ORIGINAL ARTICLE

Prevalence of *Helicobacter pylori* Infection in High-school Students on Lanyu Island, Taiwan: Risk Factor Analysis and Effect on Growth

*Hsin Chi,[1,2,3] Ming-Jong Bair,[2,4] Ming-Shiang Wu,[3] Nan-Chang Chiu,[1,2] Ya-Chun Hsiao,[4] Kuan-Yu Chang[5]**

Background/Purpose: The Yami inhabit Lanyu Island and are the smallest and most primitive aboriginal tribe in Taiwan. Lanyu Island is a closed environment and little information is available on the prevalence of *Helicobacter pylori* infection there. This study aimed to establish the prevalence of *H. pylori* infection in high-school students on Lanyu Island and its risk factors and effect on growth.
Methods: A cross-sectional population-based study was conducted among high-school students to determine the prevalence of *H. pylori* infection by using the ^{13}C urea breath test. A questionnaire was administered to the recruited population. Relevant personal and socioeconomic data for risk factors of infection were collected. Body height and weight of the recruited adolescents in relation to *H. pylori* infection were analyzed.
Results: A total of 106 high-school students (55 boys and 51 girls), with a mean age of 14.3 ± 1.4 years were enrolled. The overall prevalence of *H. pylori* infection was 54.7%. Those residing in Dongcing village had the highest rate of *H. pylori* infection (73.3%). There was no difference in the prevalence of *H. pylori* infection according to sex, ethnicity, socioeconomic level or parental education. Sixty-two students (54.8%) were completely asymptomatic and the others had at least one gastrointestinal symptom. *H. pylori* infection was asymptomatic in 56.8% and symptomatic in 53.2% of students. There was no significant difference between infected and uninfected children with regard to body weight, height and body mass index.
Conclusion: The prevalence of *H. pylori* infection is high among high-school students on Lanyu Island. There is no evidence that infection is related to growth failure. [*J Formos Med Assoc* 2009;108(12):929–936]

Key Words: adolescent, growth, *Helicobacter pylori*, prevalence, urea breath test

Helicobacter pylori is a major microorganism for the development of a diverse spectrum of gastroduodenal diseases.[1,2] Infection with *H. pylori* is acquired mainly in childhood and is life-long in the absence of treatment.[3–5] In developing countries, the prevalence of *H. pylori* infection could be as high as 80% in children < 10 years of age.[4] The major reported risk factors for infection are poor socioeconomic and hygienic conditions in childhood.[6,7] In older children, *H. pylori* infection is associated with growth delay, poor socioeconomic conditions, and household

[1]Department of Pediatrics, Mackay Memorial Hospital, [2]College of Mackay Medicine, Nursing and Management College, and [3]Graduate Institute of Clinical Medicine, National Taiwan University College of Medicine, Taipei, and Departments of [4]Internal Medicine and [5]Surgery, Mackay Memorial Hospital, Taitung, Taiwan.

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***Correspondence to:** Dr Kuan-Yu Chang, Department of Surgery, Mackay Memorial Hospital, Taitung Branch, 1 Lane 303, Changsha Street, Taitung 95054, Taiwan.
E-mail: chi.4531@ms1.mmh.org.tw

overcrowding.[8,9] *H. pylori* colonization in early infancy predisposes to the development of malnutrition and growth delay, however, the effect does not persist into later childhood in Gambia.[10]

Lanyu Island is an isolated community located about 65 km from Southeastern Taiwan, and is a closed environment. Although there have been several reports about *H. pylori* infection in Taiwan,[11–16] little information is available about its prevalence on Lanyu Island. High stomach cancer mortality areas are clustered in aboriginal townships where the prevalence of *H. pylori* is high.[17] *H. pylori* infection has been associated with gastric carcinoma.[17,18] Therefore, it is important to know the prevalence of this infection on the island. We performed this study to establish the prevalence of *H. pylori* infection among high-school students on Lanyu Island, and its associated risk factors and growth effects.

Methods

Subjects

We conducted a cross-sectional study on high-school students on Lanyu Island, Taitung County in 2008. Healthy high-school students were recruited. Signed informed consent was obtained from their parents. Questionnaires were administered to the parents to investigate possible risk factors, and the ^{13}C urea breath test (UBT) was performed to determine *H. pylori* status. This study was evaluated and approved by the Ethics Committee of Mackay Memorial Hospital, Taitung, Taiwan.

Risk factors for infection were evaluated using questionnaires about family income, number of siblings, sharing beds in childhood, and paternal and maternal educational level. Dyspepsia was defined as epigastralgia, postprandial fullness, dull pain, regurgitation, fasting discomfort, and heartburn. Dull pain was discomfort or slight pain in the stomach. Fasting discomfort was abdominal discomfort when hungry. The symptom of regurgitation was spontaneous, effortless reflux of gastric contents into the esophagus or mouth. All the participants were investigated at school and the symptoms card was explained by the authors and filled in during the day of examination by each participant. If the students had at least one of the above symptoms, they were recorded as symptomatic.

H. pylori status was assessed using the ^{13}C UBT, which indicates active *H. pylori* infection. The test detects the presence of *H. pylori* from an enrichment of breath $^{13}CO_2$, which is critically dependent on the amount of dilution by endogenous CO_2 production. A host-dependent urea hydrolysis rate was calculated independently for children. The ^{13}C UBT was administered using 75 mg ^{13}C urea dissolved in 200 mL water. Breath samples were collected before and 30 minutes after drinking the water. Breath samples were analyzed with a nondispersive infrared spectrometer, and the results were considered positive when delta over baseline was > 4.0%.[19]

All patients had their weight, height, waist circumference and hip circumference recorded at the time of the ^{13}C UBT, and body mass index (BMI) was calculated. We calculated the height, weight and BMI standard deviation (SD) scores by using the 2004 Taiwan normative data supplied by the Bureau of Health Promotion, Department of Health, Taiwan.

Statistical analysis

Continuous variables were expressed as mean ± SD and were compared using Student's *t* test. Categorical variables were expressed as absolute and relative frequencies and were compared using the χ^2 or Fisher's exact test. Independent-samples Student's *t* test was used to compare height, weight and BMI SD score of the *H. pylori*-positive and -negative groups. Significance levels were set at $p < 0.05$.

Results

There were 106 subjects from 90 families enrolled in the study. Fifty-eight patients (54.7%) were considered to have *H. pylori* infection because they had a positive ^{13}C UBT. Age, sex, class, and

area of residency for the *H. pylori*-positive patients are summarized in Table 1. The frequency of *H. pylori* infection was similar in both male and female subjects (60.0% *vs.* 49.0%, $p = 0.26$). There was a significant geographical variation, with the highest positive rate (73.3%) in Dongcing village (odds ratio = 3.93, 95% confidence interval = 1.11–13.85, $p = 0.029$). There were 14 families that had two or more adolescents who were recruited into this study. We found concordance in positivity (7/14) or negativity (4/14) for *H. pylori* infection among the siblings of each family. The distribution of *H. pylori* infection in different age groups is shown in the Figure. The > 15 years age group tended to have a higher prevalence than the younger age groups but the differences were not significant ($p = 0.25$). However, there was a marginally significant difference between adolescents aged < 13 years and > 15 years (47.6% *vs.* 72.2%, $p = 0.08$).

Risk factors of patients with and without *H. pylori* infection are listed in Table 2. The prevalence was higher for those who had no or one sibling (71.4%), but the difference was not statistically significant ($p = 0.11$). We did not find any effect of household overcrowding, educational level or family income on *H. pylori* infection. There was also no significant difference in family income ($p = 0.37$), paternal education level ($p = 0.62$) or maternal education level ($p = 0.16$) among the four villages on Lanyu Island.

From a clinical point of view, 62 (54.8%) students were completely asymptomatic and the other 44 had at least one gastrointestinal symptom. The frequency of all gastrointestinal complaints is shown in Table 3. *H. pylori* infection was found in 56.8% and 53.2% of subjects with and without gastrointestinal symptoms, respectively ($p = 0.71$). Clinical variables including epigastralgia, postprandial fullness, dull pain, regurgitation, fasting discomfort, and heartburn were all without any significant association with *H. pylori* infection.

The weight, height, BMI, and SD scores in patients with and without *H. pylori* infection are summarized in Table 4. The mean height, weight, BMI, and SD scores, and waist and hip circumferences

Table 1. Demographic factors and clinical data of adolescents with and without *Helicobacter pylori* infection*

Parameter	Positive ($n = 58$)	Negative ($n = 48$)	p
Age (yr)	14.4 ± 1.5	14.0 ± 1.2	0.13
Sex			0.26
Male	33 (60.0)	22 (40.0)	
Female	25 (49.0)	26 (51.0)	
Place of residency			0.06
Hongtou village	7 (38.9)	11 (61.1)	
Langdao village	18 (46.2)	21 (53.8)	
Yeiou village	11 (57.9)	8 (42.1)	
Dongcing village	22 (73.3)	8 (26.7)	
School grade			
Junior high school	47 (51.6)	44 (48.4)	
Grade 1, class A	4 (30.8)	9 (69.2)	0.13
Grade 1, class B	6 (60.0)	4 (40.0)	
Grade 2, class A	7 (58.3)	5 (41.7)	0.93
Grade 2, class B	12 (60.0)	8 (40.0)	
Grade 3, class A	12 (60.0)	8 (40.0)	0.18
Grade 3, class B	6 (37.5)	10 (62.5)	
Senior high school	11 (19.0)	4 (8.3)	0.07

**Data presented as mean ± standard deviation or n (%).*

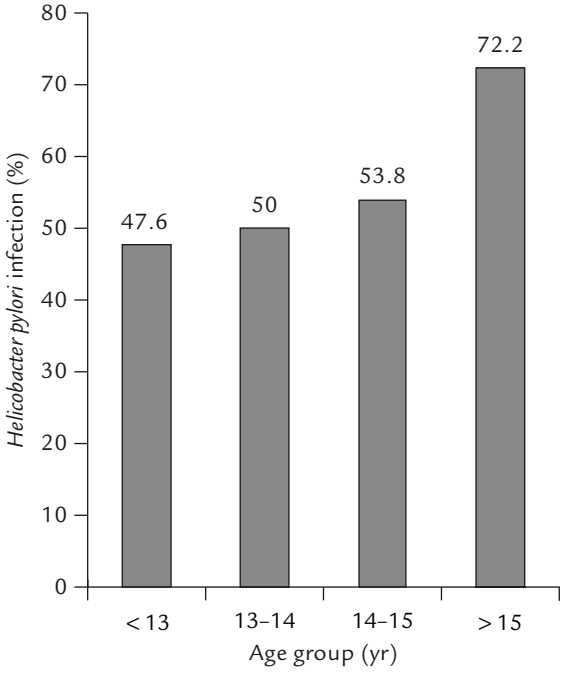

Figure. Prevalence of *Helicobacter pylori* infection diagnosed by the ^{13}C urea breath test on Lanyu Island in different age groups.

Table 2. Association of risk factors with and without *Helicobacter pylori* infection*

Parameter	Positive ($n=58$)	Negative ($n=48$)	OR	95% CI	p
Domestic crowding					
Sibship					
≤4	34 (54.5)	28 (45.2)	1	–	
>4	24 (54.8)	20 (45.5)	0.99	0.45–2.15	0.98
Siblings					
0 or 1	15 (71.4)	6 (28.6)	1	–	
2 or 3	20 (43.5)	26 (56.5)	0.50	0.16–1.58	0.24
≥4	23 (62.2)	14 (37.8)	0.66	0.21–2.09	0.48
Person sharing bed					
1 or 2	37 (55.2)	30 (44.8)	1	–	
≥3	21 (53.8)	18 (46.2)	0.95	0.43–2.09	0.89
Paternal educational level					
Primary school	15 (65.2)	8 (34.8)	2.34	0.49–11.27	0.18
High school	39 (52.7)	35 (47.3)	1.39	0.35–5.58	0.25
College	4 (44.4)	5 (55.6)	1	–	
Maternal educational level					
Primary school	9 (60.0)	6 (40.0)	1.50	0.30–7.53	0.62
High school	44 (54.3)	37 (45.7)	1.19	0.32–4.43	0.80
College	5 (50.0)	5 (50.0)	1	–	
Family annual income (NT$)					
≤300,000	2 (66.7)	1 (33.3)	2.18	0.17–27.56	0.39
300,000–1,000,000	45 (56.6)	35 (43.8)	1.4	0.55–3.55	0.47
>1,000,000	11 (47.8)	12 (52.2)	1	–	

**Data presented as n (%) or range. OR = odds ratio; CI = confidence interval; NT$ = new Taiwan dollars.*

Table 3. Gastrointestinal complaints in patients with and without *Helicobacter pylori* infection*

Symptoms	Positive ($n=58$)	Negative ($n=48$)	OR	95% CI	p
Symptomatic	25 (43.1)	19 (39.6)	1.16	0.53–2.52	0.71
Epigastralgia	16 (27.6)	15 (31.3)	0.84	0.36–1.94	0.68
Postprandial fullness	13 (22.4)	9 (18.8)	1.25	0.48–3.24	0.64
Dull pain	13 (22.4)	7 (14.6)	1.69	0.62–4.65	0.31
Regurgitation	8 (13.8)	4 (8.3)	1.76	0.50–6.25	0.17
Fasting discomfort	7 (12.1)	4 (8.3)	1.51	0.41–5.50	0.21
Heartburn	7 (12.1)	3 (6.3)	2.06	0.50–8.44	0.16

**Data presented as n (%) or range. OR = odds ratio; CI = confidence interval.*

were not significantly associated with *H. pylori* infection. The only significant difference was for waist/hip circumference ratio between *H. pylori*-positive and -negative patients ($p=0.04$). Of the 58 adolescents with *H. pylori* infection, 31% were below the 25th percentile for height compared with 33% of those without *H. pylori* infection ($p=0.80$).

Discussion

Among noninvasive methods for detecting *H. pylori* infection, serological testing by enzyme-linked immunosorbent assay (ELISA) and ^{13}C UBT are utilized frequently to investigate epidemiology.[20–22] Unlike previous studies in Taiwan that have used

Table 4. Mean weight, height, body mass index, and standard deviation score of children with and without *Helicobacter pylori* infection*

H. pylori infection	Positive ($n=58$)	Negative ($n=48$)	p
Height	159.40 ± 10.00	157.00 ± 8.10	0.17
Height SD score	–0.21 ± 1.09	–0.33 ± 0.86	0.54
Weight	56.10 ± 14.20	52.20 ± 9.90	0.10
Weight SD score	0.09 ± 0.98	–0.06 ± 0.74	0.41
BMI	21.87 ± 4.26	21.11 ± 3.12	0.31
BMI SD score	0.20 ± 1.04	0.09 ± 0.80	0.54
Waist circumference (cm)	76.10 ± 9.80	73.00 ± 7.70	0.08
Hip circumference (cm)	91.50 ± 8.20	91.10 ± 7.30	0.80
W/H ratio	0.83 ± 0.08	0.80 ± 0.06	0.04

**Data presented as mean ± standard deviation. BMI = body mass index; W/H = waist/hip circumference.*

ELISA,[11–16] we chose ^{13}C UBT to detect the prevalence of *H. pylori* infection in adolescents. The reported sensitivity and specificity of ^{13}C UBT is > 90%.[23–25] Currently, the ^{13}C UBT is accepted widely as the gold standard, noninvasive diagnostic test for *H. pylori* infection. However, the ^{13}C UBT does not reflect the severity of histological findings in children with *H. pylori* infection.[26]

In our study, the overall prevalence rate of *H. pylori* infection on Lanyu Island was 54.7% by using the ^{13}C UBT. Such prevalence is much higher than the previously reported 21.5% in 15–18-year-old non-aboriginal populations in Taipei, Taiwan.[13] The positivity of antibodies against *H. pylori* has been reported to be 21.1% in adolescents[11] and 54.4% in adults aged > 30 years in Taiwan.[14,18] Wu et al reported that the seroprevalence of *H. pylori* infection is abruptly increased in young adolescence.[12] We also found that prevalence increased with age, even during the short period of adolescence. In a previous study, the seroprevalence of *H. pylori* was 71.0% among randomly selected children aged 13–15 years on Lanyu Island.[16] Similar to previous studies selecting similar age groups, the prevalence is higher on this island. Such a high prevalence may be because we studied a Yami aboriginal population who live on a closed and isolated island.

Lanyu Island is a small and mountainous volcanic island. Most of the residents still rely on the streams on the island, and might have poorer socioeconomic status than that in the general Taiwanese population. In 75% of families, their annual income was between NT$300,000 and NT$1000,000. Major risk factors for acquiring *H. pylori* are crowding and poor hygiene conditions.[6,8,27] In the present study, the prevalence of *H. pylori* infection in high-school students on Lanyu Island was evidently higher than that in the corresponding age group in Taiwan.[12,28] We found that the highest rate was in Dongcing village, which is located on the east side of Lanyu Island. This area is relatively closed and has less communication with Taiwan than other areas on Lanyu Island because of transport problems. A significant difference in *H. pylori* seroprevalence has been observed between aboriginal townships and metropolitan precincts in central Taiwan.[29] Lin et al suggested that poor water supply and sewage disposal, and other environmental hygiene problems in aboriginal townships play a role in the acquisition of infection.

Early childhood is the age of acquisition for *H. pylori* infection in developing countries, whereas in developed countries, infection is acquired after the age of 10 years.[5,30] Direct person-to-person contact has been suggested as the primary route of transmission in developed countries, whereas fecal–oral exposure to contaminated water is implicated in developing countries.[31] Young children have many behavioral characteristics associated

with an increased risk for transmitting infectious agents, whereas children aged > 10 years begin to be more independent, with more social contact and exposure.[32]

In our study, we did not find any association between the number of siblings and *H. pylori* prevalence. However, concordance of *H. pylori* infection between the siblings was observed. Early childhood transmission among siblings seems an important determinant of *H. pylori* seropositivity in Taiwan.[14] A large number of siblings indicates crowded living conditions; the biological gradient seemed to suggest that close person-to-person contact was important in the determination of *H. pylori* infection. The Yami inhabitants of Lanyu Island are the smallest and most primitive aborigine tribe in Taiwan, and differ from the Taiwanese people in their culture and lifestyle. On Lanyu Island, the places for daily activity and sleep for children are not restricted in the family. The cultural differences might explain partially the discrepant results, for example, no difference in families with a larger number of sibling and higher rate of *H. pylori* infection in those who do not share a bed with others. We also found that there was a difference in *H. pylori* infection prevalence between two classes of the same grade, and this might reflect person-to-person transmission among teenagers.

H. pylori is associated with chronic antral gastritis that is related to duodenal ulcer, gastric ulcer, and probably gastric carcinoma.[1] In addition, a close relationship between duodenal ulcer, chronic active gastritis and *H. pylori* is present in children and adolescents.[33] Many endoscopic studies have supported the association between *H. pylori* infection and gastroduodenal pathology in children.[34,35] In our study, more than half of the students with *H. pylori* infection did not complain of any symptoms. This result supports the hypothesis that the abdominal complaints found in children with *H. pylori* infection are not caused by the infection itself.[36]

In our study, growth status did not differ significantly between the infected and uninfected adolescents. *H. pylori* colonization in early infancy predisposes to the development of malnutrition and growth failure, but the effect does not persist into later childhood.[10] However, Patel et al reported that although infected children at 7 years of age were slightly shorter than their uninfected peers, there was a greater difference in height between children with and without infection at age 11 years.[8] Fialho et al reported that *H. pylori* infection is a risk factor for short stature, especially in children aged 8–14 years.[19] This implies that the association between *H. pylori* and growth is age-specific, and explains why growth failure that accompanies *H. pylori* colonization in childhood is reported more commonly in longitudinal[8] rather than cross-sectional studies.[37,38]

Our findings should be interpreted with caution, given that the sample was limited to the 106 children who attended the only high school on Lanyu Island. The sample size may have led us to underestimate the strength of the association of risk factors and the effect on growth with *H. pylori* infection. Nevertheless, our study involved almost all of the high school students on the island.

In conclusion, this cross-sectional study found a high prevalence of *H. pylori* infection in high-school students on Lanyu Island. The growth status did not differ significantly between the infected and uninfected adolescents. Further longitudinal studies are needed to estimate the trends in infection status of children on Lanyu Island.

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