Environmental and Dietary Risk Factors for Colonic Diverticulosis and Diverticulitis

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ABSTRACT

Background & Aims: Colonic diverticulosis (CD) is among the most common conditions of the large bowel. Several factors have been associated with an increased risk of CD and its complications, including advanced age, obesity, physical inactivity, and a low-fiber diet. Available data is conflicting and a comprehensive analysis of different bowel, dietary and environmental habits linked with CD is lacking. We aimed to investigate the relationship between potential risk factors and CD prevalence using full data from a colonoscopy-based cross-sectional study in Europe.

Methods: The study was conducted at three tertiary referral centers in Germany and Lithuania. It included consecutive adult patients referred for routine colonoscopy who completed a detailed questionnaire on our considered multiple risk factors for diverticulosis and diverticulitis, including dietary and environmental factors, and bowel habits.

Results: The study included 1,333 patients, 696 women and 635 men. Colonic diverticulosis was diagnosed in 858 (64%) of patients. Multivariate analysis revealed that age (OR: 1.08, 95%CI: 1.06–1.10, p<0.001) and obesity (OR: 1.05, 95%CI: 1.02–1.09, p=0.004) were associated with CD. We also revealed new risk factors for CD: increased frequency of bowel movements (OR: 0.10, 95%CI: 0.03-0.33, p<0.001) and feeling of incomplete bowel emptying (OR: 2.05, 95%CI: 1.47–2.87, p<0.001). Older participants had reduced odds (OR: 0.921, 95 CI: 0.89–0.95, p<0.05) of diverticulitis compared to younger subjects. Feeling of incomplete bowel emptying after defecation was associated with increased odds (OR: 2.769, 95% CI 1.35–5.7, p<0.006) for diverticulitis. Moreover, participants with a higher educational status had increased odds (OR: 2.453, 95%CI: 1.31–4.59, p=0.005) for diverticulitis compared to the lower education group.

Conclusions. Study shows that older age, obesity, frequency of bowel movements, and feeling of incomplete bowel emptying are associated with the risk of CD. Furthermore, older age, feeling of incomplete bowel emptying, and higher education were associated with the risk of diverticulitis among CD patients.

Abbreviations: CD: colonic diverticulosis; CI: confidence interval; BMI: body mass index; DD: diverticular disease; DICA: Diverticular Inflammation and Complication Assessment; OR: odds ratio; NSAIDs: nonsteroidal anti-inflammatory drugs.

INTRODUCTION

Colonic diverticulosis (CD) is a chronic progressive disease of the large bowel characterized by the formation of diverticula, out-pouching of the mucosa and submucosa at weak points in the muscular layer of the colon wall. It is one of the most common gastroenterological disorders diagnosed on routine colonoscopy and its complications are an important cause of hospital admissions in Western populations [1]. The prevalence of the disease is closely associated with age [2, 3]. It is estimated that more than 50% of people older than age 60 will develop CD [4]. The majority of individuals with colonic diverticula will remain asymptomatic throughout their lifetime (termed CD) but up to 25% of them will develop symptomatic disease referred to as colonic diverticular disease [5]. The severity of the disorder can then vary from symptomatic uncomplicated diverticular disease (DD) characterized by irritable bowel syndrome-like symptoms, to complications such as diverticulitis, diverticular hemorrhage and perforation [3].

With improved life expectancy in Western societies, the prevalence of CD and DD is continuously growing, consequently increasing its burden on National Health Care systems [6]. Despite this load, data on determinants of CD is sparse and the pathophysiology of the disease remains poorly understood. To date, diverticulosis is thought to develop as a complex interaction of environmental and genetic factors [7-10]. There is also evidence showing that structural changes in the enteric nervous system and imbalances in neuromuscular transmission are other major etiological factors for the development of CD [11, 12]. However, rapid and continuous increase in DD incidence following the industrialization process in Western cultures undoubtedly points to the significance of environmental and dietary factors for the disease development.

During the last decade a number of different studies have proposed physical inactivity, low-fiber diet followed by constipation, red meat consumption, obesity, and some alternative factors such as use of nonsteroidal anti-inflammatory drugs (NSAIDs), smoking and alcohol abuse as environmental factors associated with symptomatic DD [13-20]. Nonetheless, risk factors for developing CD are likely to differ from those for CD complications. A high-powered comprehensive analysis on different dietary and environmental factors linked to CD development is thus lacking. Therefore, the aim of our study was to explore the association between potential risk factors and the prevalence of CD and diverticulitis using inclusive data from a colonoscopy-based cross-sectional study in eastern and central European population.

METHODS

Study Population

The study was conducted between 2012 and 2016 at three tertiary referral centers in Germany and Lithuania: Department of Medicine II, Saarland University Medical Center, Homburg, the Department of Gastroenterology and Hepatology, University Hospital Cologne and the Department of Gastroenterology, Lithuanian University of Health Sciences, Kaunas. Adult participants with ages 19 to 95, and without coexisting gastrointestinal disorders underwent routine screening colonoscopy. The presence of diverticula was determined by colonoscopy in all patients. Only patients with complete colonoscopy including inspection of the cecum with at least adequate preparation, as assessed by the physician performing the colonoscopy, were included in the study. All colonoscopies were performed with the use of digital video endoscopes by a senior gastroenterologist. Extension of diverticulosis was classified as follows: left-sided (including sigmoid and/or descending colon), right-sided (transversal, ascending colon and cecum) and pancolonic. Endoscopic severity of the CD was assessed using the Diverticular Inflammation and Complication Assessment (DICA) [21, 22]. Complete data for DICA score calculation was available for 523 out of 858 (60.9%) participants in the CD group of the cohort. Patients in whom complete colonoscopy, including inspection of the cecum, could not be performed or when preparation did not achieve at least moderate quality were excluded from the study. Patients in whom diverticula were absent were included in the control group.

Assessment of Variables

Prior to colonoscopy, all participants with the help of a qualified research assistant completed a standardized questionnaire on the risk factors for developing CD. Risk factors included in the study were categorized into the following groups: socio-demographic factors, factors related to nutritional status and dietary habits, and factors related to bowel habits. Among socio-demographic factors were included age, gender, ethnicity, educational and occupational status, regular consumption of alcohol and tobacco, regular consumption of prescription and over-the-counter medication (e.g. NSAIDs and laxatives). Factors related to nutritional status and dietary habits were defined by the number of meals per day, amount of daily fluid intake, amount of fish and red meat servings per week and whether participants followed a vegetarian or vegan diet. Body mass index (BMI) (kg/m^2) was calculated from self-reported height (cm) and weight (kg), and being overweight or obese was defined as a BMI ≥ 25 kg/m^2. Bowel habits were assessed as self-reported frequency of bowel movements, average duration of defecation, if present - nightly excretion, also symptoms associated with defecation such as pain, feeling of incomplete bowel emptying, requirement for digital evacuation or enemas, false urge and overall duration of constipation (years). Each patient's chart was reviewed to obtain missing data and double check data that were extracted from the questionnaires. Complete data on bowel habits and dietary factors were available for 844 study participants.

Statistical Analysis

Statistical analysis was performed using the Statistical Package for the Social Sciences (SPSS version 24.0, SPSS Inc., Chicago, IL, USA). Means and standard deviations were reported for continuous variables. The Chi-squared test was used for the comparison of discrete variables and the Student's t-test for the comparison of continuous variables. Dietary data, alcohol use, tobacco use, NSAID and laxative use, and bowel habits were converted into categorical indictor variables for analyses. Variables found to be associated with CD in the univariate analysis were reassessed using logistic regression analysis to estimate odds ratios (OR) and 95% confidence intervals (CI) while adjusting for age and gender. A p-value ≤ 0.05 was considered as statistically significant.

Ethical Approval

The local Research Ethics committees of each study center approved the study: the Regional Kaunas Ethics Committee (protocol No BE-10-2, issued on 8th of March, 2011), the Research Ethics Committee of the Saarland University (approval 63/11, issued on 10th of May, 2011) and the Research Ethics Committee of the University of Cologne (approval 16–397, issued on 12th of January, 2017). All patients signed an informed consent form to participate in the study. The study protocol conforms to the ethical guidelines of the 1975 Declaration of Helsinki.

RESULTS

The study included 1,333 participants, 635 (47.6%) males with a mean age of 61.89 years and 698 (52.4%) females with a mean age of 62.95 years. Colonic diverticulosis was diagnosed in 858 (64.4%) of the patients while the remaining 475 (35.6%) in whom diverticula were absent were assigned to the control group. Most of the participants were Lithuanians (61.1%) while the remaining 38.8% were Germans: 31.7% from Homburg and 7.1% from Cologne, accordingly (Table I).

Most CD cases (85.8%) had descending or sigmoid colon diverticula. The rest had right sided or pancolonic diverticula (14.1%). During endoscopy the DICA score was evaluated for 523 (60%) patients within the CD group. The majority (93.9%) of cases were graded as DICA I, while the rest (6.1%) were DICA II and none belonged to DICA III class. From 858 participants in the CD group, 198 (23.1%) had previous diverticulitis episodes in their medical history.

Participants with diverticulosis were older and had a higher mean BMI compared to controls (Table I). Patients with diverticulosis were significantly older than patients without diverticulosis (66.4±10.4 years vs. 55.2±14.7 years, p<0.001). There was no significant difference between groups in term of gender; 49.4% of patients in the CD group and 44.4% in the control group were males (p=0.08) (Table I). Likewise, we did not find a significant association between CD and NSAID use. There was no difference between CD and controls with respect to regular alcohol and tobacco consumption (Table I). Multivariate analysis revealed that chances of developing CD increase with age (OR: 1.079, 95%CI: 1.06–1.1, p<0.05). Being overweight or obese (BMI ≥25 kg/m²) also had increased odds of CD (OR: 1.05, 95%CI: 1.02–1.09, p=0.004) compared with subjects with normal BMI (<25 kg/m²).

Comprehensive data for dietary and bowel habits together with information about education and employment status was available for 844 study participants. Among them, 523 were from the CD group and the remaining 321 subjects were grouped as controls. Univariate analysis (Table II) showed a significant association between CD and higher education (p=0.004) as well as nocturnal work shifts (p<0.0001). However, these results did not reach statistical significance in the multivariate logistic regression.

Table I. Characteristics of the study population

	Diverticulosis (n=858)	Controls (n=475)	p
Age, years	66.39 ± 10.4 (29-95)	55.24 ± 14.6 (19-92)	**<0.001**
Gender,male/female	424 (49.4%)/434 (50.6%)	211 (44.4%)/264 (55.6%)	0.08
Ethnicity			0.022
German	353 (41.1%)	165 (34.7%)	
Lithuanian	505 (58.9%)	310 (65.3%)	
BMI, kg/m²	28.75 ± 5.4	27.27 ± 5.1	**<0.001**
Everyday cigarette smoker	300 (35.0%)	168 (35.4%)	0.883
Everyday alcohol user	50 (5.8%)	21 (4.4%)	0.273
NSAID use, ≥ 15 day/month	91 (10.6%)	47 (9.9%)	0.683

Data are expressed as mean ± standard deviation or n (%)

Table II. Association of dietary and bowel habits with diverticulosis

	Controls (n=321)	Diverticulosis (n=523)	p
Vegetarianism	6 (1.9%)	3 (0.6%)	0.076
Number of meals per day, ≥ 3 servings/day	230 (71.7%)	417 (79.9%)	**0.006**
Red meat, ≥ 3 servings/week	32 (10.0%)	41 (7.9%)	0.289
Fish, ≥ 3 servings/week	279 (86.9%)	431 (82.9%)	0.117
Fluids, < 1 liter/day	42 (13.1%)	90 (17.2%)	0.107
Bowel movements, ≤ 1 times/week	13 (4.0%)	5 (1.0%)	**0.003**
Pain with bowel movements, ≥ 25% time	83 (25.9%)	132 (25.3%)	0.846
Feeling of incomplete bowel emptying, ≥ 25% time	95 (29.7%)	247 (47.3%)	**<0.0001**
Abdominal pain, ≥ 25% time	74 (23.1%)	109 (20.9%)	0.444
Prolonged duration of defecation, > 10 min	18 (5.7%)	37 (7.1%)	0.413
Nightly defecation	12 (3.8%)	18 (3.4%)	0.819
Duration of constipation, ≥ 10 years	34 (10.6%)	64 (12.3%)	0.467
Laxative use, ≥ 1 day/week	41 (12.8%)	57 (11.0%)	0.417
Higher education	150 (46.9%)	192 (36.9%)	**0.004**
Night shifts	36 (11.2%)	18 (3.4%)	**<0.0001**

With respect to bowel habits, univariate analysis revealed a significant association between the feeling of incomplete bowel emptying after defecation (p<0.0001) and scarce bowel movements (≤ 1 time/week; p=0.003), and CD. Participants who reported feeling of incomplete bowel emptying ≥25% of the time had increased odds for diverticulosis (OR 2.05; 95%CI: 1.47–2.87) compared to the control group (Table III). Infrequent bowel movements were not associated with an increased prevalence of diverticulosis. Instead, those having less frequent bowel movements (≤1 times/week) had reduced odds compared with individuals with more than 1 bowel movement per week (OR: 0.1; 95%CI: 0.03–0.33). Colonic diverticulosis subjects reported to be having ≥3 meals per day significantly more often (79.9% vs. 71.7%, p=0.006) compared to controls, but it was not associated with increased odds of diverticulosis. The same proportions of cases and controls reported abdominal pain associated with bowel movements (25.9% vs. 25.3%, p=0.846) and there was no significant association between abdominal cramps unrelated to defecation and CD (23.1% vs. 20.9%, p=0.444). Likewise, we found no difference between cases and controls with respect to duration of defecation (5.7% vs. 7.1%, p=0.413) or overall duration of self-reported constipation (10.6% vs. 12.3%, p=0.467). There was no relationship between nocturnal bowel movements and diverticulosis (3.8% vs. 3.4%, p=0.819). There was no association between self-reported regular laxative use and CD (12.8% vs. 11.0%, p=0.417). Red meat and fish consumption, low fluid intake and vegetarian diet also had no association with CD.

Table III. Assessment of risk factors for diverticulosis (multivariate analysis)

	O.R.	95% C.I.	p-value
Age, years	1.079	1.06-1.1	**<0.001**
BMI, > 25 kg/m²	1.05	1.02-1.09	**0.004**
Feeling of incomplete bowel emptying, ≥ 25% time	2.05	1.47-2.87	**<0.001**
Bowel movements, ≤ 1 times/week	0.1	0.03-0.33	**<0.001**

We also assessed risk factors for developing diverticulitis. In the univariate analysis the risk factors not associated with a higher risk of developing colonic diverticulitis are listed in Table IV. Older participants had reduced odds (OR: 0.921, 95 CI: 0.89–0.95, p<0.05) of diverticulitis compared to younger subjects (Table V). In accordance to prior findings, the feeling of incomplete bowel emptying after defecation was associated with increased odds (OR: 2.769, 95% CI 1.35–5.7, p<0.006) for diverticulitis (Table V). Moreover, participants with a higher educational status had increased odds for diverticulitis compared to the lower education group (Table V).

DISCUSSION

We explored the relationship between environmental and dietary factors, bowel habits and the risk of developing colonic diverticulosis and diverticulitis among participants enrolled in a large multicenter colonoscopy-based study. Our study shows that older age, obesity, frequency of bowel movements and feeling of incomplete bowel emptying were associated with a higher risk of CD. We also found that older age, feeling of incomplete bowel emptying and higher education status were associated with risk of diverticulitis among CD patients. Considering the importance of symptomatic diverticular disease for health care systems worldwide, we believe that our study adds valuable insights in understanding the risk factors for CD and diverticulitis.

The majority of patients in the CD group were diagnosed with left-sided diverticula, which coincides with the published data on individuals of European descent [1, 2]. Our analysis in a large patient cohort clearly showed that prevalence of diverticulosis increased with age. This is in line with previous studies explaining the underlying mechanisms of diverticula formation by a weakening of connective tissue in the colonic wall and/or degenerative changes in the enteric nerves subsequently leading to increased intraluminal pressure, which presumably occurs with aging [5]. The hypothesis of CD as a disorder of intestinal neuromuscular malfunction was further supported by a recent genome-wide association study. The authors demonstrated that certain genetic risk variants may lead to the weakening of the connective tissue in the colonic wall and potential cause the formation of diverticula [23].

Up to now, data on the association between obesity (BMI ≥ 30 kg/m²) and CD is conflicting. Whereas some authors report that higher BMI increases the risk for developing CD [24-26], others find no such association [27] or propose an increased waist circumference due to visceral and subcutaneous fat collection to be a better predictive factor [28]. Our findings, using a colonoscopy-based cohort, are consistent with earlier studies demonstrating that obese participants (BMI≥30 kg/m2) have increased odds of diverticulosis compared with subjects a normal BMI [24-26]. The cited studies were limited by the lack of information on other important risk factors such as bowel habits and dietary patterns. Therefore, our study which shows a significant association between obesity and CD even after carefully adjusting for confounding factors, adds further emphasis to this link. To explain a mismatch with some published reports, we suggest that previous studies in which no such link was found were limited by either relying on a self-reported diagnosis, possibly leading to diagnostic bias [28] or were conducted in Asian populations in which the prevalence of obesity and diverticulosis is significantly lower [27]. The mechanism by which obesity is associated with colonic diverticula remains unknown. Although the association observed in our study does not imply causation, given the complex relationship between metabolism, the gut microbiota and the immune system [29], nutritional factors linked with BMI most likely have a role in mediating disease progression thus a further research into understanding this pathway is required.

In accordance to previous findings, we found no correlation between diverticulosis and gender. This contrasts with several published reports suggesting higher disease prevalence in males compared to females [30]. However, a recent study found that 40-49 years old women may have lower odds of all types of diverticulosis compared with men of the same age, but the strength of this association tends to decrease with aging [31]. This could indicate that sex hormones in premenopausal

Table IV. Assessment of risk factors for diverticulitis (univariate).

	Prior diverticulitis (n=198)	No diverticulitis (n=660)	p
Age, years	61.27 ± 12.34	67.93 ± 9.21	**0<.001**
Gender, male/female	105 (53.0%)/93 (47.0%)	319 (48.3%)/341 (51.7%)	0.246
BMI, kg/m^2	28.3 ± 6.0	28.88 ± 5.2	0.096
Everyday cigarette smoker	86 (43.4.0%)	214 (32.4%)	**0.004**
Everyday alcohol user	19 (9.6%)	31 (4.7%)	0.01
NSAID use, ≥ 15 day/month	19 (9.6%)	72 (10.9%)	0.599
	Total (n=522)		
	Prior diverticulitis (n=57)	No diverticulitis (n=465)	
Vegetarianism	0 (0.0%)	3 (0.6%)	0.543
Number of meals per day, ≥ 3 servings/day	44 (77.2%)	373 (80.2%)	0.591
Red meat, ≥ 3 servings/week	50 (87.7%)	431 (92.7%)	0.188
Fish, ≥ 3 servings/week	45 (78.9%)	386 (83.4%)	0.403
Fluids, < 1 liter/day	8 (14.0%)	82 (17.6%)	0.497
Bowel movements, ≤ 1 times/week	1 (1.8%)	4 (0.9%)	0.514
Pain with bowel movements, ≥ 25% time	23 (40.4%)	109 (23.5%)	**0.006**
Feeling of incomplete bowel emptying, ≥ 25% time	40 (70.2%)	207 (44.5%)	**<.0001**
Abdominal pain, ≥ 25% time	22 (38.6%)	87 (18.7%)	**<.0001**
Prolonged duration of defecation, > 10 min	6 (10.5%)	31 (6.7%)	0.286
Nightly defecation	3 (5.3%)	15 (3.2%)	0.426
Duration of constipation, ≥ 10 years	4 (7.0%)	60 (12.9%)	0.199
Laxative use, ≥ 1 day/week	8 (14.0%)	49 (10.6%)	0.431
Higher education	31 (54.4%)	161 (34.7%)	**0.004**
Night shifts	3 (5.3%)	15 (3.2%)	0.426

Data are expressed as mean ± standard deviation or n (%)

Table V. Assessment of risk factors for diverticulitis (multivariate)

	OR	95% CI	p
Age, years	0.921	0.89 - 0.95	**<0.0001**
Everyday cigarette smoker	0.516	0.25 - 1.08	0.078
Pain with bowel movements, ≥ 25% time	1.655	0.79 - 3.46	0.181
Feeling of incomplete bowel emptying, ≥ 25% time	2.769	1.35 - 5.7	**0.006**
Abdominal pain, ≥ 25% time	1.608	0.82 - 3.17	0.17
Higher education	2.453	1.31 - 4.59	**0.005**

period might play a protective role in the disease development [31]. Within our cohort the average age of enrolled subjects was over 50 years and no gender-related differences of CD incidence were evidenced.

We consider the analysis of the relationship between the participants' educational and occupational status and the prevalence of CD to be one of the novelties of this study. To our knowledge, up to this date, there is no other large-scale colonoscopy-based analysis addressing this causality to date. Our results showed that, contrary to popular belief, participants in CD group had a lower educational status compared to controls and were not as likely to be working in either sedentary jobs nor night shifts. It is debatable if the average 10-year age

difference between study groups might have affected this result or that CD is more prevalent among individuals with a lower socioeconomic status. Although this tendency did not reach statistical significance for increasing the risk of CD in our analysis, we find its importance worth considering. On the other hand, higher educational status related to a more sedentary lifestyle did increase odds for diverticulitis (2.453; 95%CI: 1.31–4.59). Similar to diverticulosis, the etiopathogenesis of diverticulitis is poorly understood. Our finding supports the idea that risk factors for the development of CD are likely different from those related to its complications. Among many factors that may contribute to the development of diverticulitis, studies consistently point towards Western dietary pattern and physical inactivity [15-18]. A recent study has shown that men who adhered to five healthy lifestyle factors (BMI 18-25 kg/m^2, fiber intake > 23 g/day, red meat < 4 servings/week, two hours of exercise/week and no smoking) had a 75% reduced diverticulitis risk compared to men who did not adhere to any healthy lifestyle habits [20]. The hypothesis is that these factors might be associated with gut dysbiosis which in turn may cause mucosal barrier defects and local immune dysfunction resulting in the mucosal inflammation of diverticulitis [32]. Adding to that, genetic data from a genome wide association study demonstrate that risk of diverticulitis might be conferred by genes related to epithelial dysfunction

[23]. Although our data showed no direct association between dietary patterns and the increased risk of diverticulitis, our assumption is that a higher educational status could be viewed as an implication of Western style of living and, therefore, as a support to aforementioned studies.

Our results showed no significant association between daily cigarette smoking and CD. Nevertheless, among subjects with prior diverticulitis, smoking was almost two times more prevalent compared to the asymptomatic group. Although in our study this factor did not reach statistical significance for increasing the odds of diverticulitis, constant smoking is more likely to be associated with symptomatic diverticular disease than asymptomatic diverticulosis in contrast to other studies [14].

We discovered that a low frequency of defecation was associated with a decreased risk of CD. The hypothesis that constipation caused by a "low residual diet" was responsible for the development of colonic diverticula was proposed and widely accepted for over 40 years [33]. Although mostly based on observational data, the hypothesis was strongly supported by evidence of alterations in colonic neurotransmission (in particular vasoactive intestinal peptide) seen in both idiopathic constipation and diverticular disease [34]. However, several recent studies have questioned the association between constipation and diverticulosis stating that an increase in fiber consumption increased the risk of diverticulosis in a dose-dependent fashion [24]. After adjusting for other variables such as age, race, and body mass index, individuals in the highest quartile of total fiber intake had an increased diverticulosis prevalence ratio (1.30; 95%CI: 1.13–1.50) compared to the lowest quartile [24]. In addition, frequent bowel movements were positively associated with diverticulosis, which corresponds well with our findings [24]. Feeling of incomplete bowel emptying after defecation, which is a classical symptom of constipation, showed to be significantly associated with a higher risk for diverticulosis in our analysis. Although rectal tenesmus is primarily associated with constipation, we argue that the experience expressed by our subjects could be explained by a smooth muscle hypersensitization to cholinergic stimulation, previously described by other groups [11, 35, 36]. This alteration to colonic musculature means the reduction in smooth muscle relaxation ability and thus infliction of symptoms. Furthermore, the feeling of incomplete bowel emptying after defecation showed an association not only with asymptomatic but with symptomatic diverticular disease as well, as it further increased odds for diverticulitis. We argue that this could indicate a gradual change in enteric neurotransmission as the disease progresses [11].

In parallel with previously published studies, we found no proof that dietary choices could have an impact on the development of CD. None of dietary elements included in our study turned out to be associated with the disease. It has been demonstrated that red meat consumption is positively associated with the risk of diverticulitis (relative risk 1.2 for each serving of red meat) but not with diverticulosis [16, 37]. A Western dietary pattern (high in red meat and refined grains) was shown to increase the risk of diverticulitis, as opposed to a prudent pattern (high in fruits, vegetables and whole grains) [16, 37], although this proved not to be the case in our analysis.

CONCLUSIONS

Our study evidenced older age, obesity and the feeling of incomplete bowel emptying as risk factors associated with CD. We found that older age, feeling of incomplete bowel emptying and higher education level were associated with the risk of diverticulitis among CD patients.

Conflicts of interest: None to declare.

Authors' contribution: J.I.L. and J.K. conceived and designed the study. All authors contributed to the data acquisition. J.I.L. performed the statistical analysis, interpreted the results and drafted the manuscript. All authors critically revised the manuscript, approved the final version to be published, and agree to be accountable for all aspects of the work.

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