatory response that is the proximate cause of tissue injury. The cag pathogenicity island encodes a type IV secretion system that injects the CagA effector protein into epithelial cells, where it undergoes tyrosine phosphorylation and deregulates SHP-2 signalling, cell polarity and junctional integrity. The vacuolating cytotoxin VacA forms anion-selective channels in host membranes, induces vacuolation and apoptosis, and suppresses T-cell proliferation, thereby helping the organism evade clearance. Lipopolysaccharide, peptidoglycan fragments sensed through NOD1, and outer membrane vesicles activate nuclear factor kappa B and drive the release of interleukin-8, interleukin-1 beta and tumour necrosis factor alpha, recruiting neutrophils and mononuclear cells to the lamina propria.[3] The resulting chronic active gastritis is present in virtually every colonised stomach, even when the patient is asymptomatic, and it is the histological substrate from which ulceration, atrophy and neoplasia later emerge.

The global burden of this infection is enormous but very unevenly distributed. A systematic review and meta-analysis of 410 studies from 73 countries estimated that approximately 4.4 billion individuals were infected, with a pooled global prevalence of about 44%.[4] A subsequent meta-analysis stratified by region and age reported broadly similar figures and confirmed a consistent gradient, with the lowest burden in Northern Europe, North America and Oceania and the highest in Africa, South America and South Asia.[5] The determinants of this gradient are largely environmental rather than genetic. Infection is acquired predominantly in childhood by faecal-oral and oral-oral routes, and the strongest correlates of acquisition are household crowding, shared sleeping arrangements, unsafe drinking water, absence of improved sanitation, low parental education and low household income. Because these exposures cluster in early life, the prevalence observed in adults reflects the sanitary conditions prevailing one or more generations earlier, which explains the birth-cohort effect seen wherever prevalence is falling.

India occupies a distinctive and much-debated position within this epidemiology. Seroprevalence surveys from the subcontinent have consistently reported infection rates between 55% and 92% in adult populations, placing India among the most heavily colonised nations in the world. Yet the age-standardised incidence of gastric adenocarcinoma in India is only a fraction of that observed in Japan, Korea and coastal China, countries in which the prevalence of H. pylori is actually lower.[6] This discordance between a very high infection burden and a comparatively modest cancer burden has been designated the Asian or Indian enigma. Several explanations have been advanced. The topographical pattern of gastritis produced by the infection in Indian patients tends to be antral-predominant, a phenotype that increases gastrin drive and acid output and therefore favours duodenal ulceration rather than the corpus-predominant, hypochlorhydric, atrophy-prone pattern that precedes intestinal-type gastric cancer. Dietary factors have also been implicated, in particular the high habitual intake of fresh vegetables, alliums, turmeric, chilli and other spices with antioxidant and antimicrobial activity, and the comparatively low intake of salt-preserved and smoked foods.[7] Regional variation within India is itself striking, with the highest gastric cancer rates recorded from the southern states and the north-east and the lowest from the northern plains, a pattern that mirrors differences in diet, tobacco habits and possibly bacterial strain composition.[8] Against this background, peptic ulcer disease continues to account for a substantial proportion of surgical and gastroenterological workload in Indian hospitals. Ulcer disease remains a common cause of emergency admission with haematemesis, melaena and perforation, and it carries appreciable mortality in the elderly and in those with comorbid illness. The two dominant aetiological factors worldwide are H. pylori infection and the use of non-steroidal anti-inflammatory drugs, and their relative contribution differs markedly between populations.[9] A classical meta-analysis demonstrated that the two factors act synergistically, that peptic ulceration is

distinctly uncommon in patients who are both H. pylori negative and NSAID naive, and that the population-attributable fraction of H. pylori is greatest where NSAID consumption is low.[10] In much of India, where over-the-counter analgesic use, although rising, remains lower than in Western populations, H. pylori is expected to account for the overwhelming majority of ulcers. Confirming this expectation with contemporary, biopsy-based, region-specific data is clinically important, because it determines whether an empirical eradication strategy is justified in a patient found to have an ulcer at endoscopy.

The diagnosis of H. pylori infection may be established by invasive or non-invasive methods. Non-invasive tests include the urea breath test, the monoclonal stool antigen assay and serology, of which the first two identify active infection while serology cannot distinguish current from past exposure. Invasive tests require endoscopic biopsy and comprise the rapid urease test, histology, culture and molecular detection. Histological demonstration retains particular value in surgical and pathological practice because a single procedure simultaneously confirms the organism, grades the intensity of inflammation, documents its topographical distribution and identifies atrophy, intestinal metaplasia and dysplasia. The updated Sydney System, formulated at the Houston workshop, provides the standard framework for this assessment, combining topography, morphology and aetiology into a reproducible report and supplying visual analogue scales for grading density of colonisation, chronic inflammation, neutrophil activity, glandular atrophy and intestinal metaplasia.[11] Silver impregnation techniques, of which the Warthin-Starry method is the best established, render the organism black against a pale background and remain among the most sensitive histological methods for detecting sparse colonisation, particularly in patients who have received partial acid suppression.

The clinical significance of accurate detection extends well beyond the immediate ulcer. Long-standing infection may progress along the sequence described by Correa, in which chronic non-atrophic gastritis gives way to multifocal atrophic gastritis, then to complete and subsequently incomplete intestinal metaplasia, then to low-grade and high-grade dysplasia, and finally to invasive intestinal-type adenocarcinoma.[12] Each step is associated with a measurable increment in cancer risk, and the identification of atrophy or metaplasia in a biopsy therefore converts a routine dyspepsia workup into an opportunity for risk stratification and surveillance. Recognition of this pathway underpinned the Kyoto global consensus, which reclassified H. pylori gastritis as an infectious disease in its own right and recommended that the infection be treated in all who harbour it, irrespective of whether symptoms or ulceration are present.[13] The Maastricht VI/Florence consensus reaffirmed this position, formally recognised H. pylori infection within the International Classification of Diseases, and emphasised that eradication before the development of atrophy offers the greatest reduction in subsequent cancer risk.[14]

Set against these arguments for widespread eradication are two practical constraints that are especially relevant in India. The first is the sheer size of the infected population, which makes any population-level treatment programme logistically and financially formidable. The second is antimicrobial resistance. A systematic review and meta-analysis across World Health Organization regions documented primary clarithromycin resistance exceeding 15% in most regions, together with high and rising rates of resistance to metronidazole and levofloxacin, and demonstrated that resistance translates directly into eradication failure.[15] In the Indian setting, extensive empirical antibiotic use, high background metronidazole exposure from the treatment of intestinal parasites and diarrhoeal illness, and limited access to susceptibility testing compound the problem. A rational policy must therefore be selective, directing eradication first towards those groups in whom the yield is highest and the benefit most clearly established, and this requires accurate local data on who is infected.

Local data are also required because prevalence estimates from one part of India cannot be transposed to another. Reported figures from Indian endoscopic series vary widely according to the diagnostic method used, the case mix referred for endoscopy, prior use of proton pump inhibitors and antibiotics, and the socioeconomic composition of the catchment population. Mysore serves a large mixed urban and rural catchment in southern Karnataka, and K.R. Hospital receives patients from both the city and the surrounding agricultural districts. This case mix provides an opportunity to examine directly whether place of residence, a proxy for water source, sanitation and household density, is associated with infection, and to determine whether lifestyle exposures such as tobacco and alcohol modify that association. The present study was therefore undertaken to establish the prevalence of H. pylori infection among patients presenting with acid peptic disease to a tertiary care surgical unit in Mysore, using endoscopic biopsy with Warthin-Starry staining as the reference method. In addition to overall prevalence, the study sought to characterise the distribution of infection across age, sex and residence, to compare infection rates between the various clinical and endoscopic phenotypes of acid

peptic disease, to examine the relationship between infection and modifiable lifestyle exposures, and to document the histological topography, colonisation density and premalignant changes present at the time of diagnosis. It was anticipated that such data would help define which patients in this population most clearly warrant testing and eradication, and would contribute region-specific evidence to the wider debate about the management of H. pylori infection in India.

Aims and Objectives

The objectives of the study were as follows:

1. To determine the prevalence of Helicobacter pylori infection among patients with acid peptic disease undergoing upper gastrointestinal endoscopy at a tertiary care centre.
2. To determine the association between Helicobacter pylori infection and demographic variables, specifically age and sex.
3. To compare the prevalence of Helicobacter pylori infection between urban and rural populations within the hospital catchment area.
4. To compare the prevalence of Helicobacter pylori infection across the different clinical and endoscopic subtypes of acid peptic disease.
5. To examine the association between Helicobacter pylori infection and modifiable lifestyle exposures, namely smoking, alcohol consumption and non-steroidal anti-inflammatory drug use, and with common comorbidities.
6. To describe the endoscopic distribution of lesions, the topographical pattern of gastritis, the density of bacterial colonisation and the histopathological findings, including premalignant changes, in the study population.

Materials and Methods

Study Design: This was a prospective, hospital-based, cross-sectional observational study conducted in a single tertiary care teaching institution. Patients were enrolled at the time of their index diagnostic endoscopy, and exposure and outcome data were collected concurrently using a structured proforma.

Study Setting and Duration: The study was carried out in the Department of General Surgery, K.R. Hospital, attached to Mysore Medical College and Research Institute, Irwin Road, Mysore, Karnataka. Recruitment extended over a period of two years, from February 2024 to February 2026. The hospital is a government-funded referral centre serving Mysore city and the surrounding rural districts of southern Karnataka, and it therefore receives a case mix drawn from both urban and rural catchment populations across a wide socioeconomic range.

Sample Size: The required sample size was calculated using the standard formula for estimation of a single proportion, $n = z^2 \times p \times (1 - p) / e^2$, where n is the required sample size, z is the standard normal deviate corresponding to the desired confidence level (1.96 for a 95% confidence interval), p is the expected proportion of H. pylori positivity derived from previously published studies of patients with acid peptic disease, and e is the acceptable margin of error. Applying this formula to the anticipated prevalence and an acceptable absolute precision, a minimum of 150 patients was required. One hundred and fifty patients were accordingly enrolled.

Sampling Technique: Consecutive sampling was used. Every patient presenting to the department during the study period with a clinical diagnosis of acid peptic disease who was scheduled for diagnostic upper gastrointestinal endoscopy was screened against the eligibility criteria, and all who qualified and consented were enrolled until the required sample size was reached. No randomisation or matching was applied.

Inclusion Criteria: Patients were eligible for inclusion if they were more than 18 years of age, had a clinical diagnosis of acid peptic disease, were scheduled to undergo diagnostic upper gastrointestinal endoscopy, and were willing to provide written informed consent for participation and for the collection of mucosal biopsies.

Exclusion Criteria: Patients were excluded if they were 18 years of age or younger, or if they had undergone recent upper gastrointestinal surgery, since altered anatomy and postoperative mucosal changes would confound both endoscopic interpretation and histological assessment of gastritis.

Ethical considerations: The study protocol was reviewed and approved by the Institutional Ethics Committee of Mysore Medical College and Research Institute before the commencement of recruitment. Written informed consent was obtained from every participant after the nature, purpose and possible risks of the study had been explained in a language the patient understood. Participation was voluntary, refusal did not alter the standard of clinical care offered, and patient identifiers were removed from the analysis dataset. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Clinical Evaluation and Data Collection: Each enrolled patient underwent a structured personal interview conducted by the investigator. Demographic details recorded included age in completed years, sex and place of residence, the last being classified as urban or rural according to the administrative status of the patient's habitual residence. The presenting complaint was recorded

as the single symptom that had prompted the patient to seek medical attention, and was categorised as epigastric pain, heartburn, generalised abdominal pain, nausea, loss of appetite, weight loss, haematemesis or melaena. A history of tobacco smoking, alcohol consumption and regular non-steroidal anti-inflammatory drug use was elicited and recorded as present or absent. Comorbid conditions, specifically diabetes mellitus, systemic hypertension, chronic kidney disease and chronic liver disease, were documented from history, existing medical records and where necessary from relevant investigations. All information was entered on a pre-designed structured proforma to ensure uniformity of data capture.

Endoscopic Procedure: Diagnostic upper gastrointestinal endoscopy was performed after an overnight fast of at least six hours, with topical pharyngeal anaesthesia and standard patient preparation, using a flexible forward-viewing videogastroscope. The oesophagus, stomach and first and second parts of the duodenum were systematically examined. The oesophageal mucosa was assessed for erosive change and the gastro-oesophageal junction for hiatal abnormality. The gastric mucosa was inspected in the fundus, body, incisura and antrum, and the duodenal bulb and descending duodenum were examined for erosions and ulceration. The principal endoscopic diagnosis for each patient was recorded as duodenal ulcer, gastric ulcer, chronic gastritis, erosive gastritis or gastro-oesophageal reflux disease, and the anatomical site of the dominant lesion was documented as duodenal bulb, antrum or corpus.

Biopsy Protocol and Histopathological Assessment: Mucosal biopsies were obtained during the same endoscopic session from representative areas of the gastric mucosa in every patient. Where an ulcer was present, additional biopsies were taken from the ulcer edge in order to exclude malignancy. Specimens were immediately transferred to 10% neutral buffered formalin, appropriately labelled and transported to the Department of Pathology for processing. Tissue was routinely processed, embedded in paraffin, and sections were cut at 4 to 5 micrometres. Sections were stained with haematoxylin and eosin for assessment of mucosal architecture, inflammatory infiltrate, glandular atrophy, intestinal metaplasia and dysplasia. Parallel sections were subjected to Warthin-Starry silver impregnation, performed according to standard laboratory protocol, for demonstration of H. pylori.

Definition of Outcome Variables: A case was classified as positive for H. pylori when the Warthin-Starry stained section demonstrated the characteristic spiral or curved argyrophilic bacilli lying within the surface mucus layer or adherent to the foveolar epithelium. Density of colonisation was graded semi-quantitatively as mild, moderate or severe in accordance with the visual analogue scales of the updated Sydney System. The topographical pattern of gastritis was classified as antral-predominant when antral inflammation exceeded corpus inflammation, corpus-predominant when the reverse obtained, and pangastritis when the two were of comparable grade. The final histopathological diagnosis for each patient was recorded as normal mucosa, chronic active gastritis, chronic active gastritis with atrophy, or chronic active gastritis with intestinal metaplasia.

Statistical Analysis: Data were entered into a spreadsheet and analysed using standard statistical software. Continuous variables were summarised as mean with standard deviation and categorical variables as frequencies with percentages. The overall prevalence of H. pylori infection was calculated as the proportion of positive cases among all patients with acid peptic disease, and its 95% confidence interval was derived using the normal approximation to the binomial distribution. Associations between H. pylori status and categorical variables, including age category, sex, residence, disease type, smoking, alcohol consumption, NSAID use and comorbidity, were tested using the Pearson chi-square test. The difference in mean age between infected and uninfected patients was tested using the independent samples t-test. Odds ratios were computed to express the strength of association for the principal exposure variables. A two-tailed p value of less than 0.05 was considered statistically significant. Results were tabulated and are presented below.

Results

One hundred and fifty patients with clinically diagnosed acid peptic disease who underwent diagnostic upper gastrointestinal endoscopy were enrolled and analysed. No patient was lost between enrolment and histopathological reporting, and biopsy material was adequate for interpretation in every case.

Age Distribution: The mean age of the study population fell predominantly in the fourth and fifth decades. As shown in Table 1, the 41 to 50 year group was the largest, accounting for 42 patients (28.0%), followed by the 31 to 40 year group with 40 patients (26.7%) and the 51 to 60 year group with 37 patients (24.7%). Only 7 patients (4.7%) were older than 60 years. Age was strongly associated with infection status. The mean age of H. pylori positive patients was 44.73 ± 9.94 years, compared with 26.93 ± 6.02 years among negative patients, a difference of 17.8 years that was highly significant on the independent samples

t-test (t = 6.563, p < 0.0001). The categorical distribution reflected the same gradient, with a chi-square value of 68.053 (p < 0.0001). Thirteen of the 14 uninfected patients (92.9%) were aged 30 years or less, and the single remaining uninfected patient fell in the 41 to 50 year band. Within the youngest age band, therefore, the observed prevalence of infection was 11 of 24 patients, or 45.8%, whereas in every age band above 30 years the prevalence exceeded 97%.

Table 1: Age distribution and its association with Helicobacter pylori status (N = 150)

Age category	H. pylori positive n (%)	H. pylori negative n (%)	Total n (%)
≤30 years	11 (8.1)	13 (92.9)	24 (16.0)
31-40 years	40 (29.4)	0 (0.0)	40 (26.7)
41-50 years	41 (30.1)	1 (7.1)	42 (28.0)
51-60 years	37 (27.2)	0 (0.0)	37 (24.7)
>60 years	7 (5.1)	0 (0.0)	7 (4.7)
Total	136 (100.0)	14 (100.0)	150 (100.0)

Chi-square = 68.053, p < 0.0001. Mean age: H. pylori positive 44.73 ± 9.94 years; H. pylori negative 26.93 ± 6.02 years; t = 6.563, p < 0.0001. Percentages are column percentages.

Sex and Place of Residence: Ninety patients (60.0%) were male and 60 (40.0%) were female, giving a male to female ratio of 1.5 to 1. Infection was present in 83 of 90 men (92.2%) and 53 of 60 women (88.3%). This difference was not statistically significant (chi-square = 0.266, p = 0.6061), and sex therefore did not discriminate between infected and uninfected patients in this cohort. Place of residence, in contrast, showed a clear and significant association. Eighty-five patients (56.7%) resided in urban areas and 65 (43.3%) in rural areas.

The prevalence of infection was 84.7% (72 of 85) among urban residents and 98.5% (64 of 65) among rural residents, an absolute difference of 13.8 percentage points that reached significance (chi-square = 6.691, p = 0.0097), corresponding to an odds ratio of 11.56 for rural residence. These findings are summarised in Table 2.

Table 2: Sex and residence in relation to Helicobacter pylori status (N = 150)

Variable	H. pylori positive n (%)	H. pylori negative n (%)	Total n (%)
Male	83 (61.0)	7 (50.0)	90 (60.0)
Female	53 (39.0)	7 (50.0)	60 (40.0)
Urban	72 (52.9)	13 (92.9)	85 (56.7)
Rural	64 (47.1)	1 (7.1)	65 (43.3)
Total	136 (100.0)	14 (100.0)	150 (100.0)

Sex: chi-square = 0.266, p = 0.6061 (not significant). Residence: chi-square = 6.691, p = 0.0097. Percentages are column percentages within each variable.

Prevalence Across Disease Subtypes: The distribution of infection across the clinical and endoscopic subtypes of acid peptic disease was strikingly polarised, as set out in Table 3. Duodenal ulcer was the commonest diagnosis, present in 67 patients (44.7%), followed by gastric ulcer in 40 (26.7%), chronic gastritis in 13 (8.7%) and erosive gastritis in 12 (8.0%). Gastro-oesophageal reflux disease accounted for the remaining 18 patients (12.0%). Every patient with duodenal ulcer, gastric ulcer, chronic gastritis and erosive gastritis was H. pylori positive, giving a prevalence of 100.0% in each of these four categories.

Among patients with reflux disease, by contrast, only 4 of 18 (22.2%) were infected, and this group accounted for all 14 negative cases in the series. The association between disease subtype and infection status was highly significant (chi-square = 113.235, p < 0.0001). The ratio of duodenal to gastric ulcers in this cohort was 1.68 to 1.

Table 3: Prevalence of Helicobacter pylori across subtypes of acid peptic disease (N = 150)

Type of disease	H. pylori positive n (%)	H. pylori negative n (%)	Total n (%)	Prevalence (%)
Duodenal ulcer	67 (49.3)	0 (0.0)	67 (44.7)	100.0
Gastric ulcer	40 (29.4)	0 (0.0)	40 (26.7)	100.0
Chronic gastritis	13 (9.6)	0 (0.0)	13 (8.7)	100.0
Erosive gastritis	12 (8.8)	0 (0.0)	12 (8.0)	100.0
GERD	4 (2.9)	14 (100.0)	18 (12.0)	22.2
Total	136 (100.0)	14 (100.0)	150 (100.0)	90.7

Chi-square = 113.235, p < 0.0001. GERD = gastro-oesophageal reflux disease.

Clinical Presentation: Epigastric pain was the dominant presenting complaint, reported by 56 patients (37.3%), followed by heartburn in 24 (16.0%), generalised abdominal pain in 19 (12.7%) and nausea in 18 (12.0%). Constitutional symptoms in the form of loss of appetite and weight loss were each recorded in 11 patients (7.3%). Complications of ulcer disease presented as overt bleeding in 11 patients (7.3%) in aggregate, comprising haematemesis in 6 (4.0%) and melaena in 5 (3.3%). The full distribution is given in Table 4.

Table 4: Distribution of presenting complaints (N = 150)

Chief complaint	Frequency (n)	Percentage (%)
Epigastric pain	56	37.3
Heartburn	24	16.0
Abdominal pain	19	12.7
Nausea	18	12.0
Loss of appetite	11	7.3
Weight loss	11	7.3
Haematemesis	6	4.0
Melaena	5	3.3
Total	150	100.0

Complaint recorded as the single dominant symptom prompting presentation.

Lifestyle Exposures and Comorbidity: Sixty-six patients (44.0%) were smokers and 60 (40.0%) consumed alcohol. As shown in Table 5, every smoker and every alcohol consumer in the series was H. pylori positive, giving prevalences of 100.0% in both groups, against 83.3% among the 84 non-smokers and 84.4% among the 90 non-consumers. Both associations were statistically significant, with chi-square values of 10.243 (p = 0.0014) for smoking and 8.538 (p = 0.0035) for alcohol. Regular NSAID use was reported by 29 patients (19.3%), all of whom were infected, but the difference in prevalence against non-users (100.0% versus 88.4%) did not reach significance (chi-square = 2.460, p = 0.1168). Hypertension was the commonest comorbidity, present in 47 patients (31.3%), followed by diabetes mellitus in 29 (19.3%); no patient in the series had chronic kidney disease or chronic liver disease. The relationship between comorbidity and infection status, together with the endoscopic site of the dominant lesion, is presented in Table 6. The duodenal bulb was the commonest site of the dominant lesion, involved in 67 of the 132 patients with a gastroduodenal lesion (50.8%), followed by the antrum in 51 (38.6%) and the corpus in 14 (10.6%). A representative endoscopic appearance of the gastric mucosa in a study patient is shown in Figure 1.

Table 5: Association of lifestyle exposures with Helicobacter pylori infection (N = 150)

Exposure	Status	H. pylori positive n (%)	H. pylori negative n (%)	Prevalence (%)	p value
Smoking	Yes	66 (48.5)	0 (0.0)	100.0	0.0014
	No	70 (51.5)	14 (100.0)	83.3	
Alcohol	Yes	60 (44.1)	0 (0.0)	100.0	0.0035
	No	76 (55.9)	14 (100.0)	84.4	
NSAID use	Yes	29 (21.3)	0 (0.0)	100.0	0.1168
	No	107 (78.7)	14 (100.0)	88.4	

Chi-square values: smoking 10.243; alcohol 8.538; NSAID use 2.460 (not significant). NSAID = non-steroidal anti-inflammatory drug.

Table 6: Comorbidities and endoscopic site of the dominant lesion

Variable	H. pylori positive n (%)	Total n (%)	p value
Diabetes mellitus	29 (21.3)	29 (19.3)	0.1168
Hypertension	47 (34.6)	47 (31.3)	0.0187
Chronic kidney disease	0 (0.0)	0 (0.0)	Not applicable
Chronic liver disease	0 (0.0)	0 (0.0)	Not applicable
Lesion in duodenal bulb	67 (49.3)	67 (50.8)	Not applicable
Lesion in antrum	51 (37.5)	51 (38.6)	Not applicable
Lesion in corpus	14 (10.3)	14 (10.6)	Not applicable

Lesion location percentages are calculated on the 132 patients in whom a discrete gastroduodenal lesion was identified; the remaining 18 patients had gastro-oesophageal reflux disease without a gastroduodenal lesion.

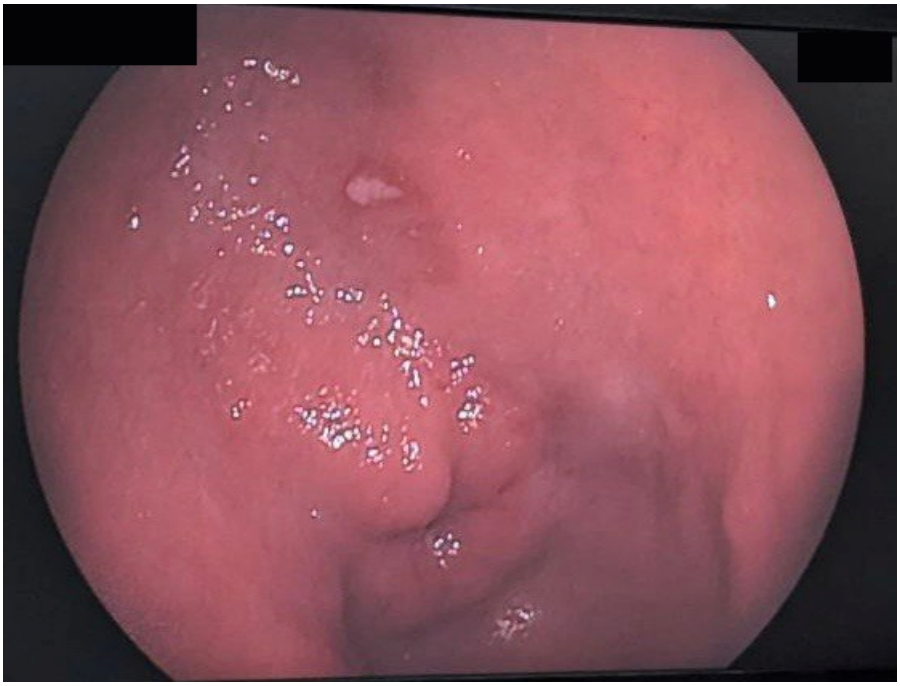

Figure 1: Endoscopic view on Antral gastritis with antral ulcer

Histological findings: Among the 136 infected patients, the topography of gastritis was antral-predominant in 108 (79.4%), pangastritis in 17 (12.5%) and corpus-predominant in 11 (8.1%). Colonisation density was moderate in 66 patients (48.5%), mild in 46 (33.8%) and severe in 24 (17.6%). Considering the whole cohort, the commonest histopathological diagnosis was chronic active gastritis, reported in 119 patients (79.3%).

Normal gastric mucosa was found in 14 patients (9.3%), a figure identical to the number of H. pylori negative cases. Premalignant change was identified in 17 patients in aggregate (11.3%), comprising glandular atrophy in 11 (7.3%) and intestinal metaplasia in 6 (4.0%). No dysplasia or malignancy was detected in any biopsy. These findings are summarised in Table 7, and representative photomicrographs of an infected biopsy are shown in Figures 2 and 3.

Table 7: Gastritis topography, colonisation density and histopathological diagnosis

Variable	Category	Frequency (n)	Percentage (%)
Gastritis pattern (positives, n = 136)	Antral predominant	108	79.4
	Pangastritis	17	12.5
	Corpus predominant	11	8.1
Colonisation density (positives, n = 136)	Mild (+)	46	33.8
	Moderate (++)	66	48.5
	Severe (+++)	24	17.6
Histopathology (all, n = 150)	Chronic active gastritis	119	79.3
	Normal	14	9.3
	With atrophy	11	7.3
	With intestinal metaplasia	6	4.0

Gastritis pattern and density graded according to the updated Sydney System.

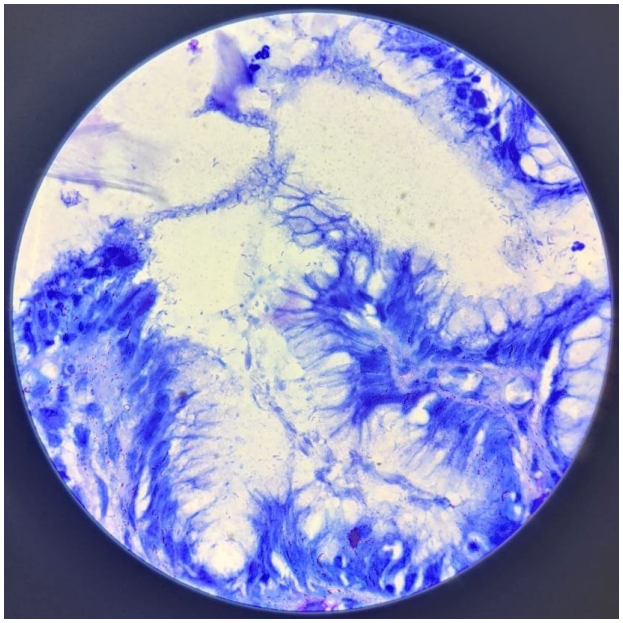

Figure 2: Antral biopsy histopathological microscopic imaging using Geimsa stain showing Gastric foveolar epithelium is seen lining mucin-filled surface pits, with a chronic inflammatory infiltrate expanding the lamina propria, consistent with chronic active gastritis with H. Pylori

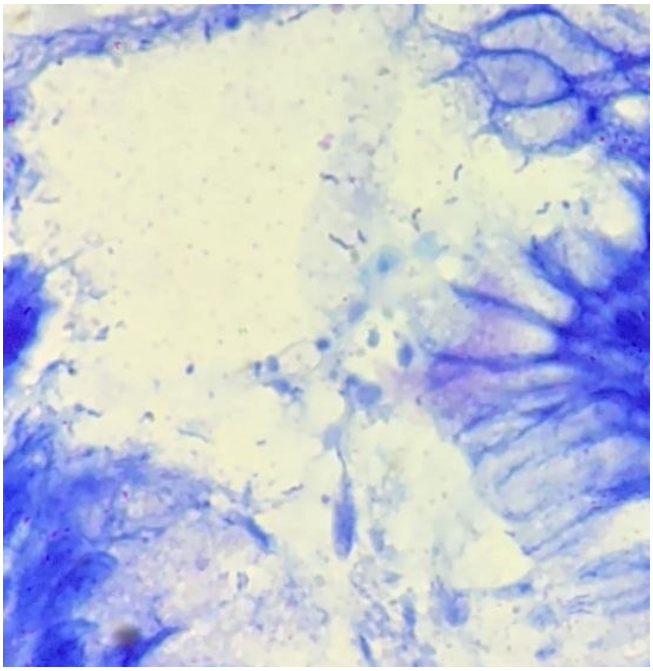

Figure 3: Magnified histopathological microscopic imaging using Geimsa stain showing H. Pylori as numerous slender curved and spiral bacilli

[Authors: please insert the stain used and the original magnification in the captions of Figures 2 and 3 before submission. Note that the blue metachromatic appearance of these sections is not that of a Warthin-Starry silver preparation, which stains the organisms black against a pale golden background. If these images were produced with Giemsa or toluidine blue, the Materials and Methods section must be amended to describe the stain that was actually used.]

Overall prevalence and risk associations: Of the 150 patients studied, 136 were positive for H. pylori on Warthin-Starry staining and 14 were negative, giving an overall prevalence of 90.7% with a 95% confidence interval of 86.0% to 95.3%. Table 8 summarises the strength of association for the principal variables examined. Age above 40 years, rural residence, smoking and alcohol consumption were all significantly associated with infection, whereas sex, NSAID use, diabetes mellitus and hypertension were not independently discriminatory once the near-universal positivity in ulcer disease was taken into account.

Table 8: Overall prevalence and strength of association of principal risk variables (N = 150)

Variable	Category	Odds ratio	p value	Significance
Overall prevalence	H. pylori positive: 136/150 (90.7%; 95% CI 86.0-95.3)	–	–	–
Age	>40 years	0.05	0.0002	***
Sex	Male	1.57	0.6061	NS
Residence	Rural	11.56	0.0097	**
Smoking	Yes	Undefined (no negatives)	0.0014	**
Alcohol	Yes	Undefined (no negatives)	0.0035	**

*** $p < 0.001$; ** $p < 0.01$; NS = not significant. Odds ratios for smoking and alcohol could not be estimated because no H. pylori negative patient reported either exposure; the association was assessed by the chi-square test.

Discussion

This prospective study of 150 patients with acid peptic disease attending a tertiary care surgical unit in Mysore found an overall H. pylori prevalence of 90.7% (95% CI 86.0-95.3) on biopsy with Warthin-Starry staining. Infection was universal in all four gastroduodenal phenotypes examined and was confined to a small minority of patients with reflux disease. Older age, rural residence, smoking and alcohol consumption were significantly associated with infection, while sex and NSAID use were not. The following paragraphs situate these observations within the published literature.

Overall prevalence in comparative context: The prevalence recorded here is roughly twice the pooled global figure of about 44% derived from 410 studies across 73 countries.[4] A separate meta-analysis of worldwide prevalence stratified by region reported a comparable global estimate with substantially higher values in South Asia.[5] Direct comparison with population estimates is, however, not appropriate.

The present cohort consists exclusively of symptomatic patients selected for endoscopy on clinical grounds, a group with a very high pre-test probability of infection, and the reference standard was histological demonstration in gastric biopsy rather than serology or breath testing. Indian endoscopic series using similar case selection report figures much closer to ours. Agarwal and colleagues, studying dyspeptic patients attending a North Indian hospital with combined serology, rapid urease testing and histology, found H. pylori in 85% of patients and in 83.3% of those with endoscopic abnormalities, with no significant variation by sex or age band.[16] Saha and co-workers, applying stool antigen testing alongside endoscopy in Indian dyspeptic patients, similarly reported a high burden and noted that antigen testing outperformed endoscopy alone for detection.[17] Our figure of 90.7% is somewhat above these, and three factors plausibly account for the difference. First, our cohort was enriched for structural disease, since 107 of 150 patients (71.3%) had frank ulceration, whereas dyspepsia series contain a large proportion of patients with normal or minimally abnormal mucosa. Second, silver impregnation is a highly sensitive histological method and will detect sparse colonisation missed by rapid urease testing. Third, the catchment population of this hospital includes a substantial rural component in which environmental transmission is intense.

Age and the pattern of acquisition: The relationship between age and infection in this series was unusually stark: the mean age of infected patients exceeded that of uninfected patients by nearly 18 years (44.73 ± 9.94 versus 26.93 ± 6.02 years, $p < 0.0001$), and 13 of the 14 uninfected patients were aged 30 years or under. This is consistent with the general epidemiological principle that H. pylori is acquired in childhood and persists lifelong, so that adult prevalence rises with age through a birth-cohort effect rather than through continuing adult acquisition.[1] It is also consistent with the observation that the clinical sequelae of infection, particularly ulceration, require years to decades of chronic inflammation to develop. The finding should nonetheless be interpreted with caution. Because all 14 negative patients had reflux disease and reflux disease presented at a younger age in this cohort, the apparent age effect is at least partly a reflection of the phenotype distribution rather than an independent effect of age on the probability of colonisation. Agarwal and colleagues, in a comparable Indian endoscopic population, found no significant age-related difference in H. pylori positivity, which supports this interpretation.[16] The pooled evidence indicates only a modest age difference between infected and uninfected individuals at the population level, and our large observed difference is therefore best regarded as

characteristic of this particular case mix rather than as a generalisable estimate.

Rural-urban disparity: The 13.8 percentage point excess prevalence among rural residents (98.5% versus 84.7%, p = 0.0097) is one of the clearer signals in this dataset and is entirely in keeping with the recognised environmental determinants of transmission. Ueda and colleagues, examining the childhood home environment of 5,854 adults, found that urban residence was independently protective against infection (OR 0.74, 95% CI 0.66-0.83), as were access to tap water (OR 0.73, 95% CI 0.55-0.96) and a flush toilet (OR 0.72, 95% CI 0.63-0.84), while a household of seven or more persons increased the odds of infection (OR 1.34, 95% CI 1.09-1.64).[18] The specific contribution of water is well documented; a review of waterborne transmission described the survival of the organism in a viable but non-culturable state in water distribution systems and summarised the evidence linking untreated water sources to infection in endemic regions.[19]

In the Mysore catchment, rural households more commonly depend on wells, borewells and surface water, have less consistent access to improved sanitation, and are more crowded, all of which favour faecal-oral and oral-oral transmission during childhood. The practical implication is that residence is a usable clinical proxy for infection risk in this setting: a rural patient presenting with dyspepsia in this region has, on the evidence of this study, close to a 99% probability of being infected.

Distribution across disease phenotypes: The observation that every patient with duodenal ulcer, gastric ulcer, chronic gastritis and erosive gastritis was infected, against only 22.2% of those with reflux disease (p < 0.0001), reproduces in an extreme form the classical relationship between H. pylori and peptic ulceration. The meta-analysis by Huang and colleagues established that H. pylori infection and NSAID use act synergistically in ulcer pathogenesis and that peptic ulceration is distinctly uncommon in patients who are neither infected nor taking NSAIDs.[10] The corollary is that in populations where NSAID consumption is low, the population-attributable fraction of H. pylori in ulcer disease approaches unity. Regular NSAID use was reported by only 19.3% of our patients, and the finding of 100% infection in ulcer cases is therefore internally consistent with that meta-analysis rather than anomalous. Even so, a prevalence of exactly 100% in 107 consecutive ulcer patients is higher than most published series and probably reflects both the sensitivity of silver staining and the intensity of transmission locally; a modest number of H. pylori negative, NSAID-associated ulcers would be expected in any larger sample. Our duodenal to gastric ulcer ratio of 1.68 to 1 is considerably lower than the ratios of 8 to 1 or more reported from India in earlier decades, which is consistent with the changing ulcer epidemiology described in contemporary Indian work and with the referral of complicated and biopsy-requiring gastric lesions to a tertiary surgical unit.[20]

Reflux disease and Helicobacter pylori: The low infection rate among patients with reflux disease deserves separate comment because this relationship remains contested. It has been proposed that H. pylori-induced corpus gastritis reduces acid output and thereby protects against reflux oesophagitis, and that eradication may unmask reflux in predisposed individuals. The evidence, however, is inconsistent. Niknam and colleagues, in a large cross-sectional endoscopic study of 1,916 patients of whom 45.6% had reflux disease and 75.3% were H. pylori positive overall, found no significant association between infection and erosive reflux disease; instead smoking, higher body mass index, older age and hiatus hernia were the variables significantly associated with reflux.[21] Our finding of 22.2% positivity in the reflux group is thus better interpreted not as evidence that infection protects against reflux, but as evidence that reflux disease in this population is largely an H. pylori independent condition driven by mechanical and lifestyle factors. This interpretation has a direct clinical consequence: an empirical eradication strategy that is highly appropriate for a patient with an endoscopically proven ulcer is not appropriate for a patient with reflux symptoms alone.

Smoking and alcohol: Both smoking and alcohol consumption were significantly associated with infection in this study, with all 66 smokers and all 60 alcohol consumers testing positive. These associations must be interpreted with considerable caution, because the literature does not support a simple causal relationship in either direction. Brenner and colleagues, using the urea breath test in 447 general practice attenders, found no significant relation between smoking and active infection and reported an inverse dose-response relationship for alcohol, with an adjusted odds ratio of 0.33 (95% CI 0.16-0.68) for consumption above 75 g of ethanol per week compared with non-drinkers (p for trend 0.005).[22] Wu and colleagues, in 7,169 asymptomatic individuals undergoing health check-up, found the direction of association to be sex-dependent: among men, smoking (OR 1.61, 95% CI 1.41-1.83) and alcohol (OR 1.30, 95% CI 1.10-1.52) were positively associated with infection, whereas among women both were inversely associated after adjustment for age.[23] Against this background, the perfect concordance observed in our data is most plausibly explained by confounding rather than by a biological effect. Smoking and alcohol use in this

cohort clustered in older men from rural backgrounds, precisely the group in which infection was near-universal for environmental reasons, and no uninfected patient reported either exposure simply because the uninfected group consisted almost entirely of young patients with reflux disease. What can reasonably be concluded is that these habits mark a high-risk demographic in this population, not that they cause colonisation.

Gastritis topography, density and premalignant change: Antral-predominant gastritis in 79.4% of infected patients is the pattern expected in a population with a high burden of duodenal ulcer and a comparatively low incidence of gastric adenocarcinoma. Antral-predominant disease increases gastrin release and acid output while sparing the oxyntic mucosa, thereby favouring duodenal ulceration; corpus-predominant and pangastritis phenotypes, by contrast, reduce acid output and predispose to atrophy and to the intestinal-type carcinoma sequence described by Correa.[12] The dominance of the antral pattern in our series is thus mechanistically consistent both with our own ulcer distribution and with the wider Asian or Indian enigma, in which very high infection prevalence in the subcontinent coexists with gastric cancer incidence far below that of Japan, Korea and China.[6] Dietary explanations for this discordance, in particular the protective contribution of fresh vegetables, alliums and spices with antioxidant activity, have been reviewed in detail.[7] Premalignant change was present in 11.3% of our cohort, comprising atrophy in 7.3% and intestinal metaplasia in 4.0%. Detection of such lesions depends heavily on biopsy technique: Latorre and colleagues demonstrated in a real-world study that endoscopists who regularly applied the updated Sydney System biopsy protocol detected chronic atrophic gastritis and intestinal metaplasia significantly more often than those who applied it infrequently.[24] Our figures should therefore be regarded as a lower bound. Colonisation density was moderate or severe in 66.1% of infected patients, a distribution comparable with that reported in South Asian series and relevant because higher bacterial load correlates with more intense neutrophilic activity.

Strain factors and regional heterogeneity: An aspect not addressed by the present study but relevant to interpretation is bacterial genotype. Strain composition varies markedly across India, and recent work from the north-east using multi-locus sequence typing has demonstrated a distinct regional gene pool with implications for the occurrence of peptic ulcer disease and gastric cancer in that population.[25] Since CagA and VacA status modulate the intensity of inflammation and the direction of the gastritis phenotype, differences in strain distribution may contribute to the variation in disease outcome reported between Indian regions. Similarly, the pooled prevalence of gastric cancer among H. pylori infected individuals worldwide has been quantified in a recent meta-analysis, providing a denominator against which regional risk can be judged.[26] Characterisation of virulence genotypes in the Mysore population would be a logical extension of the present work.

Clinical and public health implications: Three practical conclusions follow from these data. First, in a patient from this region with an endoscopically proven gastric or duodenal ulcer, the probability of H. pylori infection is so high that eradication should be regarded as the default, and a negative rapid urease test should prompt confirmatory histology rather than abandonment of treatment. This aligns with the Kyoto global consensus, which classified H. pylori gastritis as an infectious disease warranting treatment in all infected individuals,[13] and with the Maastricht VI/Florence consensus recommendation that eradication be offered to all infected patients, ideally before atrophy develops.[14]

Second, the marked rural excess argues that meaningful long-term reduction in this disease burden depends less on clinical services than on water quality, sanitation and household density, and that improvements in these domains will lower prevalence in successive birth cohorts. Third, the low infection rate in reflux disease cautions against indiscriminate empirical eradication in undifferentiated dyspepsia. This selectivity matters because antimicrobial resistance is the principal constraint on eradication policy. A systematic review and meta-analysis across World Health Organization regions documented primary clarithromycin resistance above the 15% threshold in most regions along with high metronidazole and levofloxacin resistance, and showed that resistance translates directly into treatment failure.[15] In the Indian context, where empirical antibiotic exposure is widespread and susceptibility testing is rarely available, restricting eradication to those with the clearest indication is both clinically and epidemiologically prudent. Metabolic associations of the infection reported in Indian dyspeptic patients further underline that the clinical footprint of H. pylori extends beyond the stomach and merits systematic evaluation.[27]

Limitations: Several limitations qualify these findings. The study was conducted at a single tertiary centre using consecutive sampling of endoscopy referrals, so the results describe patients selected for investigation and cannot be extrapolated to the community. The cross-sectional design precludes inference about temporal sequence or causation, which is particularly relevant to the smoking and alcohol associations. With only 14 negative patients, statistical power for

multivariable adjustment was limited, and several odds ratios could not be estimated because of zero cells; the reported associations for smoking and alcohol are consequently unadjusted and vulnerable to confounding by age, sex and residence. Only one histological method was applied, so neither the sensitivity nor the specificity of Warthin-Starry staining could be assessed against a second test such as the rapid urease test or the urea breath test, and false positives from staining artefact cannot be formally excluded. Prior proton pump inhibitor and antibiotic exposure was not systematically quantified, although such exposure would tend to depress rather than inflate observed prevalence. CagA and VacA genotyping, antimicrobial susceptibility testing, quantitative dietary assessment and objective measures of socioeconomic status, water source and household crowding were not performed, so the mechanisms underlying the rural excess were inferred rather than measured. Finally, no follow-up after eradication was undertaken, so treatment outcomes and reinfection rates in this population remain unknown.

Future directions: Future work in this population should pair histology with a second independent test to allow formal estimation of diagnostic accuracy, and should incorporate direct measurement of water source, sanitation and crowding so that the rural-urban difference can be attributed to specific exposures rather than to residence as a proxy. Larger multicentre samples with adequate numbers of uninfected patients would permit properly adjusted multivariable modelling of the lifestyle associations reported here. Local antimicrobial susceptibility surveillance is a priority, since eradication regimens are currently selected empirically. Longitudinal follow-up of the patients found to have atrophy or intestinal metaplasia would clarify the rate of progression along the precancerous cascade in an Indian population and help determine whether endoscopic surveillance is justified. Finally, cost-effectiveness analysis comparing test-and-treat with endoscopy-led strategies in Indian district and tertiary settings would provide the evidence needed to inform policy.

Conclusion

This prospective study of 150 patients with acid peptic disease at a tertiary care centre in Mysore demonstrated an overall Helicobacter pylori prevalence of 90.7% (95% CI 86.0-95.3) on gastric biopsy with Warthin-Starry staining. Infection was demonstrated in every patient with duodenal ulcer, gastric ulcer, chronic gastritis and erosive gastritis, whereas only 22.2% of patients with gastro-oesophageal reflux disease were infected, and this difference was highly significant ($p < 0.0001$). The organism is therefore confirmed as the dominant aetiological factor in peptic ulceration in this population, while reflux disease in the same population appears largely independent of it.

Infection was significantly associated with older age, with a mean age of 44.73 ± 9.94 years among infected patients against 26.93 ± 6.02 years among uninfected patients ($p < 0.0001$), and with rural residence, prevalence being 98.5% in rural against 84.7% in urban residents ($p = 0.0097$). Smoking and alcohol consumption were also significantly associated ($p = 0.0014$ and $p = 0.0035$), although the design of the study does not permit these associations to be interpreted causally, since both habits clustered within the older, rural, male group in which infection was near-universal for environmental reasons. Sex and non-steroidal anti-inflammatory drug use showed no significant association.

Histologically, antral-predominant gastritis accounted for 79.4% of infected cases and chronic active gastritis for 79.3% of the whole cohort, a pattern consistent with a population in which duodenal ulceration is common and gastric adenocarcinoma comparatively uncommon. Premalignant change was nonetheless present in 11.3% of patients, comprising atrophy in 7.3% and intestinal metaplasia in 4.0%, which underlines the value of taking and reporting biopsies according to a standard protocol rather than relying on endoscopic appearance alone. The practical implications are threefold. Patients from this region with endoscopically proven gastric or duodenal ulceration should be regarded as infected until proved otherwise and offered eradication, with confirmatory histology rather than abandonment of treatment when a rapid urease test is negative. Eradication should not be applied indiscriminately to undifferentiated reflux symptoms, both because the yield is low and because unnecessary antibiotic exposure aggravates the resistance problem that currently limits treatment success. Finally, the substantial rural excess indicates that durable reduction in the burden of this infection depends on improvements in drinking water quality, sanitation and household living conditions, and that clinical eradication programmes can only complement, not replace, such measures.

Declarations

Ethics approval and consent to participate: The study was approved by the Institutional Ethics Committee of Mysore Medical College and Research Institute. Written informed consent was obtained from all participants.

Conflict of interest: The authors declare that they have no competing interests.

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