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Dietary patterns and *Helicobacter pylori* infection in a group of Chinese adults ages between 45 and 59 years old

An observational study

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Abstract

Limited studies have reported the association between dietary patterns and the risk of *Helicobacter pylori* (*H pylori*) infection. The purpose of this study was to evaluate the relationship between dietary patterns and *H pylori* infection in a Chinese population ages from 45 to 59 years. We performed a cross-sectional examination of the associations between dietary patterns and *H pylori* infection in 3014 Chinese adults ages between 45 and 59 years from Hangzhou city, Zhejiang province, China. Dietary intake was assessed through a semi-quantitative food frequency questionnaire (FFQ). *H pylori* infection was diagnosed using the ^{13}C-urea breath test. Multivariable logistic regression analyses were used to determine the associations between dietary patterns and the risk of *H pylori* infection. The prevalence of *H pylori* infection was 27.5%. Four major dietary patterns were identified by means of factor analysis: health-conscious, Western, grains-vegetables and high-salt patterns. After adjustment for the potential confounders, participants in the highest quartile of the "grains-vegetables" pattern scores had a lower odds ratio (OR) for *H pylori* infection (OR = 0.82; 95% confidence interval [CI]: 0.732–0.973; *P* = .04) than did those in the lowest quartile. Compared with those in the lowest quartile, participants in the highest quartile of the "high-salt" pattern scores had a greater OR for *H pylori* infection (OR = 1.13; 95%CI: 1.004–1.139; *P* = .048). Besides, no significant associations were found between the "health-conscious" and "Western" dietary patterns and the risk of *H pylori* infection.

Our findings demonstrate that the "grains-vegetables" pattern is associated with a decreased risk, while "high-salt" pattern is associated with an increased risk of *H pylori* infection.

Abbreviations: BMI = body mass index, CI = confidence interval, DBP = diastolic blood pressure, FFQ = food frequency questionnaire, *H pylori* = *Helicobacter pylori*, IPAQ = International Physical Activity Questionnaire, MET = metabolic equivalent, OR = odds ratio, SBP = systolic blood pressure, SD = standard deviation, WC = waist circumference.

Keywords: China, dietary patterns, factor analysis, *Helicobacter pylori* infection, middle-ages population

1. Introduction

Helicobacter pylori (*H pylori*) is the main bacterial cause of chronic gastritis, nonulcer dyspepsia, gastroduodenal ulcer disease, and stomach cancer.[1] It is estimated that *H pylori* infection affects ~50% of the world's population.[2] In China, *H pylori* infection is a major health problem and its prevalence ranges from 41.5% to 72.3%, varying with the population and geographic area.[3] Known risk factors for *H pylori* infection included age, gender, smoking, body iron stores, and alcohol intake.[4,5] Besides, dietary factors have also been recognized as an important risk factor for *H pylori* infection.[6]

Over the past several decades, epidemiological studies have found that diet plays an important role in the development of *H pylori* infection,[7] and examined the associations between the intakes of individual foods and/or nutrients and the risk of *H pylori* infection.[6–8] Nevertheless, in reality, people do not eat foods or nutrients in isolation, but usually consume meals containing many combinations of different foods and nutrients.[9] To address this problem, dietary pattern analysis has emerged in nutritional epidemiology as a complementary approach for examining the relationship between diet and health outcomes, and it considers the combined effects of foods and potentially facilitate nutritional recommendations.[10]

Recently, some epidemiological studies have reported the associations between dietary patterns and gastric cancer risk.[11–13] Yet, limited data evaluated the associations of dietary patterns with *H pylori* infection, and only one published study to our knowledge has examined the association of dietary patterns in relation to *H pylori* infection risk in Chinese adults.[14] Owing to the absence of studies assessing the association between dietary patterns and *H pylori* infection, therefore we designed this cross-sectional

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study to ascertain the association between dietary patterns and the risk of *H pylori* infection in Chinese population ages from 45 to 59 years.

2. Subjects and methods

2.1. Study population

A population-based cross-sectional study on *H pylori* infection was performed in the city of Hangzhou, Zhejiang Province during 2015 to 2016. The study sample was taken from Zhejiang is a province in the East China with a population of 57 million, while Hangzhou is a capital of Zhejiang, with a population of 8 million. In this study, the sample was taken from 10 areas (Gongshu, Shangcheng, Xiacheng, Jianggan, Xihu, Bingjiang, Xiaoshan, Yuhang, Fuyang, and Linan) and 3 counties (Tonglu, Chunan, and Jiande) by a stratified cluster random-sampling method. We chose one residential village or community from every county or area randomly, according to resident health records, with participants ages between 45 and 59 years residing in the selected villages or communities. During the research period, participants who previously or currently received treatment to eradicate *H pylori* have been excluded in this study. A total of 3252 subjects with no history of *H pylori* eradication therapy, ages between 45 and 59 years old, were enrolled when having their annual health examinations at the Medical Center for Physical Examination, Zhejiang Hospital, where participants were interviewed face-to-face by a trained staff using a written questionnaire. We excluded subjects who did not complete data collection, for example, missing information on dietary intake or anthropometric information (n=135). Besides, we also excluded subjects who had a history of cardiovascular disease (n=82) or cancer (n=21), because we considered cardiovascular disease (e.g. coronary heart disease, hypertension, and stroke) and cancer could affect lifestyles of subjects. Finally, the study subjects comprised 3014 participants for our analyses. Written informed consent was provided from each participant, and the study protocol was in accordance with the Declaration of Helsinki and was approved by the Institutional Review and Ethics Committee of Zhejiang Hospital.

2.2. Assessment of anthropometric measurements

Height and weight were measured while the subjects wore no shoes and light clothes. Body mass index (BMI, weight in kilograms divided by squared height in meters, kg/m^2) was calculated from weight measured to the nearest 0.1 kg and height measured to the nearest 0.1 cm. Waist circumference (WC, cm) was measured at the umbilicus and rounded to the nearest centimeter.[15]

2.3. Assessment of dietary intake

Dietary intake were assessed through a validated semi-quantitative food frequency questionnaire (FFQ) containing questions on the frequency with which 135 food items were eaten in the previous 12 months. Before this study, a pilot survey on the validity of the FFQ has been performed in a middle-ages Chinese population by comparison with 3 24-h dietary recalls. Thus, the validity and the reliability of this FFQ have been documented elsewhere.[9] Briefly, participants were recorded both the frequency and portion size (grams per times or cup per times) of food items during the previous year. For instance, the frequency response for fruits intake included nine categories, as following: rarely, <1/month, 1 to 3 times/month, 1 to 2 times/week, 3 to 4 times/week, 5 to 6 times/week, 1 time/day, 2 times/day, and 3 times/day. Responses were converted to food intake in grams per day (calculated as the product of the reported frequency and portion size) and further categorized into 25 food groups based on the similar characteristics and nutritional content (Table 1).

Table 1

Food groups used in the factor analysis.

Food groups	Food items
Refined grains	Rice, porridge, rice in soup, noodles, instant noodles, steamed bun, wonton, dumplings, white breads, toasted bread
Whole grains	Corn, sorghum, millet, oats
Roots and tubers	Sweet potato, potato, taro
Vegetables	Wild vegetables, green vegetable, spinach, green peppers, tomato Chinese cabbage, radish, cucumber, eggplant
Fresh fruit	Apple, pears, peach, apricots, cherries, grapes, kiwifruit, persimmon, bananas, cantaloupe, watermelon, oranges, grapefruit, strawberries et al
Pickled vegetables	Salted vegetables, Chinese sauerkraut
Mushrooms	Mushroom, shiitakes, enoki
Red meat	Pork, mutton, beef
Poultry and organs	Chicken, duck, liver, animal blood
Processed and cooked meat	Ham and sausage, sauced pork, roast duck
Fish and shrimp	Fish, shrimp
Eggs	Duck eggs, chicken eggs
Seafood	Sea fish, shrimp, crab, squid, jellyfish, shellfish
Bacon and salted fish	Salted meat and duck, salted fish
Salted and preserved eggs	Salted duck and chicken eggs, preserved eggs
milk	Liquid milk, milk powder, yoghurt
Cheese	Cheese
Soya bean and its products	Tofu, dried bean curd, soy milk
Miscellaneous bean	Mung beans, red beans, hemp beans
Fats	Lard, butter
Vegetable oil	Soybean oil, tea oil, rapeseed oil, olive oil
Fast foods	KFC, McDonald fried dough sticks and twists, fried cakes, pizza
Nuts and seeds	All varieties including walnut, peanuts, almonds, seeds, seed products
Snacks	Cookies, sachima, bread, cake, ice cream, candy, sweets, potato chips, shrimp roll, popcorn
Chocolates	Chocolates
Honey	Honey, hydromel
Drinks	Coca-cola, sprite, fruit and vegetable drink, fruits juice
Alcoholic beverages	Beer, fruit wine, grape wine
Tea	Tea, scented tea, wong Lo Kat
Coffee	Coffee

2.4. Identification of dietary patterns

Before we performed the factor analysis, the Kaiser–Meyer–Olkin Measure was used to assess the sample adequacy and the Bartlett's test was used to assess sphericity. We applied factor analysis (principal component) with orthogonal transformation (varimax rotation) to generate the major dietary factors. The Eigenvalue and Scree plot were used to determine which factors to be remained.[16] In our analyses, factor groups with a factor loading≥|0.3| were considered to be significantly conducive to the certain pattern. The labeling of major dietary patterns was based on the interpretation of foods listed in Table 1 with high factor loadings for each dietary pattern.[9] Participant scores were then categorized into quartiles separately for each dietary pattern. Thus, for each dietary pattern, quartile 4 was composed of persons whose diets conformed most closely to that particular pattern.

Four major dietary patterns were identified: namely the "health-conscious" pattern (high in vegetables, fresh fruit, red meat, fish and shrimps, eggs, milk, vegetable oil, and tea.), the "Western" pattern (high in red meat, poultry and organs, innards, shellfish, seafood products, cheese, animal fats, fast foods, snacks, chocolates, soft drinks, and coffee.), the "grains-vegetables" pattern (high in whole-grains, roots and tubers, vegetables, mushrooms, miscellaneous bean, vegetable oils, nuts, and seeds) and the "high-salt" pattern (high in refined grains, pickled vegetables, bacon and salted fish, salted and preserved eggs, processed and cooked meat, wine and tea.).

2.5. Assessment of other variables

In our study, the International Physical Activity Questionnaire (IPAQ)[17] was used to collect the data on physical activity of the participants, and results were presented as metabolic equivalent in hours per week (MET-h/week). In our investigations, the different metabolic equivalent levels were ranged on a scale from sleeping (0.9 METs) to a high level of physical activity (>6 METs). Finally, the different MET levels were divided into 3 categories (light, moderate, and heavy). Besides, information about economic income, smoking habits (non-smokers, ex-smokers, and current smokers), educational levels, alcohol consumption have been obtained through using a written questionnaire. However, total energy intake has also been assessed through the FFQ, and results were expressed in kilo-calorie per day (kcal/d).

2.6. Diagnosis of H pylori infection

In the department of clinical pathology of our hospital, *H pylori* infection was diagnosed by using the ^{13}C-urea breath test.[18]

2.7. Definition of other variables

Hypertension was defined as a systolic blood pressure (SBP) ≥140mm Hg and/or diastolic blood pressure (DBP) ≥90mm Hg, or as having received antihypertensive treatment.[19] In China, obesity was defined by BMI > 27.9 kg/m^2 and central obesity was defined as WC≥85 cm for males or WC≥80 cm for females.[20]

2.8. Data analysis

Data were analyzed based on the quartiles of each dietary pattern score, and results for continuous variables are presented as mean ± standard deviation (SD), and categorical variables are presented as sum and percentages. For the normal distributed variables, we used Independent-Samples *T* Test to evaluate the significant differences in continuous variables. If not, the Mann–Whitney test was required. Moreover, the Chi-squared test was used to determine significant differences for categorical variables. After adjusting for potential confounders, the multivariate logistic regression analysis was applied to estimate OR and 95% CIs of *H pylori* infection risk according to the quartiles of each dietary pattern score. In our analyses, Model 1 was unadjusted; Model 2 was adjusted for age, gender and BMI; Model 3 was additionally adjusted for education level, physical activity level (continues), smoking status (never smoker, ex-smoker, and smoker), type 2 diabetes, family history of diseases (e.g. cardiovascular, hypertension, hyperlipidemia, and diabetes), and total energy intake. All tests were 2-sided, and *P*-values < .05 were considered significant. Statistical analyses were performed with version 22.0 of the SPSS software package (SPSS Inc, Chicago, IL).

Table 2

The characteristics of subjects with and without *H pylori* infection.

Variables	Subjects with *H pylori* infection (n = 829)	Subjects without *H pylori* infection (n = 2185)	*P*-value
Age, y	54.2 ± 9.60	51.5 ± 9.55	<.001
Gender			<.001
Male	490 (59.1)	1132 (51.8)	
Female	339 (40.9)	1053 (48.2)	
Smoking status (%)			.050
Non-smokers	618 (74.5)	1719 (78.7)	
Ex-smokers	49 (5.9)	103 (4.7)	
Current-smoker	162 (19.6)	363 (16.6)	
Education (%)			.588
<High school	90 (10.8)	263 (12.0)	
High school	518 (62.5)	1328 (60.8)	
>High school	221 (26.7)	594 (27.2)	
Economic income per person (%)			.027
≤36000 (RMB)	204 (24.6)	645 (29.5)	
36000–60000 (RMB)	450 (54.3)	1101 (50.4)	
>60000 (RMB)	175 (21.1)	439 (20.1)	
Obese (%)	143 (17.2)	336 (15.4)	.209
Hypertension (%)	211 (25.5)	520 (23.8)	.344
Hyperlipidemia (%)	19 (2.3)	46 (2.1)	.753
Diabetes mellitus (%)	158 (19.1)	385 (17.6)	.359
Physical activity (%)			.057
Light	585 (70.6)	1495 (68.4)	
Moderate	186 (22.4)	476 (21.8)	
Heavy	58 (7.0)	214 (9.8)	
Total energy intake (Kcal/d)	1983.4 ± 285.2	2109.3 ± 267.5	**<.05**

Categorical variables are presented as sum and percentages, and continuous variables are presented as Mean ± SD. * *P* values for continuous variables (Analysis of variance) and for Categorical variables (Chi-square test).

3. Results

In the present study population, the prevalence of *H pylori* infection was 27.5%.The characteristics of subjects with and without *H pylori* infection are presented in Table 2 (n = 3014). There were significant differences in study subjects with *H pylori* infection and without *H pylori* infection by age, gender, smoking status, economic income, and total energy intake (*P* < .05). Subjects with *H pylori* infection were significantly older (54.2 ± 9.60 vs 51.5 ± 9.55), to be male (59.1% vs 51.8%), and lower economic income (24.6% vs 29.5%) and total energy intake (1983.4 ± 285.2 vs 2109.3 ± 267.5) than those without *H pylori* infection.

In our analyses, the Kaiser–Meyer–Olkin index is 0.744 and Bartlett's test has also been performed (*P* < .001). These results demonstrated that the correlation between different variables was strong enough for conducting a factor analysis.[16] Four major dietary patterns including health-conscious, Western, grains-vegetables, and high-salt patterns accounted for 11.2%, 8.7%, 7.1%, and 6.5% of the dietary intake variance,

Table 3

Rotated factor-loading matrix for the 4 dietary patterns*.

Food groups	**Dietary patterns**			
	Health-conscious	**Western**	**Grains-vegetables**	**High-salt**
Refined grains	–	–	–	0.411
Whole grains	–	–	0.534	
Roots and tubers	–	–	0.471	
Vegetables	0.407	–	0.638	
Fresh fruit	0.462	–	–	
Pickled vegetables	–	–	–	0.509
Mushrooms	–	–	0.664	
Red meat	0.302	0.563	–	
Poultry and organs	–	0.502	–	
Innards	–	0.443	–	–
Processed and cooked meat	–	–	–	0.520
Fish and shrimp	0.486	–	–	–
Shellfish	–	0.395		–
Eggs	0.346	–	–	–
Seafood products	–	0.417	–	–
Bacon and salted fish	–	–	–	0.519
Salted and preserved eggs	–	–	–	0.414
Milk	0.360	–	–	–
Cheese	–	0.315	–	–
Soya bean and its products	0.401	–	–	–
Miscellaneous bean	–	–	0.414	–
Animal fats	–	0.501	–	–
Vegetable oils	0.445	–	0.392	–
Fast foods	–	0.407	–	–
Nuts and seeds	–	–	0.303	–
Snacks	–	0.517	–	–
Chocolates	–	0.435	–	–
Soft drinks	–	0.472	–	–
Wine	–	–	–	0.301
Tea	0.474	–	–	0.303
Coffee	–	0.390	–	–
Variance of intake explained (%)	11.2	8.7	7.1	6.5

* Absolute values < 0.3 were excluded for simplicity.

respectively. Totally, these 4 factors explained 33.5% of the whole variance. The factor-loading matrixes for these 4 factors have been shown in Table 3.

The characteristics of study subjects across the quartiles categories of dietary pattern scores in Hangzhou are shown in Table 4. Subjects with the top quartile of the "health-conscious" pattern showed to be older, female, smokers and have a higher education level, compared with those of subjects in the lowest quartile. Besides, subjects in the top quartile were young, male, smokers with light physical activity, higher income and prevalence of obesity, compared with those of subjects in the lowest quartile of the "Western" pattern. Furthermore, we also found that subjects in the highest quartile of the "grains-vegetables" pattern were older, female, non-smokers, vigorous physical activity and had a lower prevalence of obesity than those in the lowest quartile. Finally, subjects in the upper quartiles of the "high-salt" pattern were male, smokers, had lower income and higher prevalence of hypertension than those of individuals in the lowest quartile.

The associations between dietary patterns and *H pylori* infection status by the multivariable regression analysis were shown in Table 5. After adjustment for confounding variables, participants in the highest quartile of the "high-salt" pattern score had greater odds of *H pylori* infection (OR = 1.13; 95% CI: 1.004–1.139; *P* = .048) than did those in the lowest quartile, while those in the highest quartile of the "grains-vegetables" pattern score had a lower odds of the *H pylori* infection (OR = 0.82; 95%CI: 0.732–0.973; *P* = .04) than did those in the lowest quartile. Besides, no significant associations were observed between "health-conscious" and "Western" dietary patterns and the risk of *H pylori* infection.

4. Discussion

In this study, we derived 4 major dietary patterns: health-conscious, Western, grains-vegetables, and high-salt patterns. Our findings showed that the "grains-vegetables" pattern was associated with a decreased risk, whereas the "high-salt" pattern was associated with an increased risk of *H pylori* infection. In addition, no marked associations were observed between the "health-conscious" and "Western" pattern and the risk of *H pylori* infection after adjustment for potential confounding factors. To the best of our knowledge, this is the 1st study reporting the associations between dietary patterns and *H pylori* infection risk in a group of Chinese adults ages from 45 to 59 years.

In our analyses, we did not find the significant association between "health-conscious" pattern and *H pylori* infection. The complex nature of "health-conscious" pattern might explain the observed null association. First, a previous meta-analysis of studies showed that *H pylori* infection was an important risk factor for stomach cancer.[21] In a population-based case-control

Table 4

The characteristics of study subjects across quartile (Q) categories of dietary pattern scores in the Hangzhou, Zhejiang province.

	Health-conscious		Western		Grains-vegetables		High-Salt					
	Q1 (*n*=735)	Q4 (*n*=735)	**P*	Q1 (*n*=736)	Q4 (*n*=735)	**P*	Q1 (*n*=735)	Q4 (*n*=736)	**P*	Q1 (*n*=736)	Q4 (*n*=736)	**P*
Age, y	51.8±4.62	51.9±4.33	**<.001**	51.8±0.3	50.3±0.2	**<.001**	49.5±4.82	51.8±5.02	**<.001**	50.8±4.12	51.9±4.72	.789
Gender (%)			**<.001**			**<.001**			**<.001**			**<.001**
Male	476 (64.8)	286 (38.9)		394 (53.5)	516 (70.2)		422 (57.4)	311 (42.3)		297 (40.3)	480 (65.2)	
Female	259 (35.2)	449 (61.1)		342 (46.5)	219 (29.8)		313 (42.2)	425 (57.7)		439 (59.7)	256 (34.8)	
Obesity (%)	99 (13.5)	75 (10.2)	.053	74 (10.1)	123 (16.7)	**<.001**	114 (15.5)	79 (10.7)	**<.01**	91 (12.4)	110 (14.9)	.149
Hypertension (%)	209 (28.4)	184 (25.0)	.141	195 (26.5)	214 (29.1)	.262	201 (27.3)	190 (25.8)	.506	185 (25.1)	244 (33.2)	**<.01**
Smoking status (%)			**<.001**			**<.001**			**<.05**			**<.001**
Current	150 (20.4)	101 (13.7)		110 (14.9)	187 (25.5)		157 (21.4)	138 (18.8)		97 (13.2)	149 (20.2)	
Former	103 (14.0)	74 (10.1)		46 (6.3)	67 (9.1)		57 (7.8)	37 (5.0)		49 (6.6)	111 (15.1)	
Never	482 (65.6)	560 (76.2)		580 (78.8)	481 (65.4)		521 (70.8)	561 (76.2)		590 (80.2)	476 (64.7)	
Educational level (%)			**<.05**			.655			**<.001**			**<.001**
<High school	175 (23.8)	143 (19.5)		192 (26.1)	204 (27.7)		196 (26.6)	178 (24.2)		131 (17.8)	185 (25.2)	
High school	222 (30.2)	210 (28.6)		212 (28.8)	216 (29.4)		206 (28.0)	237 (32.2)		293 (39.8)	314 (42.6)	
>High school	338 (46.0)	382 (51.9)		332 (45.1)	315 (42.9)		333 (45.4)	321 (43.6)		312 (42.4)	237 (32.2)	
Economic income per person (%)			.066			**<.05**			**<.001**			**<.001**
≤3000 (RMB)	215 (29.3)	201 (27.3)		242 (32.9)	200 (27.2)		224 (30.5)	175 (23.8)		149 (20.2)	226 (30.7)	
3000–5000 (RMB)	251 (34.1)	222 (30.2)		272 (37.0)	264 (35.9)		316 (43.0)	283 (38.5)		295 (40.1)	359 (48.8)	
>5000 (RMB)	269 (36.6)	312 (42.5)		222 (30.1)	271 (36.9)		195 (26.5)	278 (37.7)		292 (39.7)	151 (20.5)	
Physical activity (%)			.052			**<.001**			**<.05**			.101
Light	503 (68.4)	540 (73.5)		517 (70.2)	586 (79.7)		557 (75.8)	534 (72.6)		560 (76.1)	593 (80.6)	
Moderate	151 (20.6)	116 (15.8)		135 (18.3)	98 (13.3)		113 (15.4)	105 (14.3)		90 (12.2)	77 (10.5)	
Vigorous	81 (11.0)	79 (10.7)		84 (11.5)	51 (7.0)		65 (8.8)	97 (13.1)		86 (11.7)	66 (8.9)	
Total energy intake (Kcal/d)	2239.3±223.5	2031.4±204.2	**<.05**	2170.7±280.4	2295.5±265.7	.337	1940.2±301.8	1738.4±285.2	**<.01**	1820.5±224.8	2040.8±230.6	**<.01**

Categorical variables are presented as sum and percentages, and continuous variables are presented as Mean±SD (standard deviation). * *P* values for continuous variables (analysis of variance) and for categorical variables (chi-square test). $P<.05$ was considered statistically significant. Monthly income per person (RMB) was presented as mean.

Table 5

Multivariate adjusted ORs (95%CI) for *H pylori* infection across quartile (Q) categories of dietary patterns scores.

	Health-conscious pattern Score			Western Pattern Score			Grains-vegetables Pattern Score			High-Salt Pattern Score		
	Q1	Q4	*P*	Q1	Q4	*P*	Q1	Q4	*P*	Q1	Q4	*P*
Model 1	1.00	0.83 (0.714, 0.956)	.013	1.00	1.23 (1.009, 1.626)	.01	1.00	0.67 (0.403,0.859)	.005	1.00	1.67 (1.223, 2.358)	.000
Model 2	1.00	0.95 (0.776,1.232)	.362	1.00	1.12 (0.980, 1.302)	.06	1.00	0.75 (0.574, 0.933)	.01	1.00	1.36 (1.170, 1.767)	.006
Model 3	1.00	1.07 (0.951, 1.340)	.557	1.00	1.04 (0.895, 1.168)	.535	1.00	0.82 (0.732, 0.973)	.04	1.00	1.13 (1.004, 1.139)	.048

Model 1: unadjusted; Model 2: further adjusted for gender, age, BMI; Model 3: additionally adjusted for education level, physical activity level (continues), smoking status (never smoker, ex-smoker, and smoker), type 2 diabetes, family history of diseases (e.g. cardiovascular, hypertension, hyperlipidemia, and diabetes), and total energy intake. Q4: the highest quartile of dietary patterns, Q1: the lowest quartile of dietary patterns (reference). BMI = body mass index, CI = confidence interval.

study in eastern Nebraska, Chen et al reported that higher red meat intake could increase the risk of gastric cancer, which has been documented to be associated with the risk of *H pylori* infection.[22] Besides, vegetables and fresh fruits in the present pattern were raw. Epidemiological studies have also verified that some raw food, such as vegetables and fruits maybe the important sources of resistant and virulent strains of *H pylori*.[23] Second, some previous studies have reported that high intake of vegetables and vitamins may protect against the pathological consequences of *H pylori* infection.[24] As you know, meat, especially red meat contains large amounts of vitamin A, D, and selenium. Several studies reported that high vitamin A, vitamin D, and selenium intake was associated with a decreased risk of *H pylori* infection.[25–26] Third, no significant association between this pattern and *H pylori* infection may also be due to the reverse causality. Those subjects who have been diagnosed with *H pylori* infection may have been advised by the physicians using eradication treatment, and changing their dietary habits. Briefly, these possibilities which are mentioned above could not be ruled out.

To our surprise, the "Western" dietary pattern (high in red meat, poultry and organs, innards, shellfish, seafood products, cheese, animal fats, fast foods, snacks, chocolates, soft drinks, and coffee) in the present study showed no significant association with the risk of *H pylori* infection. Inconsistent with our result, Nseir et al found that soft drink is associated with *H pylori* infection.[1] Besides, a previous study by Xia et al showed that the "high-protein/cholesterol" pattern (similar to the unhealthy dietary pattern) is associated with a decreased of *H pylori* infection in Chinese adults.[14] No significant association could be attributed to the complex constituents in this pattern. On the one hand, high consumption of red meat (containing amounts of saturated fat and cholesterol) has been reported to be positively associated with obesity, type 2 diabetes and metabolic syndrome,[20,27] which are significantly associated with *H pylori* infection. Previous research has indicated that *H pylori* infection was significantly associated with an elevated risk of metabolic syndrome in the Japanese population.[28] Similarly, Han et al[29] also found that *H pylori* infection was positively associated with T2DM risk in a middle-and old-ages Chinese population. Besides, high intake of soft drink may increase the risk of *H pylori* infection.[1] Although the mechanism is unclear, high soft drink intake may facilitate *H pylori* invasion, infection, and colonization by increasing urea influx and ammonia production by the bacteria due to prolonging the periods of gastric acidification.[1] On the other hand, it is well-known that animal food, especially red meat and innards are also rich in selenium, vitamin A, and vitamin D. In the present study, the "Western" dietary pattern was characterized by a high intake of red meat and innards. As mentioned above, previous studies have confirmed that selenium intake was associated with a decreased risk of *H pylori* infection.[25] Studies have found that the selenium level in gastric tissue is significantly higher in *H pylori*(+) gastritis.[26] Likewise, the results also found a significantly decrease in the levels of mucosal selenium in those patients who performed the *H pylori* eradication therapy successfully. Thus, it is believed that selenium accumulates in stomach tissue when it is need. Moreover, Kroner et al also found that vitamin D may be a central regulator of host defense against infections.[30] Furthermore, recent a study has reported that the vitamin D_3 decomposition product 1 may exert an antibacterial effect on *H pylori*.[31] Taken together, these possibilities that explained the null association couldn't be exclude in the present study.

The "grains-vegetables" pattern, characterized by high intake of whole-grains, roots and tubers, vegetables, mushrooms, miscellaneous bean, vegetable oils, nuts and seeds, was associated with a decreased risk of *H pylori* infection. In according with our study, a previous study by Wang et al showed that high consumption of vegetables and fruits was associated with a lower risk of *H pylori* infection.[7] The inverse association could be attributed to some beneficial constituents, for example, whole grains and vegetables in the "grains-vegetables" pattern. First, as mentioned above, higher vegetables and vitamins consumption may protect against the pathological consequences of *H pylori* infection.[24] Besides, fresh vegetables are rich in vitamin C. In elderly European men and women, Knoops et al has emphasized the role of vitamin C as a chemopreventive factor in *H pylori* gastric disorders.[32] As far as we know, previous studies have demonstrated that vitamin C may reduce the risk of stomach cancer and influence the course of *H pylori* infection.[33]

The "high-salt" dietary pattern in this paper was characterized by high intake of refined grains, pickled vegetables, bacon and salted fish, salted and preserved eggs, processed and cooked meat, wine and tea. In our analyses, we observed a positive association between this pattern and the risk of *H pylori* infection. Several potential explanations for this association should be discussed. First, some foods, for example, bacon, salted fish and processed meat in this pattern have higher salt concentration which has been reported to contribute to the pathogenicity of *H pylori*.[6] Second, some studies in recent years have confirmed that a high concentration of salt in my stomach may destroy the barrier of mucosa, favor colonization by *H pylori* and lead to inflammation and damage-causing gastritis and diffuse erosion.[34] Third, high consumption of refined grains rich in carbohydrates was significantly associated with an increased risk of *H pylori* infection.[14] Furthermore, the "high-salt" pattern in this study was also associated with high consumption of wine. There are a couple of studies that have reported the intimate association between heavy drinking and the risk of *H pylori* infection.[35,36] To the best of our knowledge, high alcohol intake might damage the barrier of gastric mucosa and then increase the gastric mucosa's permeability, and ultimately cause chemical inflammation. Thus, the association between alcohol intake and *H pylori* infection risk could be related to inflammation and its major inflammatory cytokine, such as interleukin-8.[37] Izzotti et al found that interleukin-8 was closely related to HP0638, which is the outer inflammatory protein, increasing the adhesion ability of *H pylori* bacteria and the colonization density.[14]

4.1. Strengths and limitations

This paper had several strengths and limitations. First, to the best of our knowledge, this is the 1st study in a middle-ages Chinese population to examine the associations between dietary patterns and the risk of *H pylori* infection. Second, in the present study, the dietary patterns were identified by principal component analysis with orthogonal transformation to identify the non-correlate factors. Third, in the multivariate logistic regression models, we have adjusted for a variety of potential confounders for reliability. However, several limitations of this study warrant mention. First, because of the cross-sectional design of this paper, we cannot assess the causal links between dietary patterns and the risk of *H pylori* infection. Hence, these findings should be confirmed in further prospective studies. Second, the use of principal component analysis requires several subjective decisions in the selection of included variables as well as in the detainment of number of factors to retain.[37] Third, the study participants were recruited in Hangzhou, the capital of Zhejiang province. Besides, in the present study, these participants tend to have higher economic income and educational level than the general population. Therefore, our results may not be extrapolated to the general population.

In summary, we identified 4 major dietary patterns in this population. The findings of the present cross-sectional study indicated that the "grains-vegetables" dietary pattern was significantly associated with a decreased risk, while the "high-salt" dietary pattern was associated with an increased risk of *H pylori* infection.

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Author contributions

Long Shu and Yu-Liang Feng conceived and designed the experiments. Long Shu, Xiao-Yan Zhang, and Pei-Fen Zheng conducted research. Long Shu and Yu-Liang Feng analyzed data and wrote the paper. All authors read and approved the final manuscript.

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