Heliyon 8 (2022) e09430

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Research article

The association of *Helicobacter Pylori* infection with dyslipidaemia and other atherogenic factors in dyspeptic patients at St. Paul's Hospital Millennium Medical College

Mujahid Hashim [a], Ousman Mohammed [b,*], Tatek G/Egzeabeher [c], Mistire Wolde [c]

[a] St. Paul's Hospital Millennium Medical College, Addis Ababa, Ethiopia
[b] Department of Medical Laboratory Sciences, College of Health Sciences, Wollo University, Dessie, Ethiopia
[c] Department of Medical Laboratory Sciences, College of Health Sciences, Addis Ababa University, Addis Ababa, Ethiopia

ARTICLE INFO

Keywords:
Helicobacter pylori infection
Dyslipidemia
Addis Ababa
Ethiopia

ABSTRACT

Background: Studies showed that more than half of Ethiopians were presumed to be chronically infected with *H. pylori*. Nowadays, evidence has come to the literature strongly suggesting the potential association between *H. pylori* and extra gastric disorders including atherosclerosis.

Objective: To assess the association of *helicobacter pylori* infection with dyslipidaemia and other atherogenic factors in dyspeptic patients at St. Paul's Hospital Millennium Medical College, from November 2019 to June 2020.

Materials and methods: This institution-based cross-sectional study was examining 346 dyspeptic patients at SPHMMC from November 2019 to June 2020. A structured questionnaire was used to collect socio-demography data and anthropometric measurement was taken. Biochemical parameters were measured in serum samples by using Cobas 6000 clinical chemistry analyzer. Data were coded and entered into a statistical package for social sciences (SPSS) version 23 for analysis. Risk factors were identified using logistic regression. Hence, a bivariate logistic regression analysis test was conducted and variables with a $p < 0.25$ were included in the multivariate logistic regression model. P-values ≤ 0.05 were considered as a cut point for statistical significance in the final model.

Results: An overall prevalence of dyslipidemia among study participants was 253 (73.12 %). Among those who tested positive for *H. pylori*, 119/174 (68.39 %) had dyslipidemia in at least one lipid profile, while 8 (4.60%) had dyslipidemia in all four lipid profiles. After adjusting for traditional dyslipidemia risk factors, age >45 (AOR 4.864, 95% CI 2.281–4.080, $P < 0.001$), systolic blood pressure >120mmHg (AOR 1.036, 95% CI 1.009–1.065, $P = 0.036$) and being *H. Pylori* seropositive (AOR 0.555, 95% CI 0.318–0.967, $P = 0.038$) were an independent predictors of dyslipidemia.

Conclusion: This study reported that more than two-thirds of the *H. pylori* seropositive groups had exhibited dyslipidemia in at least one lipid profile, which can accelerate the incidence of atherosclerosis process.

1. Introduction

Dyslipidaemia is defined as the elevation of any of the serum lipid profile such as plasma total cholesterol (TC), triglycerides (TGs), low-density lipoprotein (LDL-c), or low high-density lipoprotein cholesterol (HDL-c) level which is a contributing factor for the development of atherosclerosis [1, 2]. Dyslipidaemia may be caused by primary (genetic) or secondary factors. Lipid profile tests are used for screening atherosclerotic risk and in the diagnosis and treatment of dyslipidaemia. Hence, measuring plasma levels of total cholesterol, triglycerides, low-density lipoprotein and high-density lipoprotein are important for diagnosing dyslipidaemia [3, 4]. Globally, one-third of ischemic heart diseases are developed following hypercholesterolemia, and it is estimated that 2.6 million deaths are associated with hypercholesterolemia [5].

In 1982 *Helicobacter pylori* (*H. pylori*) was characterized as spiral-shaped, micro-aerophilic, and gram-negative bacteria from stomach biopsy specimens of patients with chronic gastritis [6]. It causes ubiquitous persistent bacterial infections supposed to be associated with cardiovascular and other pathologic conditions. Even though *H. pylori* infection in most individuals remains asymptomatic throughout life despite

* Corresponding author.
E-mail address: ousmanabum@gmail.com (O. Mohammed).

https://doi.org/10.1016/j.heliyon.2022.e09430
Received 15 January 2022; Received in revised form 15 March 2022; Accepted 11 May 2022

chronic gastritis associated with peptic ulcer disease, non-cardiac gastric adenocarcinoma, and gastric mucosa-associated lymphoid tissue lymphoma [7, 8, 9]. *H. pylori* infection can cause extra-gastric symptoms including atherosclerosis and peripheral vascular disease, which is a topic of debate [10]. Eradication of *H. pylori* infection has been proven to reduce the incidence of gastric cancer [11, 12]. And recently, studies demonstrated that *H. pylori* infection was also related to lipid and glucose metabolism abnormality [13]. Evidence from the literature had strongly suggested the potential association between *H. pylori* and extra gastric disorders. It was demonstrated that *H. pylori* infection affects the cardiovascular system which leads, leading to the alteration of total cholesterol, triglycerides, LDL-c, and HDL-c alteration [14, 15, 16, 17]. The meta-analysis performed to estimate the association between *H. pylori* infection and the serum lipid profile revealed that *H. pylori* infection is positively correlated with LDL-c, TC, and TG and negatively correlated with HDL-c. These studies indicated that *H. pylori* infection significantly affects the serum lipid, which might lead to lipid profile abnormality [18].

Alterations of serum lipid profile are widely known to be important risk factors of cardiovascular diseases and metabolic syndrome [19, 20]. Although the most reliable mechanism underlying the metabolic syndrome is insulin resistance, several studies have reported that chronic low-grade systemic inflammation could affect the development of the metabolic syndrome and lipid abnormalities [21]. Infection with *H. pylori* can disrupt lipid and lipoprotein metabolism, resulting in higher triglyceride, total cholesterol, low-density lipoprotein cholesterol (LDL-c), and apolipoprotein B (apo B) levels in the blood, as well as lower levels of apolipoprotein A and high-density lipoprotein cholesterol (HDL-c) [22].

The presence of *H. pylori* in the stomach causes chronic inflammation of the stomach wall, which may change the patient's biochemical parameters [23]. Due to molecular mimicry between bacterial structure and the host tissue, prolonged exposure to this bacterial compound can trigger autoimmune gastritis and lipid metabolism problems, and *H. pylori's* chronic low-grade activation of the coagulation cascade can increase lipid accumulation and worsen atherosclerosis [24]. Studies indicated that lipid absorption can be reduced as a result of the gastrointestinal inflammation caused by *H. pylori* [25]. Lipopolysaccharide has an effect on circulating macrophages, causing them to produce more free radicals. Free radicals have been shown to oxidize LDL-c and convert macrophages into foam cells, both of which are believed to play a role in the pathogenesis of atherosclerosis [26]. Furthermore, macrophages and other cells' Toll-like receptors (TLRs) recognize lipopolysaccharide (LPS) produced by gram-negative bacteria, resulting in significant changes in lipid and lipoprotein metabolism [27]. A rise in TC, LDL-c and a decrease in HDL-c in *H. pylori* infected individual's results in lipid pathologic modification, which can accelerate the development of atherosclerosis, myocardial infarction, stroke, and peripheral vascular disease [28].

Studies showed that more than half of Ethiopians were presumed to be chronically infected with *H. pylori* [29]. Thus, *H. pylorus* is a typical bacterium that provokes chronic inflammation in the host and many studies have evaluated the influence of *H pylori* infection on metabolic syndrome and serum lipid alteration [30, 31, 32, 33]. Despite the fact that in Ethiopia there is a scarcity of data. To our knowledge, we found a single published study in western parts of Ethiopia, and no study was conducted in Addis Ababa, Ethiopia. Therefore, the current study will provide additional information to the existing literature.

2. Materials and Methods

2.1. Study design, period and study area

An institution-based cross-sectional study was carried out at SPHMMC from November 2019 to June 2020. St. Paul's Hospital Millennium Medical College is one of the public hospitals and medical teaching colleges located in Addis Ababa, Ethiopia. The hospital is meeting the community's needs by providing comprehensive healthcare services, quality medical education through its advanced and affordable healthcare system.

2.2. Study population and inclusion criteria

During the study period, patients who come to the adult outpatient department (OPD) of SPHMMC with symptoms of dyspepsia were included in the study. Consecutive convenience sampling technique was used until the required sample sizes were attained. All adult (≥18 years) patients who present with symptoms of dyspepsia, for more than a week duration were screened by physicians at OPD and evaluated for *H. pylori* infection and dyslipidemia. Single population proportion was used for sample size determination. By the time of proposing the study, we found no published Ethiopian study; hence the sample size was determined using the prevalence of dyslipidemia among *H. pylori* suspected individuals (65.5%) in Sudan [34]. The expected margin of error (d) was taken at 0.05 with a confidence interval level of 95%. Therefore, a total of 346 adult volunteer dyspeptic patients were recruited. Individuals were excluded from the study based on the following: hyperlipidemia with taking antihyperlipidemic medications, those taking antibiotics, or proton-pump inhibitor within two weeks, and pregnant women were excluded from the study.

2.3. Data collection and measurement

Following a brief description of the study, data was collected from volunteers through face-to-face interviews using a structured questionnaire which was adapted from different kinds of literature. Information regarding the history of known diseases, medication is taken recently, medication history, duration of dyspepsia, alcohol drinking, chat chewing, smoking, and physical exercise habits were recorded by trained nurses using a standardized questionnaire. Each study participant had anthropometric measurements. The measurement of height was performed without a shoe-in-standing position in a height measure scale to the nearest 0.1 cm while weight was measured by digital scale to the nearest 0.1 kg. Weight measurement was performed after removing extra layers of clothing, shoes, and any items in their pockets. And body mass index (BMI) was measured as weight (kg) divided by height (meters) squared (kg/m2). Waist circumference (WC) was measured at the level of the iliac crest and the level of the umbilicus in cm to evaluate abdominal obesity. Measurement of blood pressure (BP) was taken in the right upper arm in the sitting posture, after a 5 min rest and three measurements were averaged to be recorded. After obtaining consent, five milliliters of blood were collected aseptically from the antecubital vein using a serum separator tube. The *H. pylori* antibody tests were performed on serum samples by rapid antibody test strip Wondfo (Guangzhou Wondfo Biotech Co., Ltd leaflet for *H. pylori* Antibody test) with 99.0% sensitivity and 99.20 %specificity. Biochemical parameters such as TG, HDL-c, LDL-c, and TC were analyzed with Cobas 6000 fully automated clinical chemistry analyzer using the direct endpoint enzymatic process. The cut-offs for abnormal serum lipid levels were: ≥200 mg/dL for total cholesterol (TC), for triglyceride (TG) concentrations of ≥150 mg/dL, for (LDL-c) ≥130 mg/dL, and HDL-c <40 mg/dL based on the National Cholesterol Education Program (NCEP) reference limits [35].

2.4. Data quality assurance

Following the completion of each questionnaire, cross-checking was done among data collectors and the principal investigator. The label on the test tube and the subject's unique identification number on the questionnaire were also checked for similarity. Since assuring the quality of laboratory test results is the core objective, all the requirements of patient preparation, sample collection, and sample handling were followed according to chemistry sample collection-handling and transport SOP, and the requirements related to proper use of all equipment, reagents, and controls was followed according to the standards on the

manufacturer's instructions. Furthermore, control samples were run with each set of patient samples for monitoring the performances of lipid profile determination in serum. And test procedures and interpretation of test results were also performed according to the precautions and instructions supplied by the manufacturer.

2.5. Data analysis and interpretation

The data were analyzed with SPSS Version 23 using descriptive statistics. For categorical variables, percentages and frequencies are used, while for continuous variables, mean and standard deviation were used. The presence of any correlation was assessed by Pearson correlation. An independent sample t-test was used to compare differences among various explanatory variables between *H. pylori* seropositive and negative study participants. A bivariate logistic regression analysis test was conducted to see the existence of crude association and magnitude of association that could exist between the various risk factors and dyslipidemia. Then risk factors with a $p < 0.25$ were included in the multivariate logistic regression model and P-values ≤ 0.05 were considered as a cut point.

2.6. Ethical approval and consent to participate

Ethical clearance was obtained from the Department of Medical Laboratory Sciences, College of Health Sciences, Addis Ababa University, ethical review Committee before the study. After getting all permission from all responsible bodies, written consent was obtained from all study participants. The collected clinical and laboratory data were kept confidential using unique identification numbers instead of individual names.

3. Results

3.1. Socio-demographic characteristics

A total of 346 subjects participated in the study. Of the 346 subjects, 186 (53.8%) were women and 160 (46.2%) were men, with the mean age of age 33 ± 13 years. The study participants were categorized into either *H. pylori* seronegative or *H. pylori* seropositive groups, and half 174 (50.3%) were *H. pylori* seropositive. The proportion of *H. pylori* seropositive was statistically higher in men subjects (52.9% vs 39.5%, P = .013). The mean age of the seropositive group was slightly higher than the seronegative group. Duration of dyspepsia was significantly associated with *H. pylori* infection ($P < 0.001$). Regarding the lifestyle of the study participants majority of them, 339 (98%) were nonsmokers, 230 (66.5%) did not drink Alcohol, 297 (85.8%) did not chew chat. Besides 67 (19.4%) had regular physical activity habits. Except for age, sex, and duration of dyspepsia, all other factors had no significant association with *H. pylori* infection as shown in Table 1.

Table 1. Socio-demographic distribution of gastritis patients attending OPD of SPHMMC from november 2019 to june 2020, Addis Ababa, Ethiopia.

Variable	Category	*H. Pylori* seropositive	*H. Pylori* seronegative	P value
Age	Age in Years	35.45 ± 13.70	31.79 ± 12.34	**0.009**
Sex	Male	92 (52.9%)	68 (39.5%)	**0.013**
	Female	82 (39.5%)	104 (60.5%)	
Smoking	Yes	3 (1.7%)	4 (2.3%)	0.691
	No	171 (98.3%)	168 (97.7%)	
Alcohol Drinking	Yes	64 (36.8%)	52 (30.2%)	0.197
	No	110 (63.2%)	120 (69.8%)	
Chewing Khat	Yes	27 (15.5%)	22 (12.8%)	0.467
	No	147 (84.5%)	150 (87.2%)	
Physical Activity (for ≥30 min at least 4 days/week)	Yes	39 (22.4%)	28 (16.3%)	0.149
	No	135 (77.5%)	144 (83.7%)	
History of Known Disease	Diabetic	6 (3.4%)	4 (2.3%)	0.215
	Hypertension	9 (9.2%)	3 (1.7%)	
	Renal Disease		1 (0.6%)	
	Liver Disease	–	–	
	Other Known Disease	159 (91.4%)	164 (95.3%)	
Duration of Dyspepsia	This week	15 (8.6%)	44 (25.6%)	**<0.001**
	≤1 Month	42 (24.1%)	77 (44.8%)	
	>Month	71 (40.8%)	32 (18.6%)	
	>Year	46 (26.4%)	19 (11.0%)	
Medication Taken Recently	Yes	14 (8.0%)	7 (4.1%)	0.107
	No	158 (90.8%)	165 (95.9%)	
Dietary habits	Injera &Wot	103 (59.2%)	97 (56.4%)	0.171
	Meat	39 (22.4%)	30 (17.4%)	
	Vegetarian	32 (18.4%)	45 (26.2%)	

Note: *injera and wot is a common Ethiopian food, injera is mostly prepared from teff.*

Table 2. Mean and SD value of lipid profile and anthropometric measurements among *H. pylori* infected and non-infected study participants.

Variables	H. Pylori Value		P Value
	H. Pylori seropositive	H.Pylori seronegative	
Total Cholesterol	181.81 ± 46.65	163.43 ± 33.41	**<0.001***
Triglyceride	165.18 ± 110.30	141.84 ± 101.50	**0.041***
HDL-c	43.13 ± 10.31	44.53 ± 38.34	0.642
LDL-c	118.64 ± 39.30	103.34 ± 28.57	**<0.001***
SBP	121.17 ± 16.15	116.15 ± 13.34	**0.005***
DBP	78.14 ± 10.35	75.20 ± 9.34	**0.006***
WC	83.43 ± 10.45	81.52 ± 8.737	0.060
HC	93.61 ± 8.89	93.63 ± 7.9	0.984
Weight	64.64 ± 10.54	61.71 ± 8.52	**0.005***
Height	1.66 ± 0.007	1.65 ± 0.007	0.185

Abbreviations: TC- total cholesterol, TG-triglycerides, HDL-c- high density lipoprotein cholesterol, LDL-c - low density lipoprotein cholesterol, SBP- systolic blood pressure, DBP- diastolic blood pressure, WC -waist circumference, HC- hip circumference. P-value determined by using independent sample t-test.

3.2. Prevalence of dyslipidemia among dyspeptic patients

Among dyspeptic patients, the overall prevalence of dyslipidemia in at least one of the four lipid profiles was 253 (73.12 %). Among study participants, 119/174 (68.39%) were *H. pylori* seropositive patients that had dyslipidemia in at least one of the lipid profiles, and 8 (4.60%) *H. pylori* seropositive had dyslipidemia in all of the four lipid profiles: meanwhile, from the total study participant (both *H. Pylori* seropositive and *H. Pylori* seronegative), patients who had an abnormality in all lipid profiles was 17 (4.91%). The mean level of serum total cholesterol, triglycerides and LDL-c were significantly higher ($P < 0.05$) among H. Pylori seropositive, whereas the levels of serum HDL-c was not significantly different between *H. Pylori* seropositive and *H. Pylori* seronegative groups. There was also a significant association between *H. pylori* positive and hypertension, for diastolic blood pressure (DBP) P-value = 0.006 and systolic blood pressure (SBP) P-value = 0.005 Table 2.

3.3. Correlation between H. Pylori infection and serum lipid profile

A significant positive correlation were observed between serum total cholesterol with age ($r = 0.409$, $p < 0.001$), weight ($r = 0.260$, $p < 0.001$), BMI ($r = 0.207$, $p < 0.001$), WC ($r = 0.159$, $p < 0.001$), HC ($r = 0.222$, $p < 0.001$), SBP ($r = 0.358$, $p < 0.001$), DBP ($r = 0.291$, $p < 0.001$), duration of dyspepsia ($r = 0.144$, $p = 0.007$) whereas there was statistically negative correlation between TC and sex ($r = -0.103$, $p = 0.007$), alcohol drinking ($r = -0.153$, $p = 0.004$). However, no significant

correlation was found between TC and cigarette smoking (r = 0.080, p = 0.137). Statistically significant correlation was also seen between serum TG with age (r = 0.266, p < 0.001), weight (r = 0.242, (p < 0.001), WC (r = 0.196, p < 0.001) whereas there was no statistically significant correlation between HDL-c and all associated factors as shown in Table 3.

In this study, a total of 191 (55.2%) of the study participants had abnormally low HDL-C, 201 (58.1%) had high LDL-C, 80 (23.1%) had high TC, and 72 (20.8%) had high TG values. The proportion of abnormally high serum TC, TG, and LDL-c among *H. pylori* seropositive subjects were 52 (65%), 47 (66.2%), and 108 (53.7%) respectively, while 75 (48.4%) of the total study participants had low HDL-c concentration. Concerning the magnitude of lipid profile abnormality among *H. pylori* seronegative for TC, TG, and LDL-c were 28 (35%), 24 (33.8%), and 93 (46.3%) respectively. The proportion of low HDL-c levels among *H. pylori* seronegative subjects was slightly higher than *H. pylori* seropositive one (51.6% vs 48.4%) as indicated in Table 4.

On Bivariate analysis *H. Pylori* status (COR 2.139, 95% CI 1.256–3.640 P = 0.005), Diastolic Blood Pressure (DBP) ≥90mmHg (COR 3.174, 95% CI 1.715–5.874, P < 0.001), Systolic Blood Pressure (SBP) ≥ 120 mmHg (COR 0.478, 95% CI 0.269–0.851, P = 0.012), age >45 years (COR 1.22, 95%CI 0.459–3.25, P < 0.001), and having BMI ≥25 kg/m^2 (COR 0.436, 95% CI 0.248–0.767, p = 0.004) were independently associated with serum total cholesterol concentrations. However, the other predictors were not associated with serum total cholesterol abnormality. On the multivariate analysis age >45 (AOR 4.864, 95% CI 2.281–4.080, P < 0.001), having SBP ≥120mmHg (AOR 1.036, 95% CI 1.009–1.065, P = 0.036) and being *H. Pylori* seropositive (AOR 0.555, 95% CI 0.318–0.967, P = 0.038) were the only independent predictors of dyslipidemia as shown in Table 5.

Table 4. Lipid profile versus *H. Pylori* status among adult patients attending at OPD of SPHMMC, Addis Ababa, Ethiopia.

Lipid Profile		*H. pylori* seropositive	*H. pylori* seronegative	COR	95% CI
TC	<200	122 (45.9%)	144 (54.1%)	0.456	0.272–0.766
	≥200	52 (65%)	28 (35%)		
TG	<200	127 (46.2%)	148 (53.8%)	0.438	0.254–0.756
	≥200	47 (66.2%)	24 (33.8%)		
HDL-c	<40	75 (48.4%)	80 (51.6%)	0.871	0.570–1.331
	≥40	99 (51.8%)	92 (48.2%)		
LDL-c	<100	66 (45.5%)	79 (54.5%)	0.847	0.680–1.055
	≥100	108 (53.7%)	93 (46.3%)		

Abbreviations: TC-Total Cholesterol, TG-Triglyceride, LDL-c-Low Density Lipoprotein-Cholesterol, HDL-c- High Density Lipoprotein Cholesterol, COR-crude odd ratio, CI-confidence interval.

4. Discussion

Globally, *H. pylori* infection is one of the most widespread bacterial infections; it affects more than 80% of the populations in developing countries [36]. Infection with *H. pylori* is usually acquired in childhood via oral-oral or fecal-oral routes. The seropositive prevalence of *H. pylori* infection among the current study population was 50.3%. Nowadays, evidence has come to the literature strongly suggesting the potential association between *H. pylori* and extra gastric disorders. It was demonstrated that *H. pylori* infection affects the cardiovascular system which leads to the alteration of total cholesterol, triglycerides, LDL-c, and HDL cholesterol [37, 38, 39].

Dyslipidemia is a group of disorders in the metabolism of cholesterol and triglycerides, which bring implications inside the cardiovascular system leads to vascular coronary disease and atherosclerosis [40]. The dyslipidemias are basically categorized as under those who experience elevated levels of triglycerides, TC, LDL-c, or a mixed form of all, and the decreased levels of the HDL cholesterol. A Result from a previous study showed that there was a relationship between *H. pylori* infection and chronic progression of atherogenesis by changes in serum lipid metabolism mainly low-density lipoprotein (LDL) cholesterol and high-density lipoprotein (HDL) cholesterol are known as the risk factors for cardiovascular diseases, but the mechanism is not understood perfectly yet [41, 42, 43, 44, 45]. The present study also revealed a significant increase in the levels of total cholesterol, triglycerides, and LDL-c among patients with *H. pylori* infection when compared with healthy individuals (p < 0.001, p = 0.041, and p < 0.00) respectively. Our findings were inconsistent with a study conducted in Korea; found that *H. Pylori* is related to higher levels of TC and LDL-c [46]. According to the results of the current study, in male subjects, *H. pylori* seropositivity resulted in a significant increase of serum LDL-c (*P* value = 0.03); even though higher levels of TG and lower levels of HDL-c were observed among *H. pylori* seropositive subjects, there was no significant difference between seropositive and seronegative subjects regarding the level of HDL-c and TG. Similarly, the result of a study done by Mohamadreza Haeri et al. showed that the level of TC and TG were significantly higher among *H. pylori* seropositive individuals than the ones without such infection [41]. This could be due to the involvement of cytokines, especially tumor necrosis factor, which inhibits lipoprotein lipase and enhances free radical generation. This in turn facilitates the oxidation of

Table 3. Correlation of lipid profiles with independent factors in *H. Pylori* Seropositive patients attending at OPD of SPHMMC, Addis Ababa, Ethiopia.

Predictors	Total Cholesterol		Triglycerides		High Density Lipoprotein-Cholesterol		Low Density Lipoprotein-Cholesterol	
	r	P	R	P	r	P	r	P
Age	0.409	<0.001	0.266	<0.001	-0.066	0.217	0.390	<0.001
Sex	-0.103	0.007	-0.179	0.001	-0.023	0.608	-0.091	0.090
Physical Activity	0.007	0.897	-0.045	0.406	0.022	0.685	0.022	0.681
Weight	0.260	<0.001	0.242	<0.001	-0.050	0.352	0.249	<0.001
BMI	0.207	<0.001	0.151	0.005	-0.005	0.356	0.203	<0.001
WC	0.159	<0.001	0.196	<0.001	-0.079	0.143	0.103	0.056
HC	0.222	<0.001	0.125	0.020	-0.036	0.500	0.238	<0.001
SBP	0.358	<0.001	0.245	<0.001	-0.036	0.500	0.322	<0.001
DBP	0.291	<0.001	0.204	<0.001	-0.004	0.947	0.275	<0.001
Alcohol Drinking	-0.153	0.004	-0.080	0.139	0.044	0.417	-0.20	0.025
Cigarette Smoking	0.080	0.137	0.013	0.816	0.002	0.976	0031	0.569
Chew chat	0.089	0.100	0.082	0.128	0.039	0.465	0.035	0.518
Duration of Dyspepsia	0.144	0.007	0.032	0.555	0.102	0.059	0.169	0.002

Abbreviations: TC- total cholesterol, TG-triglycerides, HDL-c- high density lipoprotein cholesterol, LDL-c- low density lipoprotein cholesterol, SBP- systolic blood pressure, DBP- diastolic blood pressure, WC -waist circumference, HC- hip circumference, r-Pearson correlation coefficient, p = p value for correlation.

Table 5. Odds ratios of *H. pylori* infection for high total cholesterol concentrations among adult patients attending at OPD of SPHMMC, Addis Ababa, Ethiopia.

Variable	Category	Total Cholesterol		Bivariate Analysis			Multivariate Analysis		
		<200 mg/dl No (%)	>200 mg/dl No (%)	COR	95%CI	P	AOR	95%CI	P
Age	<35	200 (87%)	30 (13%)	1	1	<0.001	1	1	**<0.001**
	35–40	22 (64.7%)	12 (35.3%)	0.667	0.280–1.588		1.476	0.980–2.262	
	41–45	11 (50%)	11 (50%)	0.818	0.57–3.47		1.765	1.606–2.592	
	>45	33 (55%)	27 (45%)	1.22	0.459–3.25		4.864	2.281–4.080	
Sex	Male	120 (75%)	40 (25%)	1	1	0.061	1	1	0.820
	Female	146 (78.5%)	40 (21.5%)	1.065	0.635–1.787		0.936	0.533–1.646	
DBP	<90mmHg	236 (80.5%)	57 (19.5%)	1	1	<0.001	1	1	0.329
	≥90mmHg	30 (56.6%)	23 (43.4%)	3.174	1.715–5.874		1.021	0.979–1.065	
SBP	<120mmHg	121 (85.2%)	21 (14.8%)	1	1	0.012	1	1	**0.036**
	≥120mmHg	145 (71.1%)	59 (28.9%)	0.478	0.269–0.851		1.036	1.009–1.065	
BMI	<25 kg/m^2	218 (80.7%)	52 (19.3%)	1	1	0.004	1	1	0.660
	≥25 kg/m^2	48 (63.2%)	28 (36.8%)	0.436	0.248–0.767		1.660	0.913–3.020	
H. Pylori status	Positive	122 (70.1%)	52 (29.9%)	2.139	1.225–3.640	0.005	0.555	0.318–0.967	**0.038**
	Negative	144 (83.7%)	28 (16.3%)	1	1		1	1	
HC	<102cm	229 (79%)	61 (21%)	1	1	0.069	1	1	0.291
	>102cm	37 (66.1%)	19 (33.9%)	0.551	0.256–1.640		1.291	0.617–2.702	
WC	<94cm	237 (78%)	67 (22%)	1	1	0.705	1	1	0.390
	>94cm	29 (69%)	13 (31%)	0.866	0.410–1.826		0.690	0.297–1.607	
Alcohol Drinking	Yes	81 (69.8%)	35 (30.2%)	1.771	1.035–3.032	0.037	0.690	0.389–0.967	0.206
	No	185 (80.4%)	45 (19.6%)	1	1		1	1	
Smoking Cigarette	Yes	6 (85.7%)	1 (14.3%)	0.462	0.054–3.986	0.483	1.748	0.158–3.014	0.748
	No	260 (76.7%)	79 (23.3%)	1	1		1	1	

Abbreviations: SBP- systolic blood pressure, DBP- diastolic blood pressure, WC -waist circumference, HC- hip circumference, COR-crude odd ratio, CI-confidence interval, AOR-adjusted odd ratio.

LDL-c, which is a key event in atherosclerosis [47, 48, 49, 50]. Several lines of evidence indicate that the secretion of inflammatory cytokines by cells induced by chronic infection of gram-negative bacteria is related to the change of lipid profiles. These investigations indicate that *H. pylori* infection may be involved in the change of lipid profiles through a systemic inflammatory response [51, 52, 53, 54].

Our study also found a significant association between *H. pylori* infection and hypertension and increased BMI. However, we found no significant association was found between *H. pylori* infection and HDL-c, this finding was comparable with a study done by Leinonen M et al. [55]. However, some studies indicated that successful eradication of *H. pylori* infection can reduce the risk of low HDL-c [56, 57]. This might be, due to lipopolysaccharide (LPS) present in the cell walls of gram-negative bacteria *H. pylori*, there is stimulation of large quantities of cytokines (TNF-α and IL-6) which inhibit lipoprotein lipase activity. The consequence being lead to lipid tissue mobilization occurs through an increase in serum TG level and in contrast, a decrease in serum HDL cholesterol level [58]. In the current study, *H. pylori*-infected patients had higher mean lipid profiles for TC, TG, and LDL-c. Similarly, previous studies indicated that *H. pylori* seropositive subjects had higher serum triglyceride, total cholesterol, and LDL-c concentrations when compared to healthy subjects [59, 60, 61, 62, 63, 64]. Our findings were also in agreement with another Korean study which showed that H. pylorus was independently associated with an increased level of TC, and LDL-C [65].

In the current study prevalence of at least one serum lipid profile abnormality among *H. pylori* seropositive was 68.39%, which was higher than those of an Iranian study 60.40% [66] and lower than the study conducted by Abdu et al who reported 87.2 % [42]. The reason for variation might be, due to sample size, methodology, population, and geographic differences. The concentration of TC, TG, and LDL-c was positively associated with *H. pylori* infection. This result was in agreement with a study conducted at Jimma, Ethiopia. With regard to risk factors, the present study found that age >45, systolic blood pressure ≥120mmHg, and being *H. Pylori* seropositive were independent predictors of dyslipidemia which was in line with the study done by Abdu et al [42]. Shreds of evidence from the current work suggest the development of hyperlipidemia might associate with *H. pylori* infection. Pieces of evidence from previous studies also indicated that activation of inflammatory mediators, the release of toxin, proinflammatory factors, autoimmune reaction, improper functioning of the immune system, altering lipid and iron metabolism are among the leading mechanisms of *H. pylori*, which contributes to cardiovascular diseases [67, 68].

In opposite to the above-mentioned facts, a number of studies did not support the concept of *H. pylori* association with lipid profile alteration. For instance, a cohort study done by Elizalde et al. reported that *H. pylori* infection had no influence on serum lipids levels before and 3 months after eradication therapy with a low treatment rate [69]. Another study done on undergraduate medical students in Iran found that *H. pylori* infected patients had lower mean concentrations of total cholesterol, LDL-c, and triglycerides but higher concentrations of HDL-C compared to *H. pylori* negative individuals [70]. Since, several studies have been performed in different populations these controversial study findings regarding lipid profile among *H. pylori* patients may be explained by the varying study methodologies employed such as different study populations, limited sample size, or inadequate consideration of potential confounders.

4.1. Limitation of the study

We were depending on only serum antibody tests for determining the presence of *H. pylori* infection. Since it is a cross-sectional analysis, it cannot create causal associations between the variables under investigation and the study was done among OPD patients so, cannot be generalized to the general population.

5. Conclusion

This study reported that more than two-thirds of the *H. pylori* seropositive groups had exhibited dyslipidemia in at least one lipid profile, which can accelerate the incidence of the atherosclerosis process. Hence, our study provided additional supporting evidence to the existing claim that *H. pylori* infection played a role in accelerating atherosclerosis by altering lipid metabolism by elevating total cholesterol and LDL-c concentrations. Therefore, it is crucial to eradicating *H. pylori* as well investigate and treat dyslipidemia in context to this infection.

Declarations

Author contribution statement

Mujahid Hashim: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data.

Ousman Mohammed: Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Tatek G/Egzeabeher, Mistire Wolde: Conceived and designed the experiments; Analyzed and interpreted the data.

Funding statement

This work was partially funded by Addis Ababa University, College of Health Science, Department of Medical Laboratory Science.

Data availability statement

Data will be made available on request.

Declaration of interests statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

Acknowledgements

We were grateful to all study participants and data collectors.

References

[1] B.J. Arsenault, J.S. Rana, E.S. Stroes, J.P. Després, P.K. Shah, J.J. Kastelein, et al., Beyond low-density lipoprotein cholesterol: respective contributions of non–high-density lipoprotein cholesterol levels, triglycerides, and the total cholesterol/high-density lipoprotein cholesterol ratio to coronary heart disease risk in apparently healthy men and women, J. Am. Coll. Cardiol. 55 (1) (2009) 35–41. https://scholar.google.com/scholar?cites=14132820912503272876&as_sdt=2005&sciodt=0,5&hl=en.

[2] S. Mora, R.J. Glynn, S.M. Boekholdt, B.G. Nordestgaard, J.J. Kastelein, P.M. Ridker, On-treatment non–high-density lipoprotein cholesterol, apolipoprotein B, triglycerides, and lipid ratios in relation to residual vascular risk after treatment with potent statin therapy: JUPITER (Justification for the Use of Statins in Prevention: an Intervention Trial Evaluating Rosuvastatin), J. Am. Coll. Cardiol. 59 (17) (2012) 1521–1528. https://scholar.google.com/scholar?cites=4921672789271276261&as_sdt=2005&sciodt=0,5&hl=en.

[3] A.V. Khera, O.V. Demler, S.J. Adelman, H.L. Collins, R.J. Glynn, P.M. Ridker, et al., Cholesterol efflux capacity, high-density lipoprotein particle number, and incident cardiovascular events: an analysis from the JUPITER Trial (Justification for the Use of Statins in Prevention: an Intervention Trial Evaluating Rosuvastatin), Circulation 135 (25) (2017) 2494–2504. https://scholar.google.com/scholar?cites=11685232805731851296&as_sdt=2005&sciodt=0,5&hl=en.

[4] P.R. Lawler, A.O. Akinkuolie, A.Y. Chu, S.H. Shah, W.E. Kraus, D. Craig, L. Padmanabhan, R.J. Glynn, P.M. Ridker, D.I. Chasman, S. Mora, Atherogenic lipoprotein determinants of cardiovascular disease and residual risk among individuals with low low-density lipoprotein cholesterol, J. Am. Heart Assoc. 6 (7) (2017), e005549. https://scholar.google.com/scholar?cites=4443794148288479546&as_sdt=2005&sciodt=0,5&hl=en.

[5] S. Mendis, P. Puska, B. Norrving, Global Atlas on Cardiovascular Disease Prevention and Control, World Health Organization, 2011. https://scholar.google.com/scholar?cites=8725182741969577825&as_sdt=2005&sciodt=0,5&hl=en.

[6] B.J. Marshall, J.R. Warren, G.J. Francis, S.R. Langton, C.S. Goodwin, E.D. Blincow, Rapid urease test in the management of Campylobacter pyloridis-associated gastritis, Am. J. Gastroenterol. 82 (3) (1987) 200–210. https://scholar.google.com/scholar?cites=11499753036001718 27&as_sdt=2005&sciodt=0,5&hl=en.

[7] P.B. Ernst, D.A. Peura, S.E. Crowe, The translation of Helicobacter pylori basic research to patient care, Gastroenterology 130 (2006) 188–206. https://scholar.google.com/scholar?cites=15513098181127831081&as_sdt=2005&sciodt=0,5&hl=en.

[8] L.E. Wroblewski, R.M. Peek Jr., K.T. Wilson, Helicobacter pylori and gastric cancer: factors that modulate disease risk, Clin. Microbiol. Rev. 23 (4) (2010) 713–739. https://scholar.google.com/scholar?cites=8176425884052745316&as_sdt=2005&sciodt=0,5&hl=en.

[9] M.L. Schubert, D.A. Peura, Control of gastric acid secretion in health and disease, Gastroenterology 134 (7) (2008) 1842–1860. https://scholar.google.com/scholar?cites=11827514292351318200&as_sdt=2005&sciodt=0,5&hl=en.

[10] G. Chimienti, F. Russo, B.L. Lamanuzzi, M. Nardulli, C. Messa, A. Di Leo, et al., Helicobacter pylori is associated with modified lipid profile: impact on Lipoprotein (a), Clin. Biochem. 36 (5) (2003) 359–365. https://scholar.google.com/scholar?cites=10064789299470799831&as_sdt=2005&sciodt=0,5&hl=en.

[11] Y.C. Lee, T.H. Chiang, C.K. Chou, Y.K. Tu, W.C. Liao, M.S. Wu, et al., Association between Helicobacter pylori eradication and gastric cancer incidence: a systematic review and meta-analysis, Gastroenterology 150 (5) (2016) 1113–1124. https://scholar.google.com/scholar?cites=10796252049962415716&as_sdt=2005&sciodt=0,5&hl=en.

[12] T. Rokkas, A. Rokka, P. Portincasa, A systematic review and meta-analysis of the role of Helicobacter pylori eradication in preventing gastric cancer, Ann. Gastroenterol. 30 (4) (2017) 414. https://scholar.google.com/scholar?cites=6829989656779111740&as_sdt=2005&sciodt=0,5&hl=en.

[13] M. Mokhtare, H. Mirfakhraee, M. Arshad, S.H. Fard, M. Bahardoust, A. Movahed, et al., The effects of helicobacter pylori eradication on modification of metabolic syndrome parameters in patients with functional dyspepsia, Diabetes Metabol. Syndr.: Clin. Res. Rev. 11 (2017) S1031–S1035. https://scholar.google.com/scholar?cites=12123303814956438188&as_sdt=2005&sciodt=0,5&hl=en.

[14] M. Ramezani-Binabaj, A. Mobasher-Jannat, M. Safiabadi, A. Saburi, M.S. Rezaee-Zavareh, H. Karimi-Sari, et al., The relationship between Helicobacter pylori infection and atherosclerosis: a meta-analysis, Erciyes Med. J. 38 (3) (2016) 90–94. https://scholar.google.com/scholar?cites=25031630370615446 2&as_sdt=2005&sciodt=0,5&hl=en.

[15] A. Shiotani, T. Miyanishi, N. Uedo, H. Iishi, Helicobacter pylori infection is associated with reduced circulating ghrelin levels independent of body mass index, Helicobacter 10 (5) (2005) 373–378. https://scholar.google.com/scholar?cites=9268251323476772329&as_sdt=2005&sciodt=0,5&hl=en.

[16] H. Satoh, Y. Saijo, E. Yoshioka, H. Tsutsui, Helicobacter Pylori Infection is a Significant Risk for Modifi ed Lipid Profi le in Japanese Male Subjects, J. Atherosclerosis Thromb. 17 (2010) 1041–1048. https://scholar.google.com/scholar?cites=17920541682271523566&as_sdt=2005&sciodt=0,5&hl=en.

[17] T. Takashima, K. Adachi, A. Kawamura, M. Yuki, H. Fujishiro, M.A. Rumi, et al., Cardiovascular risk factors in subjects with Helicobacter pylori infection, Helicobacter 7 (2) (2002) 86–90. https://scholar.google.com/scholar?cites=17220979637412319 40&as_sdt=2005&sciodt=0,5&hl=en.

[18] T. Shimamoto, N. Yamamichi, K. Gondo, Y. Takahashi, C. Takeuchi, R. Wada, et al., The association of Helicobacter pylori infection with serum lipid profiles: an evaluation based on a combination of meta-analysis and a propensity score-based observational approach, PLoS One 15 (6) (2020), e0234433. https://scholar.google.com/scholar?cites=8616502575945106141&as_sdt=2005&sciodt=0,5&hl=en.

[19] I. Ozdogru, N. Kalay, A. Dogan, M.T. Inanc, M.G. Kaya, R. Topsakal, et al., The relationship between Helicobacter pylori IgG titre and coronary, Acta Cardiol. 62 (5) (2007) 501–505. https://scholar.google.com/scholar?cites=15568914478744749514&as_sdt=2005&sciodt=0,5&hl=en.

[20] M. Kowalski, M. Pawlik, J.W. Konturek, Konturek SJ Helicobacter pylori infection in coronary artery disease, J. Physiol. Pharmacol. 57 (Suppl 3) (2006) 101–111. https://scholar.google.com/scholar?cites=8277913206617169823&as_sdt=2005&sciodt=0,5&hl=en.

[21] E. McCracken, M. Monaghan, S. Sreenivasan, Pathophysiology of the metabolic syndrome, Clin. Dermatol. 36 (2018) 14–20. https://scholar.google.com/scholar?cites=9613127560221027562&as_sdt=2005&sciodt=0,5&hl=en.

[22] R. Gen, M. Demir, H. Ataseven, Effect of Helicobacter pylori eradication on insulin resistance, serum lipids and low-grade inflammation, South. Med. J. 103 (3) (2010) 190–196. https://scholar.google.com/scholar?cites=7751532707476198604&as_sdt=2005&sciodt=0,5&hl=en.

[23] M.E. Ndebi, Y.A.T. Guimtsop, J.D. Tamokou, The assessment of risk factors, lipid profile, uric acid and alanine aminotransferase in Helicobacter pylori-positive subjects, Int. J. Res. Med. Sci. 6 (9) (2018) 2889. https://scholar.google.com/scholar?cites=15785512104969377 5&as_sdt=2005&sciodt=0,5&hl=en.

[24] J.G. Kusters, A.H.M. Van Vliet, E.J. Kuipers, Pathogenesis of Helicobacter pylori infection, Clin. Microbiol. Rev. 19 (3) (2006) 449–490. https://scholar.google.com/scholar?cites=9321095496829589980&as_sdt=2005&sciodt=0,5&hl=en.

[25] F. Franceschi, T. Annalisa, D. Di Rienzo Teresa, G. Ianiro, S. Franco, G. Viviana, et al., Role of Helicobacter pylori infection on nutrition and metabolism, World J. Gastroenterol.: WJG 20 (36) (2014) 12809. https://scholar.google.com/scholar?cites=6301199987480039489&as_sdt=2005&sciodt=0,5&hl=en.

[26] C.-J. Tsai, T.-Y. Huang, Relation of Helicobacter pylori infection and angiographically demonstrated coronary artery disease, Dig. Dis. Sci. 45 (6) (2000) 1227–1232. https://scholar.google.com/scholar?cites=17551664682784968300&as_sdt=2005&sciodt=0,5&hl=en.

[27] K.R. Feingold, C. Grunfeld, Lipids: a key player in the battle between the host and microorganisms, J. Lipid Res. 53 (12) (2012) 2487–2489. https://scholar.google.com/scholar?cites=10618172531985519083&as_sdt=2005&sciodt=0,5&hl=en.

[28] H.-L. Kim, H.H. Jeon, I.Y. Park, J.M. Choi, J.S. Kang, K.-W. Min, Helicobacter pylori infection is associated with elevated low density lipoprotein cholesterol levels in elderly Koreans, J. Kor. Med. Sci. 26 (5) (2011) 654–658. https://scholar.google.com/scholar?cites=6013888968981310204&as_sdt=2005&sciodt=0,5&hl=en.

[29] A. Melese, C. Genet, B. Zeleke, T. Andualem, Helicobacter pylori infections in Ethiopia; prevalence and associated factors: a systematic review and meta-analysis, BMC Gastroenterol. 19 (1) (2019) 1–5. https://scholar.google.com/scholar?cites=15225933378353830204&as_sdt=2005&sciodt=0,5&hl=en.

[30] A. Nakagomi, M. Sasaki, Y. Ishikawa, M. Morikawa, T. Shibui, Y. Kusama, et al., Upregulation of monocyte tissue factor activity is significantly associated with low-grade chronic inflammation and insulin resistance in patients with metabolic syndrome, Circ. J. 74 (3) (2010) 572–577. https://scholar.google.com/scholar?cites=12904931390120368310&as_sdt=2005&sciodt=0,5&hl=en.

[31] E.Z. Jia, F.J. Zhao, B. Hao, T.B. Zhu, L.S. Wang, B. Chen, et al., Helicobacter pylori infection is associated with decreased serum levels of high density lipoprotein, but not with the severity of coronary atherosclerosis, Lipids Health Dis. 8 (1) (2009) 1–7. https://scholar.google.com/scholar?cites=3845342739288344016&as_sdt=2005&sciodt=0,5&hl=en.

[32] R. Refaeli, G. Chodick, S. Haj, S. Goren, V. Shalev, K. Muhsen, Relationships of H pylori infection and its related gastroduodenal morbidity with metabolic syndrome: a large cross-sectional study, Sci. Rep. 8 (2018) 4088. https://scholar.google.com/scholar?cites=11916987663849200 21&as_sdt=2005&sciodt=0,5&hl=en.

[33] A. Takeoka, J. Tayama, H. Yamasaki, M. Kobayashi, S. Ogawa, T. Saigo, et al., Impact of Helicobacter pylori immunoglobulin G levels and atrophic gastritis status on risk of metabolic syndrome, PLoS One 11 (11) (2016), e0166588. https://scholar.google.com/scholar?cites=10169929326086493446&as_sdt=2005&sciodt=0,5&hl=en.

[34] I. Karim, A.K. Zardari, M.K. Shaikh, Z.A.Q. Baloch, S.Z.A. Shah, Dyslipidemia, Profession. Med. J. 21 (5) (2014) 956–959. https://scholar.google.com/scholar?cites=16674477482392140662&as_sdt=2005&sciodt=0,5&hl=en.

[35] National Cholesterol Education Program (US), Expert Panel on Detection, Treatment of High Blood Cholesterol in Adults. Third Report of the National Cholesterol Education Program (NCEP) Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III), The Program, 2002. https://scholar.google.com/scholar?cites=18411472548426927644&as_sdt=2005&sciodt=0,5&hl=en.

[36] J.C. Atherton, Thepathogenesis of Helicobacter pylori-induced gastro-duodenal diseases, Annu. Rev. Pathol. 1 (2006) 63–96. https://scholar.google.com/scholar?cites=9952133299206825098&as_sdt=2005&sciodt=0,5&hl=en.

[37] B.E. Dunn, H. Cohen, M.J. Blaser, Helicobacter pylori, Clin. Microbiol. Rev. 10 (4) (1997) 720–741. https://scholar.google.com/scholar?cites=15677730513918945172&as_sdt=2005&sciodt=0,5&hl=en.

[38] A.C. Boullart, J. de Graaf, A.F. St alenhoef, Serum triglycerides and risk of cardiovascular disease, Biochim. Biophys. Acta 1821 (2012) 867–875. https://scholar.google.com/scholar?cites=11065173921112633288&as_sdt=2005&sciodt=0,5&hl=en.

[39] R. Karbasi-afshar, H. Khedmat, M.H. Izadi, Pylori infection and atherosclerosis: a Systematic Review, Acta Med. Iran. 53 (2) (2013) 78–88. https://scholar.google.com/scholar?cluster=5715110362149734 60&hl=en&as_sdt=0,5.

[40] P. Durrington, Dyslipidaemia, The Lancet 362 (9385) (2003) 717–731. https://scholar.google.com/scholar?cites=9160177192990671979&as_sdt=2005&sciodt=0,5&hl=en.

[41] Y. Guo, C. Xu, L. Zhang, Z. Chen, X. Xia, Helicobacter pylori infection acts as an independent risk factor for intracranial atherosclerosis in women less than 60 Years old, Front. Cardiovasc. Med. 8 (2021).

[42] A. Abdu, W. Cheneke, M. Adem, R. Belete, A. Getachew, Dyslipidemia and associated factors among patients suspected to have Helicobacter pylori infection at Jimma university medical center, Jimma, Ethiopia, Int. J. Gen. Med. 13 (2020) 311. https://scholar.google.com/scholar?cites=8641466219406569569&as_sdt=2005&sciodt=0,5&hl=en.

[43] B. Longo-Mbenza, J.N. Nsenga, E. Mokondjimobe, T. Gombet, I.N. Assori, J.R. Ibara, et al., Helicobacter pylori infection is identified as a cardiovascular risk factor in Central Africans, Vasc. Health Risk Manag. 8 (2012) 455. https://scholar.google.com/scholar?cites=18655828567036639 56&as_sdt=2005&sciodt=0,5&hl=en.

[44] G.M. Buzás, Metabolic consequences of Helicobacter pylori infection and eradication, World J. Gastroenterol.: WJG 20 (18) (2014) 5226. https://scholar.google.com/scholar?cites=6260312217852809503&as_sdt=2005&sciodt=0,5&hl=en.

[45] N. Iwai, T. Okuda, K. Oka, T. Hara, Y. Inada, T. Tsuji, et al., Helicobacter pylori eradication increases the serum high density lipoprotein cholesterol level in the infected patients with chronic gastritis: a single-center observational study, PLoS One 14 (8) (2019), e0221349. https://scholar.google.com/scholar?cites=15843207118055595285&as_sdt=2005&sciodt=0,5&hl=en.

[46] C. He, Z. Yang, N.-H. Lu, Helicobacter pylori infection and diabetes: is it a myth or fact? World J. Gastroenterol.: WJG 20 (16) (2014) 4607. https://scholar.google.com/scholar?cites=12107417481590233405&as_sdt=2005&sciodt=0,5&hl=en.

[47] M. Haeri, M. Parham, N. Habibi, J. Vafaeimanesh, Effect of Helicobacter pylori infection on serum lipid profile, J. Lipids (2018). https://scholar.google.com/scholar?cites=12914130571637020425&as_sdt=2005&sciodt=0,5&hl=en.

[48] S. Aydemir, H. Eren, I.O. Tekin, F.A. Harmandar, N. Demircan, M. Cabuk, Helicobacter pylori eradication lowers serumasymmetric dimethylarginine levels, Mediat. Inflamm. 2010 (2010) 1–4.82. https://scholar.google.com/scholar?cites=14354350313486616569&as_sdt=2005&sciodt=0,5&hl=en.

[49] J. Frostegård, Immunity, atherosclerosis and cardiovascular disease, BMC Med. 11 (1) (2013) 1–3. https://scholar.google.com/scholar?cites=7922564883741038971&as_sdt=2005&sciodt=0,5&hl=en.

[50] M.F. Lopes-Virella, Interactions between bacterial lipopolysaccharides and serum lipoproteins and their possible role in coronary heart disease, Eur. Heart J. 14 (1993 1) 118–124. https://scholar.google.com/scholar?cites=2984449725216531288&as_sdt=2005&sciodt=0,5&hl=en.

[51] W. Khovidhunkit, M.S. Kim, R.A. Memon, J.K. Shigenaga, A.H. Moser, K.R. Feingold, et al., Effects of infection and inflammation on lipid and lipoprotein metabolism: mechanisms and consequences to the host, J. Lipid Res. 45 (7) (2004) 1169–1196. https://scholar.google.com/scholar?cites=8772711677084321714&as_sdt=2005&sciodt=0,5&hl=en.

[52] K.R. Feingold, B. Anawalt, A. Boyce, G. Chrousos, K. Dungan, A. Grossman, et al., The Effect of Inflammation and Infection on Lipids and Lipoproteins-Endotext, 2000.

[53] M. Leinonen, P. Saikku, Evidence for infectious agents in cardiovascular disease and atherosclerosis, Lancet Infect. Dis. 2 (1) (2002) 11–17. https://scholar.google.com/scholar?cites=4240101660977028730&as_sdt=2005&sciodt=0,5&hl=en.

[54] S.Y. Nam, K.H. Ryu, B.J. Park, S. Park, Effects of Helicobacter pylori infection and its eradication on lipid profiles and cardiovascular diseases, Helicobacter 20 (2) (2015) 125–132. https://scholar.google.com/scholar?cites=15306267817179118939&as_sdt=2005&sciodt=0,5&hl=en.

[55] M.T. Coronado, A.O. Pozzi, M.A. Punchard, P. González, P. Fantidis, Inflammation as a modulator of the HDL cholesterol-induced inteleukin-10 production by human circulating mononuclear cells, Atherosclerosis 1 (202) (2009) 183–184. https://scholar.google.com/scholar?cites=505566573904342475&as_sdt=2005&sciodt=0,5&hl=en.

[56] H. Scharnagl, M. Kist, A.B. Grawitz, W. Koenig, H. Wieland, W. März, Effect of Helicobacter pylori eradication on high-density lipoprotein cholesterol, Am. J. Cardiol. 93 (2) (2004) 219–220. https://scholar.google.com/scholar?cites=13704512363589257982&as_sdt=2005&sciodt=0,5&hl=en.

[57] K.C. Sung, E.J. Rhee, S.H. Ryu, S.-H. Beck, Prevalence of Helicobacter pylori infection and its association with cardiovascular risk factors in Korean adults, Int. J. Cardiol. 102 (3) (2005) 411–417. https://scholar.google.com/scholar?cites=18735094543213617 51&as_sdt=2005&sciodt=0,5&hl=en.

[58] H. Vahedi, M. Yarmohammadi, M.B. Sohrabi, P. Zolfaghari, E. Yahyaei, M. Rezaali, et al., Comparison of the diagnostic accuracy of serological and histology tests for Helicobacter pylori in patients with dyspepsia and metabolic syndrome, Int. J. Health Stud. 2 (2) (2016).

[59] Y. Sun, D. Fu, Y.K. Wang, M. Liu, X.D. Liu, Prevalence of Helicobacter pylori infection and its association with lipid profiles, Bratisl. Lek. Listy 117 (9) (2016) 521–524. https://scholar.google.com/scholar?cites=11829371354962369988&as_sdt=2005&sciodt=0,5&hl=en.

[60] C.R. Baudron, F. Franceschi, N. Salles, A. Gasbarrini, Extragastric Diseases and H elicobacter pylori, Helicobacter 1 (18) (2013) 44–51. https://scholar.google.com/scholar?cites=18402623822596028149&as_sdt=2005&sciodt=0,5&hl=en.

[61] Y. Hissun, G.A. Modawe, A.E.A. Abdrabo, Association between H. Pylori and coronary heart disease among Sudanse Patients, Int. J. Inf. Retr. Res. (IJIRR) 3 (2016) 1589–1593. https://scholar.google.com/scholar?cites=25913624531978905 67&as_sdt=2005&sciodt=0,5&hl=en.

[62] Y. Yang, B. Sheu, Metabolic interaction of H. pylori infection and gut microbiota, J. Microorganism. 4 (15) (2016). https://scholar.google.com/scholar?cites=11390605146470349804&as_sdt=2005&sciodt=0,5&hl=en.

[63] F. Franceschi, A. Gasbarrini, S.A. Polyzos, J. Kountouras, Extragastric diseases and Helicobacter pylori, Helicobacter 20 (2015) 40–46. https://scholar.google.com/scholar?cites=32435095213694335 07&as_sdt=2005&sciodt=0,5&hl=en.

[64] K.I. Seo, J.J. Heo, S.E. Kim, S.J. Park, M.I. Park, W. Moon, et al., Sex differences between Helicobacter pylori infection and cholesterol levels in an adult health checkup program, Helicobacter 25 (4) (2020), e12704. https://scholar.google.com/scholar?cites=16926861929956654206&as_sdt=2005&sciodt=0,5&hl=en.

[65] S. Al-Fawaeir, M.A. Zaid, A.A. Awad, B. Alabedallat, Serum lipid profile in Helicobacter pylori infected patients, Am. J. Physiol. Biochem. Pharmacol. 2 (2) (2013) 1–4. https://scholar.google.com/scholar?cites=74484047614858813 00&as_sdt=2005&sciodt=0,5&hl=en.

[66] Y. Ishida, K. Suzuki, K. Taki, T. Niwa, S. Kurotsuchi, H. Ando, et al., Significant association between Helicobacter pyloriinfection and serum C-reactive protein, Int. J. Med. 5 (2008) 224–229. https://scholar.google.com/scholar?cites=25903302845612205 9&as_sdt=2005&sciodt=0,5&hl=en.

[67] I. Nabipour, K. Vahadt, S.M. Jafari, R. Pazoki, Z. Sanjdideh, Theassociation of metabolic syndrome Chlamydia pneumonia,Helicobacter pylori, cytomegalovirus, and herpes simplexvirus type 1: the Persian Gulf Healthy Heart Study, Cardiovasc. Diabetol. 5 (2006) 2840. https://scholar.google.com/scholar?cites=17264151202829728416&as_sdt=2005&sciodt=0,5&hl=en.

[68] N.A. Kaloorazi, M. Mohammadi, Helicobacter pylori infectionand extragastric diseases, J. Biol. Today's World 2 (2013) 121–132. https://scholar.google.com/scholar?cites=13947922583959033199&as_sdt=2005&sciodt=0,5&hl=en.

[69] J.I. Elizalde, J.M. Piqué, V. Moreno, J.D. Morillas, I. Elizalde, L. Bujanda, et al., Influence of helicobacter pylori infection and eradication on blood lipids and fibrinogen, Aliment. Pharmacol. Ther. 16 (3) (2002) 577. https://scholar.google.com/scholar?cites=88055269076642984 54&as_sdt=2005&sciodt=0,5&hl=en.

[70] M. Binabaj, A. Mobasher-Jannat, M. Safiabadi, A. Saburi, M.S. Rezaee-Zavareh, H. Karimi-Sari, et al., The relationship between Helicobacter pylori infection and atherosclerosis: a meta-analysis, Erciyes Med. J. 38 (3) (2016) 90–94. https://scholar.google.com/scholar?cites=25031630370615446 2&as_sdt=2005&sciodt=0,5&hl=en.