Western Dietary Pattern Increases, and Prudent Dietary Pattern Decreases, Risk of Incident Diverticulitis in a Prospective Cohort Study

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BACKGROUND & AIMS: Dietary fiber is implicated as a risk factor for diverticulitis. Analyses of dietary patterns may provide information on risk beyond those of individual foods or nutrients. We examined whether major dietary patterns are associated with risk of incident diverticulitis. **METHODS:** We performed a prospective cohort study of 46,295 men who were free of diverticulitis and known diverticulosis in 1986 (baseline) using data from the Health Professionals Follow-Up Study. Each study participant completed a detailed medical and dietary questionnaire at baseline. We sent supplemental questionnaires to men reporting incident diverticulitis on biennial follow-up questionnaires. We assessed diet every 4 years using a validated food frequency questionnaire. Western (high in red meat, refined grains, and high-fat dairy) and prudent (high in fruits, vegetables, and whole grains) dietary patterns were identified using principal component analysis. Follow-up time accrued from the date of return of the baseline questionnaire in 1986 until a diagnosis of diverticulitis, diverticulosis or diverticular bleeding; death; or December 31, 2012. The primary end point was incident diverticulitis. **RESULTS:** During 894,468 person years of follow-up, we identified 1063 incident cases of diverticulitis. After adjustment for other risk factors, men in the highest quintile of Western dietary pattern score had a multivariate hazard ratio of 1.55 (95% CI, 1.20–1.99) for diverticulitis compared to men in the lowest quintile. High vs low prudent scores were associated with decreased risk of diverticulitis (multivariate hazard ratio, 0.74; 95% CI, 0.60–0.91). The association between dietary patterns and diverticulitis was predominantly attributable to intake of fiber and red meat. **CONCLUSIONS:** In a prospective cohort study of 46,295 men, a Western dietary pattern was associated with increased risk of diverticulitis, and a prudent pattern was associated with decreased risk. These data can guide dietary interventions for the prevention of diverticulitis.

Keywords: PCA; HPFS; Alternative Healthy Eating Index; Diverticular Disease.

The incidence of diverticulitis has risen precipitously in the past century from a virtually unknown diagnosis in the early 1900s, to one of the most common gastrointestinal indications for hospital admission in the United States.[1–3] In 2010 in the United States, the prevalence of diverticulitis was estimated to be 92/100,000 persons and was higher on average in women than in men (76 vs 99/100,000).[3] More than $2 billion are spent caring for patients hospitalized for diverticulitis each year.[4] This figure does not account for the nearly 3 million patients with diverticulitis who are managed in the outpatient setting.[4]

The increasing incidence of diverticulitis has been attributed to changes in diet and lifestyle, predominantly a decrease in dietary fiber consumption. Several population-based studies have examined fiber intake in association with diverticular disease. In an earlier analysis of the Health Professionals Follow-up Study (HPFS) from 1988 to 1992, dietary fiber and, in particular, insoluble fruit and vegetable fiber, was inversely associated with symptomatic diverticular disease.[5,6] Two cohort studies in the United Kingdom also found inverse associations between fiber intake and hospitalizations for diverticular disease.[7,8] Vegetarians were at lower risk of diverticular disease when compared to omnivores after adjustment for fiber intake and other confounders. Several studies have noted a positive association between red meat consumption and diverticular disease.[5,9,10] In addition, in the HPFS cohort, nut and popcorn consumption were associated with a modest inverse risk of diverticulitis after adjustment for other potential risk factors including dietary fiber.[11]

Most existing studies of diet have examined symptomatic diverticular disease or hospitalization for diverticular

Abbreviations used in this paper: **AHEI, Alternative Healthy Eating Index; CI, confidence interval; FFQ, food frequency questionnaire; HPFS, Health Professional Follow-Up Study; HR, hazard ratio.**

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disease, but not specifically diverticulitis, a manifestation that is distinct in presentation, treatment, and pathophysiology from other manifestations, including symptomatic uncomplicated diverticular disease and diverticular bleeding. In addition, the UK studies included only diverticular disease requiring hospitalization (diverticulitis, diverticulosis, diverticular bleeding), and most patients with diverticulitis are managed in the outpatient setting.[4] Dietary patterns and timing of dietary intake have not been previously examined except with respect to vegetarianism.

The study of dietary patterns rather than individual dietary components captures interactions between specific foods and nutrients, as well as the combined influence of multiple dietary components on disease risk.[12] Knowledge of associations between dietary patterns and disease risk also facilitates population-based disease-prevention strategies.[13]

Therefore, we prospectively examined the associations between dietary patterns and risk of diverticulitis in the HPFS, a cohort with 26 years of detailed, updated data on dietary intake. We identified a posteriori dietary patterns using data from food frequency questionnaires (FFQs) and also examined an a priori dietary pattern, the Alternative Healthy Eating Index (AHEI).[14,15]

Methods

Study Population

The HPFS is a prospective cohort of 51,529 male dentists, veterinarians, pharmacists, optometrists, osteopathic physicians, and podiatrists, aged 40 to 75 years at time of study entry in 1986. Each study participant completed a detailed medical and dietary questionnaire at baseline. Medical information has been updated biennially and dietary information has been updated every 4 years with an mean follow-up >90%. The study was approved by the Institutional Review Board at the T.H. Chan School of Public Health, Boston, MA.

Men who reported a diagnosis of diverticulosis or its complications (n = 227), cancer (except non-melanoma skin cancer, n = 2000), or inflammatory bowel disease (n = 475) at baseline in 1986 were excluded from the analysis. In addition, we excluded study participants for whom dietary information (n = 1596) or date of birth (n = 18) was not available, participants with a date of death before 1986 (n = 4), and those who returned the 1986 baseline questionnaire and then were lost to follow-up (n = 914). After these exclusions, there were 46,295 men in our baseline study population.

Assessment of Diverticulitis

The primary end point of this study was incident diverticulitis. Beginning in 1990, participants who reported newly diagnosed diverticulitis or diverticulosis on the biennial study questionnaire were sent supplementary questionnaires that ascertained the date of diagnosis, presenting symptoms, diagnostic procedures, and treatment. Diverticulitis was defined as abdominal pain attributed to diverticular disease and one of the following criteria: complicated by perforation, abscess, fistula, or obstruction; requiring hospitalization, antibiotics, or surgery; pain categorized as severe or acute; or abdominal pain presenting with fever, requiring medication, or evaluated using abdominal computed tomography. We have previously used these case definitions and documented the validity of self-reported diverticulitis in this population.[11,16,17]

Beginning in 2006, we administered a revised supplementary diverticular disease questionnaire. This questionnaire assessed uncomplicated diverticulitis, complications of diverticulitis including abscess, fistula, perforation and obstruction, diverticular bleeding and diverticulosis using questions that included definitions for each disease outcome.[18] Diverticulitis was defined using the algorithm outlined.

Assessment of Dietary Patterns

Dietary information was obtained from study participants using a semi-quantitative FFQ that was previously validated in this cohort.[19] Study participants were asked to quantify how frequently they consumed a standard portion of a food item during the prior year using 9 categories ranging from never or less than once per month to more than 6 times daily. The FFQ was modified over time to account for secular changes in culinary preferences. At baseline, it contained 131 food items and in 2010 it contained 148 items (mean, 140 items). For the most part, food items were added over time to account for low-fat or fortified options, such as lean hamburger and calcium-fortified orange juice. These changes were incorporated into the calculation of dietary patterns for each biennial questionnaire cycle. The correlation coefficients between the FFQ and diet records in a sample of 323 men were 0.59 for red meats, 0.52 for processed meats, 0.67 for fruit, 0.26-0.55 for vegetables, and 0.27 for whole grains.[20]

The procedure for defining a posteriori dietary patterns in the HPFS has been detailed in prior publications.[20] In brief, we assigned food items to 40 prespecified food groups based on nutrient profiles or cooking usage (Supplementary Table 1). For example, white bread, pasta, and white rice were classified as refined grains; and chili sauce, ketchup, and pepper were classified as condiments. We then conducted principal component factor analysis[21] on the 40 food groups to identify dietary patterns. The obtained factors were rotated using orthogonal rotation so that the factors (dietary patterns) were uncorrelated with each other and were easier to interpret. We used the eigenvalue (>1), Scree test,[22] and interpretability to determine the number of factors to retain. To calculate the factor score for each pattern, we summed the intake of the component food groups weighted by the factor loadings (the correlation coefficient between a food group and a particular dietary pattern). A factor score for each pattern was calculated for each participant. The continuous dietary pattern scores were categorized in quintiles.

We also calculated the AHEI for each participant. The AHEI-2010 is a modified version of the Healthy Eating Index 2005, which was constructed based on expert opinion to represent optimal dietary behavior for disease prevention.[14,15,23] The score includes 10 dietary components (vegetables, fruits, nuts and legumes, red meat, trans fat, polyunsaturated fat, long-chain fats, whole grains, sugar-sweetened beverages and fruit juice, and alcohol). Each component is scored from 0 to 10 with higher scores representing more optimal intake up to a maximum of 100 points. For the analysis, we categorized the AHEI in quintiles.

Assessment of Other Potential Risk Factors

We assessed a number of other lifestyle and medical factors that have been associated with risk of diverticulitis, including nonaspirin nonsteroidal anti-inflammatory drug, aspirin use and acetaminophen use, physical activity (expressed as metabolic equivalent hours per week), smoking (past, current, never), and body mass index (weight in kilograms divided by height in meters squared). These risk factors were assessed using biennial questionnaires starting at baseline, except height, which was measured only at baseline. Prior studies in this cohort have demonstrated the validity and reproducibility of the assessment of body measurements, aspirin use, and physical activity.[24–26]

Statistical Analysis

Follow-up time accrued from the date of return of the baseline questionnaire in 1986 to the first of the following: a diagnosis of diverticulitis, diverticulosis or diverticular bleeding, death or December 31, 2012. We censored men at the time of a new diagnosis of gastrointestinal cancer or inflammatory bowel disease or at the last questionnaire response. A total of 9.7% of person-years were lost to follow-up due to censoring at the last questionnaire returned. We calculated age-adjusted and multivariate hazard ratios (HR) and 95% confidence interval (CI) using Cox proportional hazards regression. Multivariate models were adjusted for age (1-year intervals), study period (2-year intervals), current aspirin use (yes/no), current nonsteroidal anti-inflammatory drug use (yes/no), current acetaminophen use (yes/no), body mass index (<21, 21–22.9, 23–24.9, 25–27.4, 27.5–29.9, 30+ kg/m^2),[27] total physical activity level (quintiles), total calorie intake (quintiles), and smoking (current/past). In additional analyses, we further adjusted for caffeine intake (quintiles) and alcohol intake (quartiles). In the main analysis, we used simple updating or the most recent dietary information available (ie, the intake reported on the most recent FFQ before each 2-year follow-up interval; range within 1 to 4 years). In secondary analyses, we also examined baseline dietary information as assessed in 1986, as well as the cumulative mean of dietary pattern scores derived from all available dietary questionnaires before each 2-year follow-up interval. For example, the cumulative mean for 1990 included dietary data from 1986 and 1990. For tests of linear trend, we treated the median value of each dietary quintile as a continuous variable. We conducted analyses to examine the joint influence of the dietary patterns on risk of diverticulitis. To examine the degree to which the association between dietary patterns and diverticulitis was due to fiber and red meat, 2 dietary factors previously found to be associated with diverticular disease,[5] we included these foods in our models. We used SAS software, version 9.3 (SAS Institute, Inc, Cary, NC) for all analyses. All reported *P* values are 2-sided.

Results

We identified 2 major dietary patterns.[28,29] In summary, the pattern with high intake of red and processed meats, refined grains, sweets, french fries, and high-fat dairy products was labeled the western pattern (Supplementary Table 2). The second pattern, the prudent pattern, was high in fruits, vegetables, whole grains, legumes, poultry, and fish (Supplementary Table 2). The Western pattern explained 7.1% of the total dietary variance and the prudent pattern explained 9.2% of the dietary variance. The mean AHEI-2010 score for the cohort at baseline in 1986 was 47.8 (range, 11.7–91.9). Baseline characteristics of the cohort are summarized in Table 1 according to quintile of dietary pattern score and standardized for age and study period. Men with the highest Western dietary pattern scores were, on average, less likely to be physically active and more likely to smoke and drink alcohol when compared to men with the lowest Western dietary pattern scores. In contrast, men with the highest prudent and AHEI scores tended to be more physically active and less likely to drink alcohol and smoke than men with low prudent and AHEI scores and men with high Western dietary pattern scores.

During 894,468 person years of follow-up, 1063 incident cases of diverticulitis were identified. After adjustment for other risk factors, a higher Western dietary pattern score was associated with an increased risk of diverticulitis, and higher prudent and AHEI dietary pattern scores were associated with decreased risk (Table 2). Men in the highest quintile of Western dietary pattern score had a multivariate HR of 1.55 (95% CI, 1.20–1.99) when compared to men in the lowest quintile. The corresponding multivariate HRs comparing extreme quintiles were 0.74 (95% CI, 0.60–0.91) for prudent pattern and 0.67 (95% CI, 0.55–0.82) for AHEI pattern. When we added caffeine and alcohol intake to the multivariate models, the results were nearly identical (data not shown).

We also examined the risk of diverticulitis according to the joint classification of Western and prudent dietary patterns (Table 3). The multivariate HR for diverticulitis was 1.72 (95% CI, 1.29–2.28) in men in the highest tertile of western and lowest tertile of prudent dietary scores when compared to men with the lowest western and highest prudent scores.

When we added red meat and fiber to the models, the association between Western dietary pattern and diverticulitis was attenuated (multivariate HR, 1.15; 95% CI, 0.86–1.52). The inverse associations were attenuated when fiber intake was added to the models for prudent pattern (multivariate HR, 0.99; 95% CI, 0.77–1.28) and AHEI (multivariate HR, 0.81; 95% CI, 0.64–1.04). However, after adjustment for red meat intake, the inverse associations were not materially altered for prudent pattern (multivariate HR, 0.81; 95% CI, 0.66–1.01) and AHEI pattern (multivariate HR, 0.75; 95% CI, 0.61–0.93). Because the HR for the AHEI pattern remained <1 after adjustment for fiber and red meat, we tested other food groups in our models including fruits, vegetables, total fat, saturated fat, nuts (without soy), and yogurt. These food groups did not alter the relationship between the AHEI pattern and risk of diverticulitis (data not shown).

In additional analyses, we evaluated the timing of dietary intake relative to the diagnosis of incident diverticulitis. For Western, prudent, and AHEI patterns, we found that for baseline dietary patterns and cumulative averaged

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Table 1. Baseline Characteristics of the Study Population According to Quintile of Dietary Pattern Score (N = 46,295)

	Western			Prudent			AHEI[a]		
Characteristic	Q1 (n = 9220)	Q3 (n = 9272)	Q5 (n = 9260)	Q1 (n = 9301)	Q3 (n = 9250)	Q5 (n = 9217)	Q1 (n = 9215)	Q3 (n = 9238)	Q5 (n = 9252)
Age, *y*, mean (SD)	55.4 (9.8)	53.8 (9.8)	52.6 (9.5)	51.8 (9.6)	54.1 (9.6)	55.3 (9.6)	52.1 (9.6)	53.9 (9.7)	55.5 (9.5)
Physical activity, *MET h/wk*, mean (SD)	24.9 (33.4)	20.7 (27.3)	18.2 (26.2)	15.5 (22.1)	21.0 (30.1)	28.1 (36.3)	15.1 (22.2)	20.7 (30.1)	28.4 (36.8)
BMI, kg/m^2, mean (SD)	24.4 (4.9)	24.9 (5.0)	25.3 (5.2)	25.0 (4.9)	25.0 (4.8)	24.8 (5.2)	25.2 (5.0)	25.0 (5.0)	24.5 (5.0)
Daily intake, mean (SD)									
Alcohol, *g/d*	8.4 (12.1)	11.6 (15.0)	13.7 (17.9)	10.4 (15.5)	11.7 (15.3)	11.7 (15.3)	13.7 (21.1)	10.9 (14.6)	10.1 (9.9)
Total fat, *g/d*	61.7 (14.5)	72.3 (12.4)	78.5 (11.9)	77.4 (13.9)	71.7 (12.8)	64.1 (14.1)	75.3 (13.4)	71.7 (13.5)	66.3 (14.7)
Total fiber, *g/d*	25.0 (8.8)	20.6 (6.4)	18.4 (5.0)	15.6 (4.7)	20.7 (5.3)	27.5 (7.7)	15.6 (4.2)	20.7 (5.3)	27.5 (7.4)
Red meat servings, n[b]	1.7 (1.4)	4.1 (2.3)	7.3 (3.7)	4.5 (3.2)	4.4 (3.1)	3.8 (3.2)	5.8 (3.4)	4.3 (3.1)	2.7 (2.3)
Smoking status, %									
Never	49	46	40	43	45	46	44	44	45
Former	42	42	42	39	42	44	37	43	46
Current	5	9	15	14	9	6	15	9	5
Current aspirin use, %	29	28	30	28	30	30	28	29	31
Current NSAID use, %	5	6	6	5	5	5	6	5	5

NOTE. Values are means (SD) or percentages and are standardized to the age distribution of the study population.
MET, metabolic equivalent; NSAID, nonsteroidal anti-inflammatory drug.
[a]Mean (SD) AHEI-2010 scores were 32.6 (4.5) in Q1, 47.6 (1.7) in Q3, and 63.7 (5.3) in Q5.
[b]Red meat serving was defined as: beef, pork, or lamb as a main dish (4−6 oz); pork, beef, or lamb as a sandwich or mixed dish; hamburger (1 patty); hot dog (1); processed meat (2 oz or 2 small links) and bacon (2 slices).

patterns (that reflect long-term intake) the tests for trend were not as strong as for simple updated dietary patterns. For example, when adjusted for simultaneously, the multivariate HR for diverticulitis was 1.36 (95% CI, 0.96−1.94; *P* for trend = .02) for simple updated Western pattern, and 1.25 (95% CI, 0.88−1.76; *P* for trend = .53) for cumulative averaged Western pattern. We also performed 4- and 8-year time-lag analyses with respect to the assessment of diet and the diagnosis of diverticulitis. The multivariate HRs for Western diet were attenuated (HR, 1.24; 95% CI, 0.98−1.57 for 4-year and HR, 1.16; 95% CI, 0.89−1.50 for 8-year lag). The associations between prudent and AHEI dietary patterns were not materially changed.

Discussion

In this large, prospective study of men, higher Western dietary pattern scores were associated with an increased risk of incident diverticulitis. In contrast, higher prudent and AHEI pattern scores were associated with decreased risk of diverticulitis. Among specific foods, fiber and red meat appeared to be the most strongly associated components of the relationship between dietary patterns and risk of diverticulitis. Recent dietary intake appeared to have a somewhat greater association than long-term or past intake.

Previous population-based studies of diet and diverticular disease have focused on individual dietary components. Similar to our findings, these studies have found an inverse association between fiber and symptomatic diverticular disease or hospitalization for diverticular disease.[5–8] A few studies have also found positive, nonlinear associations between red meat intake and symptomatic diverticular disease.[5,9] Vegetarians have been found to be at decreased risk of diverticular disease when compared with individuals who eat meat after adjustment for fiber intake.[7]

To expand on these earlier findings, we investigated the association between dietary patterns and risk of diverticulitis. Dietary pattern analysis considers the entire diet and not just a single nutrient or food and, therefore, accounts for the complex interaction between dietary components. In addition, dietary patterns more closely represent dietary practices in the real world, and can be translated readily into public health interventions.[13] Our results indicate that the diets recommended to decrease the risk of a number of chronic health conditions, including diabetes, coronary artery disease, and cancer[23,30] are also likely to decrease the risk of diverticulitis. Our work also adds to knowledge about the timing of dietary intake in relation to risk of diverticulitis. Although earlier studies were limited to data on recent intake, we collected detailed dietary data over extended follow-up in order to examine baseline, long-term, and recent intake. We found that recent dietary intake (within 1 to 4 years), particularly for the Western pattern, was somewhat more strongly

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Table 2. Risk of Diverticulitis According to Quintile of Simple Updated Dietary Pattern Score (N = 46,295)

Variable	Quintile of dietary pattern score 1	2	3	4	5	*P* value for trend
Western pattern						
No. of cases	174	189	243	235	222	
Person-years	183,670	180,359	177,226	176,729	176,483	
Age-adjusted HR (95% CI)	1.0	1.12 (0.91–1.38)	1.47 (1.21–1.79)	1.44 (1.18–1.75)	1.36 (1.12–1.66)	.0001
Multivariate 1 HR[a] (95% CI)	1.0	1.10 (0.89–1.35)	1.46 (1.18–1.80)	1.49 (1.19–1.86)	1.55 (1.20–1.99)	<.0001
Multivariate 2 HR[b] (95% CI)	1.0	0.96 (0.77–1.19)	1.19 (0.95–1.49)	1.16 (0.90–1.48)	1.15 (0.86–1.52)	.15
Multivariate 3 HR[c] (95% CI)	1.0	0.99 (0.80–1.23)	1.27 (1.02–1.58)	1.27 (1.00–1.61)	1.31 (1.00–1.72)	.01
Multivariate 4 HR[d] (95% CI)	1.0	1.03 (0.84–1.28)	1.32 (1.06–1.63)	1.29 (1.02–1.63)	1.28 (0.98–1.68)	.02
Prudent pattern						
No. of cases	243	221	213	201	185	
Person-years	180,482	178,753	177,977	178,403	178,853	
Age-adjusted HR (95% CI)	1.0	0.90 (0.75–1.08)	0.87 (0.72–1.05)	0.81 (0.67–0.98)	0.74 (0.61–0.89)	.001
Multivariate 1 HR[a] (95% CI)	1.0	0.89 (0.74–1.06)	0.85 (0.70–1.03)	0.80 (0.65–0.97)	0.74 (0.60–0.91)	.004
Multivariate 2 HR[b] (95% CI)	1.0	0.95 (0.78–1.15)	0.97 (0.79–1.19)	0.97 (0.78–1.22)	1.02 (0.78–1.31)	.89
Multivariate 3 HR[c] (95% CI)	1.0	0.90 (0.75–1.08)	0.88 (0.73–1.06)	0.84 (0.69–1.03)	0.81 (0.66–1.01)	.05
Multivariate 4 HR[d] (95% CI)	1.0	0.95 (0.78–1.14)	0.96 (0.78–1.17)	0.96 (0.77–1.20)	0.99 (0.77–1.28)	.97
AHEI						
No. of cases	262	246	195	189	171	
Person-years	178,180	179,135	179,564	178,739	178,851	
Age-adjusted HR (95% CI)	1.0	0.93 (0.78–1.10)	0.72 (0.60–0.87)	0.71 (0.58–0.85)	0.63 (0.52–0.76)	<.0001
Multivariate 1 HR[a] (95% CI)	1.0	0.94 (0.79–1.12)	0.74 (0.62–0.90)	0.73 (0.61–0.89)	0.67 (0.55–0.82)	<.0001
Multivariate 2 HR[b] (95% CI)	1.0	0.98 (0.82–1.17)	0.81 (0.66–0.99)	0.85 (0.68–1.06)	0.87 (0.68–1.12)	.11
Multivariate 3 HR[c] (95% CI)	1.0	0.95 (0.80–1.13)	0.77 (0.64–0.93)	0.78 (0.64–0.94)	0.75 (0.61–0.93)	.0009
Multivariate 4 HR[d] (95% CI)	1.0	0.97 (0.81–1.16)	0.79 (0.65–0.97)	0.82 (0.66–1.02)	0.81 (0.64–1.04)	.03

[a]Multivariate model 1 HRs are adjusted for age, study period, current aspirin use (yes/no), current nonsteroidal anti-inflammatory use (yes/no), current acetaminophen use (yes/no), body mass index (<21, 21–22.9, 23–24.9, 25–27.4, 27.5–29.9, 30+ kg/m^2), physical activity level (quintiles), total calorie intake (quintiles), smoking (current/past).
[b]Multivariate model 2 HRs are additionally adjusted for red meat and fiber intake.
[c]Multivariate model 3 HRs are additionally adjusted for red meat intake.
[d]Multivariate model 4 HRs are additionally adjusted for fiber intake.

associated with risk of incident diverticulitis than long-term (cumulative) intake, indicating that relatively short-term dietary interventions can modify disease risk. Lastly, in comparison to earlier population-based studies,[5–7] we examined diverticulitis separately from diverticular bleeding and symptomatic uncomplicated diverticular disease. These are distinct manifestations of diverticular disease that likely have different biologic pathways and risk factors. Furthermore, other studies have focused on hospitalized events,[7,8] whereas we examined the full spectrum of diverticulitis, including cases managed in the outpatient setting, which represent the majority of cases in the United States.[4]

Table 3. Risk of Diverticulitis According to Joint Classification of Western and Prudent Dietary Patterns in Tertiles (N = 46,295)

Prudent pattern	Western pattern 1	2	3
1	1.30 (0.95–1.77)	1.87 (1.43–2.45)	1.72 (1.29–2.28)
2	1.24 (0.92–1.67)	1.37 (1.03–1.81)	1.63 (1.22–2.18)
3	1.0	1.55 (1.16–2.06)	1.56 (1.15–2.13)

NOTE. Values are multivariate HR (95% CI) adjusted for age, study period, current aspirin use (yes/no), current nonsteroidal anti-inflammatory use (yes/no), current acetaminophen use (yes/no), body mass index (<21, 21–22.9, 23–24.9, 25–27.4, 27.5–29.9, 30+ kg/m^2), physical activity level (quintiles), total calorie intake (quintiles), smoking (current/past).

Red meat may influence the risk of diverticulitis via a number of potential mechanisms. First, red meat can promote chronic low-grade systemic inflammation, which is hypothesized to play a role in diverticulitis.[31] Greater red meat intake is associated with higher levels of inflammatory biomarkers, such as C-reactive protein and ferritin,[32] as well as an increased risk of chronic diseases associated with elevated levels of circulating inflammatory markers including type 2 diabetes and cardiovascular disease.[33,34] Second, red meat can contain specific compounds that are important in the etiopathogenesis of diverticulitis. For example, heme, N-nitroso compounds, and heterocyclic amines affect colon epithelial homeostasis and have been proposed as mediators of the association between meat consumption and risk of colorectal cancer.[35] Third, long-term adherence to a diet high in red meat can contribute to the development of obesity, a known risk factor for diverticulitis.[17,36,37] However, in our analysis, dietary patterns remained significant predictors of diverticulitis after adjustment for body mass index, and short-term diet was a somewhat stronger risk factor than long-term diet.

There are also a number of mechanisms by which fiber intake can influence the risk of diverticulitis. Dietary fiber increases stool bulk and, therefore, decreases colon pressures and stool transit time.[38–40] Dietary fiber also influences the composition and metabolic activity of the gut microbiota, and provides a source of short-chain fatty acids, such as butyrate, which are important to colon mucosa integrity.[41] In addition, high fiber intake is inversely associated with markers of systemic inflammation even after adjustment for other lifestyle factors.[42] Lastly, long-term dietary fiber intake is inversely associated with weight gain.[43] However, as noted here, in our study, recent diet was more significant than long-term diet, and the risk was independent of body mass index.

Our study utilized a large cohort of men with detailed, prospectively collected data on diet and other lifestyle and medical factors with minimal loss to follow-up. Therefore, recall and selection bias are unlikely to have influenced our results, and we were able to comprehensively control for purported risk factors for diverticulitis. Nonetheless, our study has several potential limitations. First, some misclassification is possible because exposure and outcomes data were self-reported. However, health care professionals are more likely to accurately self-report medical information, and reports of diverticulitis and dietary intake have been validated in this cohort.[11,19] In addition, misclassification would be expected to be random biasing the results toward the null. Second, FFQs provide an imperfect assessment of dietary intake, and the methods for defining a posteriori dietary patterns (factor analysis) are, to some extent, subjective. However, the Western and prudent dietary patterns derived from FFQs in this cohort have been reproducible, and correlate with patterns derived from diet records.[20] These 2 patterns have also been associated with a number of other diseases, including cardiovascular disease, colon cancer, and diabetes and correlate with plasma concentrations of biomarkers.[28,29,44,45] Other methods for extrapolating dietary patterns in this cohort have produced results similar to principal component analysis.[28] Third, a posteriori dietary patterns, such as Western and prudent, can vary according to sex, culture, and socioeconomic status and, therefore, our results might not be broadly generalizable. Nonetheless, our results are consistent with previous studies and proposed biologic mechanisms. Fourth, we had limited power to examine complicated diverticulitis (n = 106). However, our outcomes represent the spectrum of diverticulitis encountered in clinical practice. Lastly, although we controlled for known and proposed risk factors, the observational study design does not allow us to exclude residual confounding as a reason for our findings.

In summary, we found that the Western dietary pattern was associated with increased risk of incident diverticulitis and the prudent pattern and AHEI were associated with decreased risk. Recent dietary intake may be more strongly associated with diverticulitis than long-term intake. The associations between dietary pattern and diverticulitis were largely due to red meat and fiber intake. These results suggest that diets currently recommended for prevention of cardiovascular and other chronic diseases will also be beneficial in individuals with diverticulosis. In addition, short-term dietary interventions can mitigate the risk of diverticulitis.

Supplementary Material

Note: To access the supplementary material accompanying this article, visit the online version of *Gastroenterology* at www.gastrojournal.org, and at http://dx.doi.org/10.1053/j.gastro.2016.12.038.

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Conflicts of interest
The authors disclose no conflicts.

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Supplementary Table 1. Food Items and Food Groups Utilized in the Dietary Pattern Analyses

Food group	Food items[a]
Other vegetables	Celery, corn, mixed vegetables, eggplant or zucchini or other summer squash, green/red peppers, beets, onion
Leafy green vegetables	Spinach cooked, spinach raw, iceberg or head lettuce, romaine or leaf lettuce
Yellow vegetables	Carrots raw, carrots cooked, yellow (winter) squash, yams or sweet potatoes
Legumes	String beans, peas or lima beans, beans or lentils, tofu or soybeans
Cruciferous vegetables	Broccoli, cabbage or coleslaw, cauliflower, Brussels sprouts, kale or mustard greens or chard
Fruit	Raisins or grapes, bananas, cantaloupe, fresh apples or pears, oranges, grapefruit, strawberries, blueberries, peaches, apricots or plums, prunes, avocado
Tomatoes	Tomatoes, tomato juice, tomato sauce
Fish and other seafood	Canned tuna, dark-meat fish, other fish, breaded fish, shrimp, lobster or scallops
Garlic	Garlic
Whole grains	Cooked oatmeal, other cooked cereal, whole-grain ready-to-eat cereal, dark or wheat bread, brown rice, oat bran, wheat germ, oats, other grains
Poultry	Chicken or turkey with skin, without skin
Other soup	Ready-made soup, homemade soup
Salad dressing	Oil and vinegar salad dressing, other salad dressing
Fruit juice	Apple juice or cider, orange juice, grapefruit juice, other fruit juice
Water	Plain water (sparkling or tap)
Red meats	Beef, pork or lamb sandwich, pork main dish, beef or lamb main dish, hamburger
Processed meats	Salami or bologna, other processed meats, bacon, beef hot dogs, chicken or turkey hot dog, chicken/turkey sandwich
French fries	French fries
Refined grains	White bread, English muffins or bagel, muffins or biscuits, white rice, pasta, pancakes or waffles, refined grain ready-to-eat cereals
High-fat dairy	Whole milk, cream, sour cream, ice cream, cream cheese, other cheese
Eggs	Eggs
Condiments	Red chili sauce or ketchup, pepper, jam, jelly, syrup or honey
Desserts and sweets	Chocolate bars or pieces, candy bars, cookies or brownies, doughnuts, cake, pie, sweet roll or coffee cake or pastry
Snack foods	Potato chips or corn chips, crackers, popcorn
Sugar beverages	Cola with sugar, other carbonated beverages with sugar, fruit drinks
Butter	Butter
Margarine	Margarine
Mayonnaise	Mayonnaise
Potatoes	Potatoes baked, boiled or mashed
Coffee	Regular coffee, decaffeinated coffee
Pizza	Pizza
Cream soup	Cream soup or chowder
Nuts/peanut butter	Peanuts, other nuts, peanut butter
Tea	Decaffeinated/herbal tea, tea with caffeine
Wine	White wine, red wine
Liquor	Liquor
Beer	Regular beer, light beer
Diet beverages	Diet cola, diet caffeine-free cola, other low-calorie carbonated beverage
Organ meats	Beef, calf or pork liver, chicken or turkey liver
Low-fat dairy	Skim milk, 2% milk, yogurt, sherbet or sorbet or low-fat ice cream, cottage cheese or ricotta

[a]Food items are separated by commas.

Supplementary Table 2. Factor Loadings for the Western and Prudent Dietary Patterns in the Health Professionals Follow-Up Study (N = 46,295)[a]

Variable	Prudent	Western
Other vegetables	0.73	—
Leafy green vegetables	0.62	—
Yellow vegetables	0.61	—
Legumes	0.59	—
Cruciferous vegetables	0.58	—
Fruit	0.56	−0.17
Tomatoes	0.53	—
Fish and other seafood	0.46	—
Garlic	0.38	—
Whole grains	0.36	—
Poultry	0.33	—
Other soup	0.26	0.20
Salad dressing; oil/vinegar	0.25	—
Fruit juice	0.24	—
Water	0.22	—
Red meats	—	0.64
Processed meats	—	0.60
French fries	—	0.45
Refined grains	—	0.45
High-fat dairy	—	0.44
Eggs	—	0.42
Condiments	0.18	0.41
Desserts and sweets	—	0.38
Snack foods	—	0.33
Sugar beverages	—	0.32
Butter	—	0.32
Margarine	—	0.28
Mayonnaise	—	0.28
Potatoes	0.23	0.28
Coffee	—	0.27
Pizza	—	0.26
Cream soup	—	0.23
Nuts/peanut butter	0.17	0.18
Tea	—	—
Wine	—	—
Liquor	—	—
Beer	—	—
Diet beverages	—	—
Organ meats	—	—
Low-fat dairy	—	—

[a]Using orthogonal rotation, correlation coefficients are nearly identical to the factor loading matrix. To simplify data presentation, loadings with an absolute value <.15 are not shown.