

Incidence of Colorectal Polyps and Its Association with Dietary Patterns in the Xiangshan Island Region

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Abstract: Residents of the Xiangshan Island region share similar dietary and lifestyle characteristics. This study aimed to investigate the relationship between the incidence of colorectal polyps and dietary protein patterns in this population, with a focus on the effects of red meat and plant-based protein intake. A total of 1500 residents aged 18–75 years from the Xiangshan Island region who underwent colonoscopy were enrolled. General demographic data, lifestyle habits, and dietary questionnaire responses were collected. All participants underwent colonoscopy and histopathological diagnosis of polyps. Multivariate logistic regression analysis was performed to evaluate the association between dietary factors and the occurrence of colorectal polyps. High-frequency consumption of red meat significantly increased the risk of colorectal polyps (OR = 11.454, 95% CI: 3.669–35.755, $P < 0.001$). High-frequency consumption of plant-based proteins such as soy products was also associated with a markedly higher incidence of polyps (OR = 3.458, 95% CI: 1.493–8.010, $P = 0.004$). In contrast, egg and fruit intake showed no significant association with polyp occurrence ($P > 0.05$ for both). After adjusting for confounding factors, general demographic and lifestyle variables such as age, sex, smoking, and alcohol consumption were not significantly associated with polyp incidence ($P > 0.05$). The occurrence of colorectal polyps in the Xiangshan Island region is closely related to dietary patterns. Frequent consumption of red meat is a major risk factor, whereas adequate intake of plant-based foods may offer some protective effects. The findings suggest reducing red meat intake, balancing animal and plant protein sources, and increasing dietary fiber to help prevent colorectal polyps and colorectal cancer.

Keywords: Colorectal Polyps; Red Meat; Plant-Based Protein; Dietary Factors; Logistic Regression

1. Introduction

Colorectal cancer (CRC) is one of the most common malignant tumors of the digestive tract, ranking among the leading cancers in China ^[1]. Most CRC cases gradually evolve from colorectal adenomatous polyps, a process that typically takes about 10 to 15 years ^[2]. Therefore, identifying the risk factors for colorectal polyps and implementing targeted interventions are key measures for CRC prevention ^[3].

Previous studies have shown that the occurrence of colorectal polyps is influenced by multiple factors such as lifestyle, genetics, age, and environment. Among these, dietary factors, as a fully modifiable external element, play a significant role in the development and progression of colorectal tumors ^[4,5]. Numerous studies from both China and abroad have reported that diets high in fat and animal protein, particularly red and processed meats prepared by high-temperature cooking methods such as frying and grilling, are important risk factors for colorectal polyps ^[6–8]. The high saturated fat content in meat may generate carcinogenic compounds and promote polyp formation ^[9,10], whereas foods rich in unsaturated fatty acids do not produce such carcinogens and may even have a protective effect ^[11].

In contrast, dietary fiber and plant-based foods are considered protective against colorectal polyps ^[1,4,12]. Epidemiological research has demonstrated that increased dietary fiber intake reduces the risk of colorectal adenomas and cancer ^[13–15], with high-fiber diets helping to lower CRC incidence ^[16,17]. The protective mechanisms may include resistance to digestive enzyme degradation, increased stool bulk that dilutes carcinogens, adsorption of fatty acids and bile acids (the latter being tumor promoters), and fermentation by gut microbiota producing short-chain fatty acids that lower intestinal pH and inhibit tumor cell proliferation ^[9,12,18]. In addition, frequent consumption of legumes, soy products, and fruits and vegetables has been associated with a reduced risk of colorectal adenomatous polyps ^[6,12,19], possibly

due to the supply of dietary fiber, antioxidants, folate, and other bioactive compounds [4,10,18].

Overall, excessive red meat consumption is thought to promote the occurrence of colorectal adenomas and cancer [7,8], while soy products and other plant proteins may provide protective benefits [6,12,19]. However, some studies have failed to confirm the significant protective effect of soy products [20], suggesting that their mechanisms may vary depending on population characteristics and dietary patterns. To date, the relationships between different protein sources, such as fish, eggs, dairy products, and legumes, and the development of colorectal polyps remain insufficiently clarified [3,5,8].

Residents of the island areas of Xiangshan County share similar dietary habits and lifestyles, and this region has long been identified as a high-incidence area for colorectal cancer. According to local cancer surveillance data in 2019, CRC ranked third among all cancers in the county. Therefore, it is necessary to conduct research on the association between dietary factors and colorectal polyps in this population, with the aim of providing scientific evidence to guide dietary interventions and polyp prevention strategies in high-risk regions.

2. Materials and Methods

2.1 Study Population

The study population consisted of adults aged 18–75 years from the southern island regions of Xiangshan County, all of whom voluntarily scheduled colonoscopy examinations. Inclusion criteria were long-term residence in the above-mentioned regions and agreement to participate in the survey. Exclusion criteria included patients undergoing emergency colonoscopy; individuals with severe heart, liver, or kidney failure or other major diseases; pregnant or lactating women; those with incomplete colonoscopy or inadequate bowel preparation prior to examination; individuals with missing key clinical data; and those who declined to sign the informed consent form. A total of 1,500 eligible participants were finally enrolled (Figure 1).

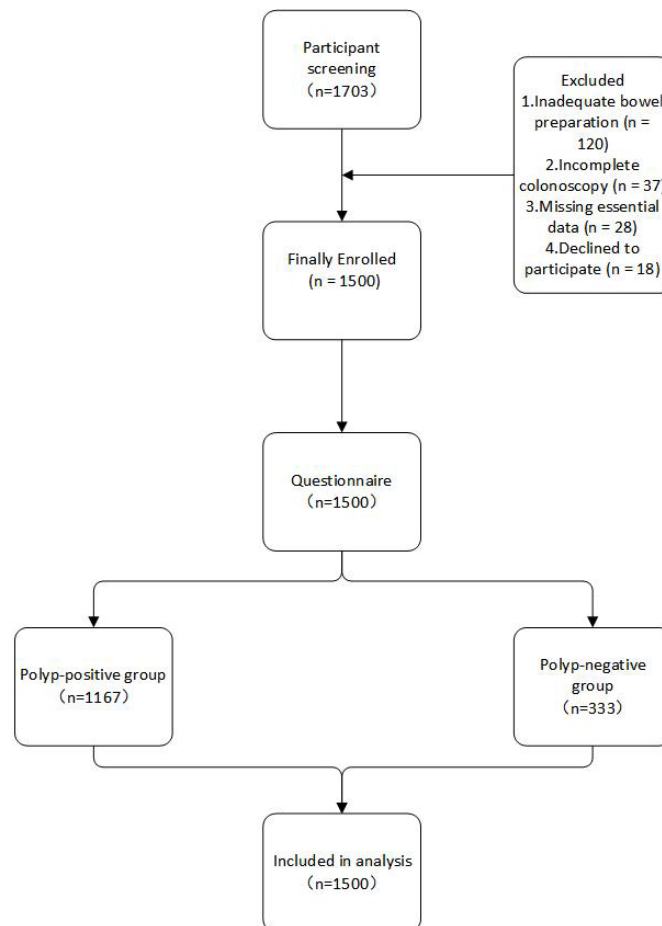


Figure 1 Flow chart of patient selection.

2.2 Survey Methods

A comprehensive, interviewer-administered questionnaire was conducted with all participants before their scheduled colonoscopy to minimize recall bias. Data were collected on a range of potential covariates. These included basic demographics and anthropometrics, personal and family medical history relevant to colorectal health, and modifiable lifestyle factors such as smoking and alcohol consumption. Furthermore, a detailed dietary assessment was performed to capture usual intake patterns. This assessment evaluated the consumption of specific food groups—including red meat, seafood, eggs, milk, soy products, fruits, vegetables, and seaweeds—as well as cooking practices, to facilitate the analysis of animal versus plant protein intake and dietary fiber consumption. Questionnaire responses were provided by the participants themselves, with verification from family members sought in cases where assistance was required.

2.3 Endoscopic Examination and Diagnosis

All participants underwent bowel preparation (oral polyethylene glycol electrolyte solution, etc.) according to standard procedures prior to electronic colonoscopy. If polyps were detected during the examination, they were completely removed endoscopically and submitted for pathological evaluation to determine histological characteristics. For each polyp, clinical features including anatomical location (rectum, sigmoid colon, descending colon, transverse colon, ascending colon, or cecum), size (diameter in mm), and number were recorded.

Histological types were classified as adenomatous polyps (e.g., tubular adenoma, tubulovillous adenoma, villous adenoma) and non-adenomatous polyps (e.g., hyperplastic polyp, inflammatory polyp). Adenomatous polyps were considered neoplastic (precancerous lesions), whereas all others were considered non-neoplastic. If pathology indicated advanced adenoma (e.g., diameter ≥ 10 mm, villous component $>25\%$, or severe dysplasia), the lesion was categorized as having a high risk of malignant transformation and prioritized for follow-up management.

2.4 Statistical Analysis

Collected clinical and questionnaire data were entered into a database using SPSS statistical software. Continuous variables were expressed as mean $\pm$ standard deviation ($\bar{x} \pm s$), while categorical variables were presented as counts (percentages). Between-group comparisons were performed using independent-sample t-tests (for continuous variables) or χ^2 tests (for categorical variables). A significance level of $P < 0.05$ was considered statistically significant. Logistic regression models were constructed with colorectal polyp detection (yes/no) as the dependent variable and dietary as well as demographic variables as independent variables, in order to perform multivariate analysis and calculate odds ratios (ORs) with 95% confidence intervals (CIs).

3. Results

3.1 Baseline Characteristics

A total of 997 participants were enrolled in this study, including 769 males (51.3%) and 731 females (48.7%). The participants ranged in age from 18 to 75 years, with a mean age of 60.6 ± 10.6 years. The average height was 164.7 ± 7.8 cm, and the mean weight was 64.9 ± 9.5 kg. Regarding smoking status, 659 (43.9%) were current smokers, 74 (4.9%) were former smokers, and 767 (51.1%) had never smoked. For alcohol consumption, 771 (51.4%) were current drinkers, 99 (6.6%) were former drinkers, and 630 (42.0%) had never consumed alcohol. Educational background revealed that 18.3% were illiterate or semi-literate, 31.5% had primary school education, 32.9% had secondary school education, and 8.8% had college education or above.

Sixty-three participants (6.3%) reported a family history of colorectal cancer among first-degree relatives, and 134 (8.9%) reported a family history of colorectal polyps. The primary indications for colonoscopy were health screening (981 cases, 65.4%), follow-up for previous polyps (381 cases, 25.4%), postoperative surveillance for colorectal cancer (39 cases, 2.6%), and other reasons (99 cases, 6.6%). These findings indicate that the study population was predominantly middle-aged and elderly, with a near 1:1 sex ratio, relatively high rates of smoking and drinking, and predominantly low-to-medium educational attainment (Table 1).

Table 1 Baseline Characteristics of the Study Population.

Characteristic (n=1500)	
Male, n (%)	769 (51.3)
Age, years, mean (SD)	60.6 (10.6)
Height, cm, mean (SD)	164.7 (7.8)
Weight, kg, mean (SD)	64.9 (9.5)
Smoking history, n (%)	
Current	659 (43.9)
Former	74 (4.9)
Never	767 (51.1)
Alcohol consumption, n (%)	
Current	771 (51.4)
Former	99 (6.6)
Never	630 (42.0)
Educational level, n (%)	
Illiterate or semi-literate	275 (18.3)
Primary school	473 (31.5)
Middle school	494 (32.9)
College or above	132 (8.8)
Unknown	126 (8.4)
Family history of colorectal cancer, n (%)	
Yes	95 (6.3)
No	1267 (84.5)
Unknown	138 (9.2)
Family history of colorectal polyps, n (%)	
Yes	134 (8.9)
No	875 (58.3)
Unknown	491 (32.7)
Indication for colonoscopy, n (%)	
Health screening	981 (65.4)
Polyp follow-up	381 (25.4)
Postoperative surveillance for colorectal cancer	39 (2.6)
Other	99 (6.6)

SD, Standard deviation.

3.2 Dietary Factors and Colorectal Polyp Occurrence

Multivariate logistic regression analysis (Table 2) showed that the frequency of red meat consumption was significantly positively associated with the detection of colorectal polyps. After adjusting for confounding factors such as age and sex, individuals who frequently consumed red meat had an approximately 11.45-fold higher risk of colorectal polyps compared with those who rarely consumed red meat (OR = 11.454, 95% CI: 3.669–35.755), with a highly significant difference ($P < 0.001$).

The frequency of soy products and other plant protein intake was also positively correlated with polyp occurrence, with higher consumers having a 3.46-fold increased risk compared to low consumers (OR = 3.458, 95% CI: 1.493–8.010, $P = 0.004$).

In addition, daily milk intake showed a trend toward increased polyp risk (OR = 1.598), as did weekly consumption of seaweed (e.g., kelp, laver) (OR = 1.456), though neither reached statistical significance ($P = 0.060$ and $P = 0.059$, respectively). In contrast, egg consumption was not significantly associated with colorectal polyp occurrence (OR = 0.829, $P = 0.729$), nor was fruit consumption (OR = 0.756, $P = 0.406$). Regular seafood intake also showed no significant association with polyp risk (OR close to 1, $P > 0.90$).

Overall, excessive red meat consumption emerged as the most significant dietary risk factor for polyp development. Interestingly, frequent soy product consumption was associated with higher polyp

detection.

Table 2 Association between Dietary Habits and Colorectal Polyp Occurrence.

Variable	Regression Coefficient	Standard Error	Wald	P value	OR	95% CI for OR
Red meat consumption	2.438	0.581	17.626	<0.001	11.454	3.669-35.755
Egg consumption	-0.187	0.541	0.120	0.729	0.829	0.287-2.395
Milk consumption	0.469	0.250	3.527	0.060	1.598	0.980-2.605
Seafood consumption	-0.021	0.299	0.005	0.944	0.979	0.545-1.758
Plant protein consumption	1.241	0.429	8.382	0.004	3.458	1.493-8.010
Fruit consumption	-0.280	0.337	0.690	0.406	0.756	0.391-1.463
Seaweed consumption	0.376	0.199	3.573	0.059	1.456	0.986-2.150

3.3 Basic Factors and Colorectal Polyp Occurrence

Logistic regression analysis incorporating demographic and lifestyle variables such as age, sex, smoking, and drinking (Table 3) showed no significant associations with polyp occurrence (all $P > 0.05$). For example, the OR for males compared to females was 0.632 ($P = 0.350$); the OR per one-year increase in age was 2.132 ($P = 0.648$). Smokers compared to non-smokers had an OR of 0.959 ($P = 0.925$), and drinkers compared to non-drinkers had an OR of 0.776 ($P = 0.408$), none of which were statistically significant.

Similarly, anthropometric indicators such as height and weight were not significantly associated with polyp occurrence ($P > 0.5$). Moreover, participants with a family history of colorectal cancer or polyps among first-degree relatives did not show a significantly different risk of polyp detection compared with those without such a history ($P > 0.1$).

These results suggest that, when dietary factors are included in the analysis, traditional demographic risk factors (such as older age, male sex, smoking, and alcohol consumption) did not significantly predict polyp occurrence in this study cohort, possibly due to the relative homogeneity of the population or limitations of sample size.

Table 3 Association between Baseline Characteristics and Colorectal Polyp Occurrence.

Variable	Regression Coefficient	Standard Error	Wald	P value	OR	95% CI for OR
Age	0.757	1.657	0.209	0.648	2.132	0.083-54.799
Sex (male)	-0.459	0.491	0.874	0.350	0.632	0.241-1.654
Smoking (yes)	0.042	0.446	0.009	0.925	0.959	0.400-2.300
Alcohol consumption (yes)	0.254	0.307	0.684	0.408	0.776	0.425-1.416
Height	0.002	0.023	0.005	0.944	1.002	0.957-1.049
Weight	-0.008	0.015	0.321	0.571	0.992	0.963-1.021
Family history of colorectal cancer (yes)	1.172	0.929	1.592	0.207	0.310	0.050-1.913

4. Discussion

This study, conducted in Xiangshan's island population, one of the high-incidence regions for colorectal cancer in China, provided an in-depth analysis of the association between dietary patterns and the occurrence of colorectal polyps. The results demonstrated that excessive red meat consumption was significantly associated with the development of colorectal polyps. This finding is highly consistent with numerous studies reported both domestically and internationally [6,7,14].

Excessive consumption of red meat (such as beef, lamb, and pork) and its processed products has long been recognized as a risk factor for colorectal adenomas and cancer [6,7,14]. Studies have reported that a daily intake of 100 grams of red meat increases the risk of CRC by approximately 16% [14]. High-temperature cooking methods such as frying and grilling can generate heterocyclic amines and other potent mutagens, which cause DNA damage and thereby promote colorectal tumorigenesis [7,8]. In addition, heme iron contained in red meat may induce oxidative stress by promoting the formation of reactive oxygen species, leading to mucosal injury and carcinogenesis [7,14]. At the level of dietary guidelines, the American Cancer Society has recommended reducing red meat intake and promoting Mediterranean-style or plant-based dietary patterns to lower the risk of colorectal tumors [4,18]. Data from our study population indicate that red meat consumption is highly prevalent among local residents. We observed that individuals who frequently consumed red meat had more than a tenfold higher prevalence of polyps compared with those who rarely consumed it (data not yet published), suggesting that excessive red meat intake markedly increases the risk of colorectal polyps and even colorectal cancer. These findings provide strong evidence to support dietary cancer-prevention recommendations for residents in this high-risk region.

In contrast to the carcinogenic effects of red meat, plant-based protein foods (such as soybeans and soy products) are generally considered beneficial for colorectal health [4,6,12,19]. Legumes are rich in dietary fiber, vitamins, and phytochemicals such as isoflavone phytoestrogens, which may help prevent intestinal tumors by modulating gut microbiota, providing antioxidant effects, and inhibiting abnormal cellular proliferation. Epidemiological studies also support an association between higher soy intake and reduced risk of colorectal tumors [12,19]. For example, one study reported that consuming legumes at least three times per week was associated with an approximately 33% reduction in the risk of colorectal adenomas [19]. However, our study showed that participants with frequent soy product consumption had a higher risk of colorectal polyps ($OR > 3$), a finding inconsistent with general expectations. Several explanations may account for this result. First, the influence of sample size and population specificity cannot be excluded, and residual confounding or statistical bias may not have been fully controlled [3,5]. Second, the dietary patterns and total intake of soy products in the Xiangshan island population may differ from those in other regions. For instance, the use of fried soy products or high-salt cooking methods may offset or even reverse the inherent health benefits of soy [19,20]. In addition, our questionnaire did not precisely quantify intake in grams, nor did it distinguish between different types of soy products (e.g., fermented soy foods, soy protein powders, etc.), which may have contributed to confounding.

In summary, our findings suggest that the effects of plant-based proteins may vary across different populations, highlighting the need for larger, multicenter studies to further evaluate the relationship between soy product consumption and the development of colorectal polyps or adenomas. Until such evidence becomes available, the overall benefits of soy products should still be recognized, as legumes are rich in fiber and nutrients and are advantageous in preventing cardiovascular and metabolic diseases. Nonetheless, for individuals at high risk of colorectal tumors, moderate rather than excessive intake of soy products should be encouraged, with particular attention to adopting healthier cooking methods.

This study also examined the effects of other dietary factors on colorectal polyp occurrence. The results showed that frequent milk consumption was associated with a trend toward increased risk, though not reaching statistical significance. The relationship between dairy intake and colorectal tumors remains controversial across studies. On the one hand, milk is rich in calcium, which may reduce harmful stimulation of the colonic mucosa by binding bile acids and fatty acids, thus suggesting a potential protective role. On the other hand, whole milk products are often high in saturated fat, and whether this increases tumor risk remains inconclusive [11,16]. The positive trend observed in our study may be related to the generally low levels of dairy consumption among local residents, with limited variability between individuals, which may have hindered statistical detection of a clear effect. We also found that participants who frequently consumed seaweed products such as kelp and laver showed a trend toward increased polyp risk ($P = 0.059$). Seaweed is rich in dietary fiber and trace elements and theoretically should benefit colon health. However, its intake is often associated with high-salt preparation methods (e.g., pickled kelp) or combined with seafood-based cooking, which may introduce confounding

influences^[14,16]. This finding suggests that further research is needed to clarify the relationship between seaweed consumption and intestinal health. Fruit intake was not significantly associated with polyp occurrence in this study, possibly because nearly all participants reported at least some level of fruit consumption, minimizing detectable differences. Similarly, frequent seafood consumption was very common among island residents, with limited variability across the population, which may explain the absence of significant statistical associations^[11,18]. Nevertheless, previous reports indicate that fish-derived unsaturated fatty acids may help reduce colorectal tumor risk, supporting continued recommendations to replace red meat with fish or poultry when possible. Egg consumption showed no significant impact on colorectal polyp risk, suggesting that moderate intake (approximately one egg per day) is safe, with no clear evidence of either promoting or preventing colorectal adenomas.

It should be noted that in this study, traditional demographic risk factors such as age and sex did not show statistical significance. Generally, increasing age and male sex are well-recognized risk factors for colorectal adenomas^[2,3]. The lack of association in our cohort may be explained by several factors. First, the study population mainly consisted of individuals with medical consultation or screening awareness (approximately two-thirds were undergoing health examinations), who were relatively health-conscious. Moreover, the age distribution was concentrated in the middle-aged and elderly (mean age 60 years), creating a relatively homogeneous high-risk profile that reduced the detectability of age- and sex-related differences. Second, more importantly, dietary factors appeared to play a dominant role in the multivariate model, which may have “masked” the effects of age and sex. For example, men typically consume more red meat and alcohol than women, but since these dietary variables were independently evaluated in the model, sex itself no longer showed a significant association^[14,16]. Similarly, age-related differences in dietary patterns may have been partly explained by dietary covariates. In addition, smoking and alcohol consumption were not significantly associated with polyp detection rates in this study. This does not imply that smoking and drinking have no impact on colorectal health. Previous studies have demonstrated that long-term heavy alcohol consumption can increase the risk of hyperplastic and adenomatous polyps, while smoking is also linked to colorectal adenoma development. In our study population, the prevalence of smoking and drinking was high, but these behaviors were often accompanied by unhealthy dietary habits, suggesting that the primary risk attribution may have been absorbed by diet-related variables. Overall, our multivariate analysis emphasized the independent impact of dietary structure on colorectal polyp occurrence.

This study also has several limitations. First, it was a single-center cross-sectional observation, so causal inferences must be drawn with caution. Although we surveyed participants’ long-term dietary habits prior to colonoscopy, recall bias and information bias cannot be entirely ruled out. Second, due to the constraints of questionnaire-based surveys, dietary assessment was based mainly on frequency rather than precise intake amounts, and gram-level quantification of specific foods was not obtained, which may have underestimated intake differences. Third, we did not perform separate analyses for different polyp subtypes (e.g., adenomatous vs. non-adenomatous), which should be further explored in future research. Finally, because the dietary structure of this regional population is unique, the generalizability of our conclusions to other populations requires further validation.

5. Conclusion and Recommendations

This study confirmed that the occurrence of colorectal polyps among residents in the Xiangshan island region is closely associated with their daily dietary patterns. Frequent red meat consumption was found to significantly increase the risk of polyps, whereas moderate increases in plant-based protein and dietary fiber intake may help reduce risk. Based on our findings, we propose the following targeted dietary interventions for this population: Reduce red meat intake, limit the frequency and quantity of pork, beef, lamb, and processed meats; choose lean meat and avoid high-temperature cooking methods such as frying and grilling; Increase white meat consumption, encourage greater intake of fish and poultry as partial substitutes for red meat, along with higher consumption of fresh vegetables, fruits, and whole grains rich in dietary fiber; Encourage moderate soy product intake, incorporate foods such as tofu and soybeans to diversify protein sources, but adopt light cooking methods and avoid excessive or monotonous intake; Limit high-fat, high-salt foods and alcohol consumption, promote balanced, low-fat, and low-salt dietary habits.

These measures may help prevent the development of colorectal adenomatous polyps and thereby reduce the potential incidence of colorectal cancer. This study provides valuable preliminary data on the relationship between diet and colorectal polyp occurrence in a high-risk island population. However, larger-scale prospective studies are still needed to further validate and refine dietary intervention

strategies for the prevention and control of colorectal tumors.

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