Original Article
Running Title: Dietary Patterns and the Odds of Colorectal Cancer

Association of Dietary Patterns and the Odds of Colorectal Cancer in a Sample of the Population in Southern Iran: An Observational Case-Control Study

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Abstract

Background: Colorectal cancer is the second leading cause of cancer-related deaths for both men and women. This study aimed to explore the association between dietary patterns and the odds of colorectal cancer in an Iranian adult population.

Method: This observational case-control study was conducted at three educational and therapeutic centers affiliated with Shiraz University of Medical Sciences. A total of 207 participants were enrolled in the study, comprising 103 individuals with colorectal cancer (case group) and 104 individuals without colorectal cancer (control group). The participants' dietary intake was assessed using a valid and reliable food frequency questionnaire comprising 117 items. Dietary patterns were analyzed using principal component analysis, and their relationship with colorectal cancer was investigated using logistic regression, reporting odds ratios with 95% confidence intervals.

Results: Two main dietary patterns were identified in this study; the high-fiber pattern (HFP) and the unhealthy pattern (UHP). These patterns explained 11.46% and 11.98% of the total variance, respectively. An HFP was significantly associated with reduced odds of colorectal cancer in both the crude and adjusted models. Conversely, adherence to a UHP was significantly associated with an increased risk of colorectal cancer in both crude and adjusted models.

Conclusion: These findings suggest that adherence to an HFP is associated with a reduced risk of colorectal cancer, whereas adherence to a UHP is associated with an increased risk. Overall, these results underscore the importance of modifying dietary habits as a strategic approach to the prevention of colorectal cancer among the adult population in Iran.

Keywords: Dietary pattern, Colorectal neoplasms, Dietary fiber, Fast food

Introduction

According to a report published by the International Agency for Research on Cancer, colorectal cancer is the second most common cause of cancer-related death in the world after lung cancer, with an estimated 173,935 deaths and an age-standardized mortality rate of 9 per 100,000.[1] The highest and lowest death rates from this disease have been reported in Europe and the Western Mediterranean region, with 12.3 and 5.3 deaths per 100,000 people, respectively. In Iran, colorectal cancer is the third leading cause of cancer-related deaths, following stomach cancer (12.3) and lung cancer (8.3), with an age-specific standardized mortality rate of 5.6.[2]

Most colorectal cancers type, regardless of etiology, have relatively distinct cellular and molecular stages. Common types of colorectal cancers take 7 to 10 years to develop into cancer cells due to mutations in somatic cells. This period represents an important window of opportunity for the screening and prevention of this disease. Several key steps are involved in carcinogenesis, including reduced DNA methylation, mutations in the K-RAS proto-oncogene, allelic loss on the long arm of chromosome 5 (5q21) at the locus of a tumor suppressor gene, allelic loss at the tumor suppressor gene locus on chromosome 18q, and allelic loss on chromosome 17p accompanied by mutations in the p53 tumor suppressor gene.[3]

Risk factors for developing colorectal cancer include dietary habits, hereditary syndromes, polyposis coli, non-polyposis syndromes, inflammatory bowel disease, Streptococcus bovis bacteremia, uretersigmoid vesicostomy, and tobacco use.[4] Strong epidemiological evidence shows that diet plays a significant role in the occurrence of this disease.[5] Reports indicate varying incidence rates of this disease across socioeconomic classes.[6] Disease incidence varies by geographical area, but it is not solely attributed to genetic differences.[7] Research indicates that immigrant populations exhibit disease patterns similar to those of their host countries.[8] Evidence indicates that the adoption of Western dietary patterns by the Japanese has led to an increase in colorectal cancer incidence in recent decades.[9]

Many studies have explored the relationship between dietary factors and the occurrence of the disease.[10, 11] In recent years, nutritional research has shifted from examining individual food items or food groups to exploring overall dietary patterns. This shift is important because the assessment of single dietary components does not fully capture the effects of the total diet. By focusing on dietary patterns, researchers can better understand the synergistic effects of different foods and their complex interactions, thereby providing a more accurate representation of habitual dietary intake.[12] Safari et al. found an inverse association between this disease and a healthy dietary pattern in a study involving 71 patients in Tehran.[13] Research focusing on Middle Eastern populations, particularly in Iran, is limited, and Iranian dietary patterns significantly differ from Western dietary habits in both composition and structure. The present study aimed to identify dietary patterns and their association with the odds of colorectal cancer in Shiraz, Iran, through a case-control design.

Method

Study design and participants

The present observational case-control study was approved by the Office of Vice-Chancellor for Research of Shiraz University of Medical Sciences in accordance with the Declaration of Helsinki and approved by the Ethics Committee (ethics code IR.SUMS.SCHEANUT.REC.1403.059).

The study participants signed an informed consent form.

Sampling commenced following the approval of the study protocol in September 2024 and continued until July 2025. The case group participants were selected from eligible patients with colorectal cancer referred to the chemotherapy department of Amir Teaching Hospitals and the general surgery department of Shahid Faghihi Hospital of Shiraz University of Medical Sciences. An oncologist confirmed the diagnosis of these patients. A case in this study was defined as any patient with cancer in the colon (the longest part of the large intestine) and/or rectum (the last few inches of the large intestine before the anus) diagnosed by a clinician based on clinical symptoms, examination, and biopsy. The inclusion criteria for the study were as follows: participants must be willing to take part and sign an informed consent form. Eligible patients included those with colorectal cancer who are currently undergoing treatment or are candidates for treatment. Participants needed to be aged between 18 and 75 years, have received their diagnosis within the past six months, and possess Iranian nationality. The exclusion criteria were: unwillingness to participate, presence of multi-organ failure, and patients with recurrent cancer. The participants in the control group were selected from patients referred to various clinics at the Shahid Motahari Educational and Therapeutic Policlinic of Shiraz University of Medical Sciences. These patients were identified through posters and announcements. The control group consisted of individuals who met all inclusion criteria similar to the cases but did not have colorectal cancer and exhibited no gastrointestinal symptoms that were suspicious of colorectal cancer.

Matching

In this case-control study, frequency matching was employed to account for potential confounding variables. The case and control groups were matched by age and gender, ensuring that the distribution of these characteristics was similar in both groups. Age matching was conducted based on predetermined age categories, and the sex ratio in both groups was kept consistent. This method facilitated more valid comparisons between the two groups and minimized bias stemming from demographic differences.

Dietary assessment

The participants' dietary intake was assessed through face-to-face interviews by two of the authors who were individual trained (M.M and S.Z.H) using a 117-item food frequency questionnaire, the validity and reliability of which have been previously confirmed.[14] Participants' intake was determined based on the amount of each food consumed in the year before diagnosis (in the case group) or before the interview (in the control group). The study participants were asked to report the frequency of consumption of each food item in different time periods, including daily, weekly, monthly, and yearly. After collecting the data, the reported frequency was standardized to a daily consumption scale. Also, the volume of each meal was converted to grams, and the final amount of consumption of each food item in grams was calculated by multiplying the weight of each meal by the number of times it was consumed daily. Nutritionist 4 software[15] was used to calculate the nutritional value of the foods. Seasonal fruits were considered throughout the year. The food groups included are presented in Table 1.

Statistical analysis

Statistical analyses for this study were conducted using SPSS software (version 27; IBM Corporation, USA). Continuous variables are presented as mean ± standard deviation, while categorical variables are reported as frequency (percentage). To compare demographic characteristics, lifestyle factors, and clinical variables between the case and control groups, independent t-tests were employed for

continuous variables, and chi-square tests were used for categorical variables.

To identify dietary patterns, principal component analysis was performed using data from 20 food groups. The adequacy of the sample for factor analysis was evaluated using the Kaiser–Meyer–Olkin (KMO) index, which yielded a value of 0.688 in our study. Factors were selected based on eigenvalues greater than 1.7, the results of the scree plot, and interpretability. Varimax rotation was applied to enhance the interpretation of the factors. Food groups with absolute factor loading values of less than 0.17 in both extracted patterns were excluded for clarity. Factor scores for each dietary pattern were computed for all participants and utilized in subsequent analyses.

To assess the relationship between dietary patterns and the risk of colorectal cancer, results are presented as odds ratios (ORs) with 95% confidence intervals. Initially, a crude model was analyzed, followed by an adjusted model that accounted for potential confounding variables, specifically total energy intake (kcal/day) and marital status (single/married). These variables were chosen based on prior research and their significant differences between the case and control groups. All statistical tests were two-sided, with a significance level set at less than 0.05.

Results

A total of 207 patients, with a mean age of 56.94 ± 11.85 years, participated in this study. Table 2 presents the demographic and lifestyle characteristics of the participants, separated into case and control groups. There was no statistically significant difference in age and gender distribution between the two groups (P = 0.946 and P = 0.696, respectively), indicating success in homogenizing these variables. Marital status significantly differed between the two groups, with a higher percentage of married individuals in the control group (P = 0.015). Other variables, including education level, employment status, smoking and alcohol consumption, adherence to specific diets, specific eating habits, regular physical activity, and physical activity level, did not differ significantly between the two groups ($P > 0.05$).

According to the results of the factor analysis, two main dietary patterns were identified: HFP and the un-healthy pattern (Table 3). HFP was characterized by a higher consumption of medium and high-fiber fruits, green, yellow, and red vegetables, nuts and seeds, other vegetables, legumes, and olive oil, all of which had positive factor loadings and contributed significantly. In contrast, the un-healthy pattern included a higher intake of processed meats, cream and sour cream, organ meats, mayonnaise, industrial fruit juices, simple sugars, sugar-sweetened beverages, refined grains, solid fats, and fast food.

In Table 4, based on the level of adherence to high-fiber and un-healthy dietary patterns for colorectal cancer, ORs with 95% confidence intervals are reported in both crude and adjusted models. Both in the crude model and after adjusting for confounding variables, including total energy intake and marital status, it was found that an HFP is significantly associated with a reduced risk of colorectal cancer. That is, people with a dietary pattern of higher consumption of high-fiber foods had a lower risk of colorectal cancer than people with a dietary pattern of lower consumption of high-fiber foods (OR= 0.298; CI= 0.163-0.545; $P < 0.001$). In contrast, a "high" level of un-healthy dietary pattern was associated with an increased risk of colorectal cancer; Thus, people with higher consumption of this pattern were associated with an increased chance of colorectal cancer (OR= 4.263; CI= 2.213-8.212; $P < 0.001$).

Discussion

In this study, we identified two dietary patterns with acceptable distributions. Based on the factor loadings of each pattern, we designated one as HFP and the other as UHP. The findings show that these patterns are differentially associated with the risk of colorectal cancer in the Iranian adult population. Specifically, greater adherence to an HFP was associated with a significantly reduced risk of colorectal cancer. In contrast, a UHP was associated with an increased risk of this cancer in both the crude and adjusted models. These findings underscore the significant role of dietary patterns, encompassing various nutrients and food items, in the development of colorectal cancer.

Conflicting results have been reported regarding the protective effects of high-fiber diets against colorectal cancer in different countries and populations with varying levels of fiber intake. Some studies have found no association between fiber consumption and overall colorectal cancer risk. A large study involving 88,757 women in the United States found reported no protective effect of fiber against colorectal cancer after adjusting for confounding factors.[16] A recently published meta-analysis reported that higher dietary fiber intake was associated with a 22% reduction in overall cancer risk and a 17% reduction in cancer mortality. In this study, instead of examining dietary fiber alone, we examined the dietary pattern of high-fiber sources. This dietary pattern is known for the food groups of green, yellow, and red vegetables, other vegetables, low, medium, and high-fiber fruits, nuts and seeds, legumes, and olive oil. Together, these food groups provide a good source of dietary fiber, antioxidants, and phytochemicals in individuals' diets. The findings regarding the protective effects of an HFP can be explained by the biological impacts of fiber. Dietary fiber may lower the risk of colorectal cancer by decreasing the transit time of intestinal contents, diluting possible carcinogens, and promoting a healthier intestinal microbiota.[17] The fermentation of fibers by intestinal bacteria results in the production of short-chain fatty acids, particularly butyrate. These fatty acids have anti-inflammatory effects, help regulate cell growth, and can induce apoptosis in colon cancer cells. Furthermore, a diet high in fruits and vegetables provides a rich source of vitamins, polyphenols, and carotenoids, which contribute to cancer protection by reducing oxidative stress and chronic inflammation.[18] The significance of this study lies in its demonstration of the association within an Iranian population, which has distinct dietary patterns compared to many other countries, particularly Western nations. These differences encompass food types, cooking methods, and meal combinations. The findings indicate that, even within a traditional diet, increasing the intake of high-fiber food groups can provide considerable protective benefits.

In contrast, an unhealthy dietary pattern, characterized by higher consumption of processed meats, organs, cream and sour cream, mayonnaise, sugar-sweetened beverages, simple sugars, refined grains, and solid fats, was associated with an increased risk of colorectal cancer. This finding can also be explained from the perspective of biological mechanisms.[19] Processed meats also contain N-nitroso compounds and iron, which can cause DNA damage and increase oxidative stress in intestinal epithelial cells.[20] High intake of saturated and trans fats is associated with increased systemic inflammation, insulin resistance, and altered bile acid composition in the intestine, all of which are known risk factors for colorectal cancer.[21] Excessive consumption of simple sugars and sugar-sweetened beverages can promote the growth of cancer cells by

increasing the glycemic load of the diet and stimulating insulin pathways.[22]

The findings regarding UHP are consistent with several study results in Western and Asian countries.[23] The increased incidence of colorectal cancer in countries that have moved towards Western dietary patterns in recent decades, including Japan and some Middle Eastern countries, provides indirect evidence of the role of these dietary patterns in the occurrence of the disease.[9] The results of the present study strengthen the hypothesis that the Westernization of the diet, even in populations with different cultural and nutritional backgrounds, can have adverse consequences on gut health and colorectal cancer risk.

This study has several notable strengths. The use of a valid and reliable food frequency questionnaire allowed for a relatively accurate assessment of participants' usual dietary patterns. Also, the use of a pattern-based approach, rather than focusing on individual nutrients or food items, provided a more comprehensive picture of actual dietary habits. Matching the case and control groups for age and sex and adjusting for potential confounding variables in the analyses strengthens the internal validity of the results. However, some limitations should be considered. The case–control design of the study limits the possibility of inferring causal relationships, and there is also the possibility of recall bias in reporting dietary intake. Social reporting bias is also possible, such that participants underreport unhealthy foods and overreport healthy foods. Furthermore, measurement errors from using FFQ can impact the accuracy of dietary intake estimates. Finally, despite adjustment for known confounding variables, the possibility of residual confounding cannot be ignored.

Conclusion

Our study indicates that dietary patterns significantly influence the risk of colorectal cancer. Dietary modification is a viable and cost-effective strategy for disease prevention. Therefore, promoting fiber-rich diets while reducing the consumption of fast foods and processed foods should be prioritized in public health programs and nutrition education. Future research using cohort and intervention designs is necessary to confirm these findings and explore the underlying mechanisms in greater detail.

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Authors' Contribution

The research was conceptualized and designed by MM, NH, SZH, MRR and SVH. MRR and SVH reported the cases of cortical cancer. MM, SZH collected the data. MM conducted a statistical analysis of the data. The draft of the manuscript was written by MM, NH. MM, NH, SZH, MRR and SVH revised the manuscript. Also, the final version of the manuscript was read and approved by all authors.

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Conflict of Interest

None declared.

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Table 1. Food group classifications used for dietary pattern analysis

Food group	**Components**
Refined grains	Lavash bread, baguette, rice, pasta, biscuits
Whole grains	Sangak bread, cooked barley
Legumes	Beans, chickpeas, mung beans, lentils, split peas, cooked broad beans
Red meat	Red meat
Poultry	Chicken meat
Organ meats	Heart, liver, kidney, brain, lamb tongue, head and trotters, tripe, rennet, other chicken organs (liver, heart, gizzard)
Eggs	Eggs
Fish	Fish, canned tuna
Processed meat	Sausage, hamburger
Fast food	Pizza
Low-fiber fruits	Watermelon, cantaloupe, honeydew melon, natural fruit juice, canned fruits
Moderate-fiber fruits	Apple, pear, peach, nectarine, apricot, yellow and red plum, cherry, sour cherry, green plum, grapes, citrus fruits, kiwi, pomegranate, fresh berries, strawberries
High-fiber fruits	Banana, persimmon, fresh fig, dates, raisins, currants, dried mulberries, dried fruits
Green, yellow, and red vegetables	Lettuce, cucumber, cooked vegetables, mixed fresh herbs, green pepper, cabbage, celery, green beans, bell pepper, carrot, pumpkin, tomato, beetroot, green peas, corn
Starchy vegetables	Potatoes
Other vegetables	Onion, eggplant, garlic, mushrooms
Solid fats	Margarine, butter, hydrogenated oils
Liquid oils	All liquid oils except olive oil
Olive oil	Olives and olive oil
Mayonnaise	Mayonnaise
Nuts and seeds	Walnuts, peanuts, almonds, cashews, pistachios, hazelnuts, seeds (pumpkin, sunflower, watermelon)
Cream and clotted cream	Cream, clotted cream
Simple sugars	Sugar, sugar cubes, rock candy, chocolate, dry sweets, cream-filled pastries, halva
Sugar-sweetened beverages	Soft drinks, malt beverages
Coffee	Coffee
Processed snacks	Chips, cheese puffs
Industrial fruit juice	Industrial fruit juice
Ice cream	Ice cream
Pickled vegetables	Pickles, salted vegetables
Tomato paste	Tomato paste
Salt	Salt

Table 2. Characteristics of the control and case groups

Variable	**Case** (n = 103), n (%)	**Control** (n = 104), n (%)	***P-value***
Gender			0.946
Male	53 (51.5%)	54 (51.9%)	
Female	50 (48.5 %)	50 (48.1 %)	
Age (years)	56.62 ± 12.30	57.26 ± 11.44	0.696
Marital status			0.015
Single	24 (23.3%)	11 (10.6%)	
Married	79 (76.7 %)	93 (89.4 %)	
Level of education			0.206
Illiterate	5 (4.9 %)	9 (8.7 %)	
Less than a high school diploma	37 (35.9 %)	24 (23.1 %)	
High school diploma	30 (29.1 %)	26 (25.0 %)	
Bachelor's degree	13 (12.6 %)	18 (17.2 %)	
Master's degree	17 (16.5 %)	24 (23.1 %)	
Doctoral degree (PhD)	1 (1 %)	3 (2.9 %)	
Employment status			0.059
Unemployed	5 (4.9 %)	2 (1.9 %)	
Homemaker	39 (37.9 %)	41 (39.4 %)	
Employed	7 (6.8 %)	19 (18.3 %)	
Self-employed	33 (32 %)	22 (21.2 %)	
Retired	19 (18.4 %)	20 (19.2 %)	
Cigarette smoking			0.181
Yes	29 (28.2 %)	21 (20.2 %)	
No	74 (71.8 %)	83 (79.8 %)	
Alcohol consumption			0.093
Yes	10 (9.7 %)	4 (3.8 %)	
No	93 (90.3 %)	100 (96.2 %)	
Special diet			0.307
Yes	6 (5.8 %)	10 (9.6 %)	
No	97 (94.2 %)	94 (90.4 %)	
Specific dietary habits			0.186
Yes	5 (4.9 %)	10 (9.6 %)	
No	98 (95.1 %)	94 (90.4 %)	
Having a regular exercise program			0.783
Yes	26 (25.2 %)	28 (26.9 %)	
No	77 (74.8 %)	76 (73.1 %)	
Level of physical activity			0.441
Low	44 (42.7 %)	48 (46.2 %)	
Moderate	40 (38.3 %)	32 (30.8 %)	
High	19 (18.4 %)	24 (23.1 %)	

Note: Values are reported as number (percentage). These values were obtained using the Chi-square (X^2) test. For the age variable, the independent-samples t-test was applied, and values are reported as mean ± standard deviation. A *P*-value less than 0.05 was considered statistically significant.

Table 3. Factor loading matrix of food groups for high fiber and un-healthy dietary patterns

Food groups	**High fiber pattern**	**Un-healthy pattern**
Moderate-fiber fruits	.676	
Green, yellow, and red vegetables	.669	
High-fiber fruits	.665	
Nuts and seeds	.518	
Other vegetables	.504	-.183
Legumes	.395	.304
Olive oil	.390	-.241
Low-fiber fruits	.323	
Processed meat		.545
Cream and clotted cream		.508
Organ meats		.496
Mayonnaise		.492
Industrial fruit juice		.475
Simple sugars	-.172	.468
Sugar-sweetened beverages	-.344	.447
Refine graine	-.233	.436
Solid oils	-.203	.349
Fast food		.343
Red meat	.188	.253
Processed snacks	-.175	.244
Liquid oil		.170
Whole graine		
Variance distribution	11.98 %	11.46 %

To facilitate interpretation, factor loadings with absolute values under 0.15 for both patterns were excluded.

Table 4. Association of identified dietary patterns and colorectal cancer

Dietary pattern	**Control, n (%)**	**Case, n (%)**	**Crude OR (95 % CI)**	**Adjusted OR (95 % CI)***
High fiber pattern				
Low	38 (36.5 %)	65 (63.1)	1	1
High	66 (63.5%)	38 (36.9 %)	0.337 (0.191, 0.592)	0.298 (0.163, 0.545)
P-value			<0.001	<0.001
Un-healthy pattern				
Low	68 (65.4 %)	35 (34 %)	1	1
High	36 (34.6 %)	68 (66 %)	3.670 (2.067, 6.515)	4.263 (2.213, 8.212)
P-value			<0.001	<0.001

Note: * Adjusted for total energy intake and marital status. A P-value less than 0.05 was considered statistically significant. OR: Odds ratio; CI: Confidence interval.