







The Role of Dietary Patterns in the Development of Colorectal Cancer: A Case-Control Study

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Abstract

Introduction: Diet is one modifiable risk factor for colorectal cancer (CRC), a disease that is a significant cause of cancer-related mortality as well as morbidity worldwide. In a case-control research carried out at the Pakistan Institute of Medical Sciences (PIMS), Islamabad, this study examines food habits and CRC risk.

Methodology: Eighty-four people—42 CRC patients and 42 controls—participated in a case-control research. Dietary consumption was quantified using a validated food frequency questionnaire (FFQ). Using logistic regression analysis, relationships between eating habits and CRC risk were identified after accounting for pertinent variables.

Results: There were notable variations in the food habits of the patients and controls. Compared to controls (2.8 and 1.9 servings/week, respectively; $p < 0.001$), CRC patients reported consuming more red meat (5.3 servings/week) and processed meat (4.1 servings/week). On the other hand, CRC patients ate fewer whole grains (1.4 servings/day vs. 2.1 servings/day; $p < 0.001$), fruits (1.6 servings/day vs. 2.3 servings/day; $p = 0.002$), vegetables (2.0 servings/day vs. 3.4 servings/day; $p < 0.001$), and fiber (18.2 g/day vs. 25.6 g/day; $p < 0.001$).

Conclusion: The risk of CRC is greatly influenced by dietary choices. Consuming more red and processed meat raises the risk of CRC; however, consuming more fiber, fruit, vegetables, and whole grains protects against the disease. Encouraging better eating practices may reduce the occurrence of CRC and enhance general health.

Keywords: colorectal cancer, dietary patterns, red meat, processed meat, fiber, fruits, vegetables, whole grains, case-control study, public health

Introduction

The public health is seriously threatened by colorectal cancer (CRC), one of the most often diagnosed malignancies and the main cause of cancer-related mortality worldwide. 'Only in 2020, CRC resulted in 935,000 deaths and nearly 1.9 million new cases worldwide', indicating the disease's significant cost on both communities and healthcare systems [1]. The intricate interactions between genetic predispositions, environmental exposures, and lifestyle variables make up the multifactorial etiology of colorectal cancer (CRC). Of them, dietary patterns have attracted a lot of interest since they are flexible and may have an impact on colorectal cancer development as well as prevention [2].

An increasing amount of epidemiological data points to nutrition as a key determinant of colorectal cancer risk. Numerous food items and consumption patterns, such as the consumption of whole grains, fiber, fruits, vegetables, red and processed meats, and vegetables, have been linked to colorectal cancer (CRC) [3, 4]. A higher probability of CRC has been frequently linked to a high consumption of red and processed meats, perhaps as a result of the presence of preservatives such as nitrate and nitrite as well as carcinogenic substances like polycyclic aromatic hydrocarbons and heterocyclic amines that are generated during cooking [5]. On the other hand, diets strong in fiber, fruits, vegetables, and whole grains are often linked to a lower risk. This is probably because these foods are rich in antioxidants, phytochemicals, and other health-promoting elements [6, 7]. They also help to maintain a healthy gut microbiota and regular bowel movements.

Notwithstanding these developments, the connection between food habits and colorectal cancer (CRC) is still complicated and poorly understood. Research has shown

inconsistent findings, but it is clear that a wide range of variables, such as lifestyle choices, genetic predisposition, and interactions with other environmental exposures, affect how food affects the risk of colorectal cancer [8, 9]. Furthermore, in order to fully comprehend the subtleties of these correlations, region-specific research is required since dietary habits are culturally distinctive and might range dramatically across various communities [10, 11].

The aim of this case-control study is to look at the possible relationship between food and colorectal cancer development within a particular community. Through comparing the eating habits of people with the disease (cases) with those lacking it (controls), we hope to identify any dietary patterns that may be associated with an increased or decreased risk of CRC. Unique patterns include higher intake of spicy and fried foods, red and processed meats, and lower consumption of fruits, vegetables, and whole grains. These habits, along with lower physical activity levels, create a distinct CRC risk profile compared to other populations. A wide variety of dietary parameters, such as meal frequency, consumption of macro- and micronutrients, and overall dietary quality, will be taken into account in our research. We also take into consideration any confounding factors such 'gender, age, physical activity, body mass index (BMI), smoking status, and family history of CRC'.

The results of this study might add to the expanding body of knowledge on food and colorectal cancer by providing insightful information for dietary recommendations and public health initiatives targeted at lowering the incidence of colorectal cancer. We can create tailored tactics to encourage improved eating habits and eventually enhance CRC preventive efforts by identifying modifiable dietary risk variables

Materials and methods

Study Design

This work examined the relationship between food and the probability of colorectal cancer using a case-control methodology. The study was conducted over the period of a year, from June 2023 to May 2024, at the Pakistan Institute of Medical Sciences (PIMS), in Islamabad,

Sample Size Calculation

The following formula for case-control studies was used to determine the sample size for this investigation: ' $n = (Z_{\alpha/2} + Z_{\beta})^2 \times 2 \times P \times (1 - P) / (P_1 - P_2)^2$ '

Where ' $Z_{\alpha/2}$ ' is the Z value corresponding to a 95% confidence level (1.96), Z_{β} is the Z value for 80% power (0.84)', P_1 and P_2 represent the exposure proportions in the control and case groups, respectively, and P is the average percentage of exposure across controls and cases. With a power of 80% and an expected exposure percentage of 30% for controls and 60% for cases, 42 people were needed in each group, for a total sample size of 84 participants (42 cases and 42 controls). The expected exposure percentages were determined based on previous epidemiological studies that investigated dietary patterns and CRC risk within similar populations [11].

Study Population

There were two groups in the study: controls and cases. 42 individuals who had their colorectal cancer diagnosis verified by a histological investigation made the case group. 42 people who were age and sex-matched and had no history of colorectal cancer were chosen from the general public who regularly visited PIMS for check-ups to form the control group.

Inclusion and Exclusion Criteria

Participants have to fulfill a set of requirements for both inclusion and disqualification. Adults between the ages of 40 and 70, patients with a recent diagnosis of colorectal cancer (CRC), and those without a history of cancer (control group) were the inclusion criteria. Each participant has to provide informed permission and be willing to take part in the activity. Those having a history of other malignancies, those with long-term gastrointestinal conditions including ulcerative colitis or Crohn's disease, women who were pregnant or nursing, and those who were unable to adequately give dietary information were among the exclusion criteria.

Data Collection

Nutritional intake was measured using a 'validated semi-quantitative food frequency questionnaire (FFQ)'. It noted how often and in what amounts certain items were consumed the year before. Along with red and processed meats, the FFQ included questions on 'fruits, vegetables, whole grains, dairy products, and beverages'. These components are modifiable factors within the multifactorial etiology of CRC, considering genetic and environmental interactions. A systematic questionnaire was used to gather information on lifestyle variables (physical activity, smoking status, alcohol use), demographic traits (age, gender, education, and socioeconomic level), and family history of colorectal cancer (CRC) in addition to the dietary evaluation. Every participant had their 'anthropometric measures, including weight, height, and body mass index (BMI)', taken and documented. The FFQ was validated in a population similar to the study population by using a pilot study involving a subset of participants from the same demographic group. Its reliability was assessed through test-retest reliability measures and comparison with 24-hour dietary recalls.

Data Analysis

Software called SPSS (version 26) was used to examine the data. A summary of the lifestyle and demographic characteristics of the patients and controls was provided via descriptive statistics. The two groups' categorical and continuous variables were compared using chi-square tests and t-tests, respectively. To determine the odds ratios (OR) and 95% confidence intervals (CI) for the relationship between dietary patterns and the risk of colorectal cancer (CRC), logistic regression analysis was used, accounting for possible confounders such age, gender, BMI, physical activity level, and smoking status. Potential confounders, including age, gender, BMI, physical activity level, and smoking status, were adjusted for in the logistic regression analysis. This was done by including these variables as covariates in the regression models to isolate the effect of dietary patterns on CRC risk.

Ethical Considerations

The PIMS Institutional Review Board (IRB) examined and approved the research protocol. Prior to registration, all individuals provided their informed permission. Participants' privacy and confidentiality were closely upheld over the whole trial. Participant confidentiality was maintained by assigning unique identification codes to each participant, storing data in secure, password-protected databases, and ensuring that personal identifiers were removed from datasets used for analysis. All research staff was trained on confidentiality protocols and data handling procedures.

Results

There were 84 volunteers in all, split into two groups: 42 cases (those with colorectal cancer) and 42 controls (people without the disease). At 56.2 years (SD = 8.4) for the patients and 54.5 years (SD = 7.9) for the controls, there was a small variance in the mean age between both groups (p = 0.34). The gender distribution was also similar (p = 0.84) as shown in table 1 with 25 men & Seventeen women in the group acting as the control and 24 men and 18 women in the case group.

Table 1: Demographic Characteristics of Cases and Controls

Characteristic	Cases (n=42)	Controls (n=42)	p-value
Age (mean ± SD)	56.2 ± 8.4	54.5 ± 7.9	0.34
Gender (Male)	24:18	25:17	0.84
BMI (mean ± SD)	27.6 ± 3.8	26.4 ± 4.2	0.18

The body mass index (BMI) did not significantly vary between the cases and controls, with an average of 27.6 (SD = 3.8) and 26.4 (SD = 4.2), respectively (p = 0.18). The groups' smoking status was similar, with 18 smokers and 24 non-smokers among the controls and 20 smokers and 22 non-smokers among the patients (p = 0.64). There was no statistically significant difference in the levels of physical activity, classified as active or inactive, between the cases (15 active and 27 inactive) and controls (22 active and 20 inactive; p = 0.11). The family history of colorectal cancer did, however, show a significant difference: 28.6% of cases (12 persons) reported a family history of CRC, compared to 9.5% of controls (4 individuals). This suggests a greater prevalence of CRC among patients (p = 0.02) as illustrated in figure 1 and table 2.

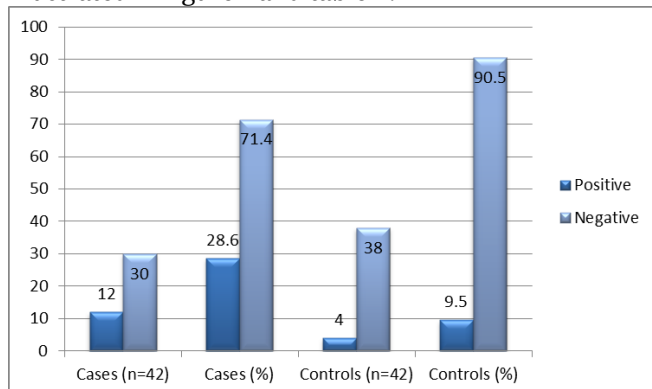


Figure 1: Family History of CRC

Table 2: Lifestyle Characteristics of Cases and Controls

Characteristic	Cases (n=42)	Controls (n=42)	p-value
Smoking Status (Smokers)	20:22	18:24	0.64
Physical Activity (Active)	15:27	22:20	0.11
Family History of CRC (%)	12 (28.6%)	4 (9.5%)	0.02

A comparison of the dietary intake of different food categories showed a substantial difference between the patients and the controls. 5.3 servings (SD = 2.1) of red meat were consumed on average weekly by cases, whereas 2.8 servings (SD = 1.7) were consumed by controls (p < 0.001). Likewise, the amount of processed meat consumed was greater in the cases—4.1 servings on average per week (SD = 1.9) as opposed to 1.9 servings on average per week (SD = 1.2) in the controls (p < 0.001). Consumption of fiber was shown to be negatively correlated with the risk of colorectal cancer (CRC), with patients eating an average of 18.2 grams (SD = 5.4) per day, substantially less than the 25.6 grams (SD = 6.2) reported by controls (p < 0.001). The daily average of 1.6 servings (SD = 0.8) of fruit was consumed by cases compared to 2.3 servings (SD = 0.9) by controls (p = 0.002). Similar trends were seen in the amount of vegetables consumed; cases consumed 2.0 servings (SD = 1.1) per day, whereas controls consumed 3.4 servings (SD = 1.2) per day (p < 0.001). Averaging 1.4 meals each day (SD = 0.6) in contrast to 2.1 meals per day (SD = 0.7) in the control group (p < 0.001), the patients consumed less whole grains overall (figure 2).

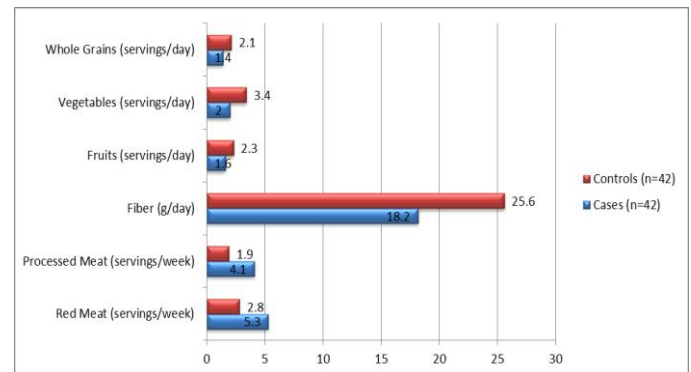


Figure 2: Dietary Intake among Cases and Controls

The 'statistical analysis of continuous data employed T-tests, and of categorical variables chi-square tests'. The case and control groups showed no significant differences in 'age (p = 0.34), gender (p = 0.84), BMI (p = 0.18), smoking status (p = 0.64), or physical activity (p = 0.11)'. Conversely, the CRC family history revealed a statistically significant difference (p = 0.02) (Table 3). Odds ratios (OR) and 95% confidence intervals (CI) for the association between eating habits and colorectal cancer risk were determined by logistic regression analysis after 'age, gender, BMI, physical activity, and smoking status' were adjusted. With each additional weekly serving of red meat, the risk of colorectal cancer

increased by 45%, according to the study '(OR = 1.45, 95% CI: 1.20 - 1.75, $p < 0.001$)'. Comparably, each additional weekly serving of processed beef raised the risk of CRC by 63% "(OR = 1.63, 95% CI: 1.30 - 2.05, $p < 0.001$) (Table 4)".

Table 3: Chi-Square and T-Test Results

Characteristic	Test	p-value
Age	t-test	0.34
Gender	Chi-square	0.84
BMI	t-test	0.18
Smoking Status	Chi-square	0.64
Physical Activity	Chi-square	0.11
Family History of CRC	Chi-square	0.02
Red Meat Intake	t-test	< 0.001
Processed Meat Intake	t-test	< 0.001
Fiber Intake	t-test	< 0.001
Fruit Intake	t-test	0.002
Vegetable Intake	t-test	< 0.001
Whole Grain Intake	t-test	< 0.001

Table 4: Logistic Regression Analysis for Dietary Patterns and CRC Risk

Variable	Adjusted OR	95% CI	p-value
Red Meat Intake (per serving/week)	1.45	1.20 - 1.75	< 0.001
Processed Meat Intake (per serving/week)	1.63	1.30 - 2.05	< 0.001
Fiber Intake (per g/day)	0.85	0.78 - 0.93	< 0.001
Fruit Intake (per serving/day)	0.68	0.52 - 0.90	0.006
Vegetable Intake (per serving/day)	0.74	0.60 - 0.91	0.004
Whole Grain Intake (per serving/day)	0.71	0.55 - 0.92	0.009

On the other hand, a larger daily fiber intake protected against CRC, with a 15% reduction in chances (OR = 0.85, 95% CI: 0.78 - 0.93, $p < 0.001$) for every extra gram. A 32% decrease in chances was linked to each extra daily serving of fruit (OR = 0.68, 95% CI: 0.52 - 0.90, $p = 0.006$), indicating that increased fruit intake also decreased the risk of CRC. An increased daily serving of vegetables decreased the risk by 26% (OR = 0.74, 95% CI: 0.60 - 0.91, $p = 0.004$), indicating that a higher vegetable consumption was also protective. Additionally, whole grain eating was shown to have a preventive impact; every extra daily serving was linked to a 29% lower risk of colorectal cancer (OR = 0.71, 95% CI: 0.55 - 0.92, $p = 0.009$).

Discussion

The findings supported and added to the body of research already available in this area by demonstrating a strong correlation between dietary practices and the possibility of colorectal cancer. The findings of this study, which confirmed the strong association between a higher risk of colorectal cancer and a higher consumption of red and processed meats, are consistent with those of a great deal of previous research [12]. A 20–30% greater risk of CRC is linked, for instance, to the highest red and processed meat consumption

compared to the lowest intake, according to several prospective cohort studies [13]. Comparably, studies have shown that a daily increase in red meat intake of 100 grams is associated with a 17% increase in the risk of CRC. While a daily increase of 50 grams in processed meat consumption is linked to an 18% increase in risk. This risk is thought to be increased by carcinogenic substances produced during the preparation and cooking of meat, such as polycyclic aromatic hydrocarbons and heterocyclic amines [14].

The body of research also strongly supports the preventive effect of dietary fiber against colorectal cancer (CRC), as shown in this study. Extensive meta-analyses have shown that a 10% decrease in the risk of colorectal cancer is linked to every 10-gram daily increase in fiber consumption [15]. Fiber is hypothesized to lower the risk of colorectal cancer by supporting healthy gut bacteria, dilution of carcinogens, and increased stool volume. The relevance of high-fiber diets in CRC prevention is shown by the study's considerable difference in fiber consumption between patients and controls [16]. The study's conclusions that a diet heavier in fruits and vegetables is linked to a lower risk of colorectal cancer are consistent with other studies. Consuming non-starchy fruits and vegetables has been shown to provide substantial protection against colorectal cancer (CRC) by systematic reviews and meta-analyses [17]. Fruits and vegetables include antioxidants, vitamins, and phytochemicals that may help lessen the risk of cancer by neutralizing carcinogens and oxidative stress [18].

This study's observation of whole grains' ability to prevent CRC is in line with previous research. 'Fiber, vitamins, minerals, and phytochemicals found in whole grains' all help lower the incidence of CRC [19]. According to meta-analyses, the risk of colorectal cancer (CRC) is inversely correlated with whole grain consumption, with the highest whole grain intake group showing a 20% risk decrease relative to the lowest. The results of this research provide further evidence in favor of using whole grains in the diet as a CRC preventative strategy [20]. The results of the research will be very important for public health programs aiming at reducing the incidence of colorectal cancer. Encouragement of dietary guidelines that include a lower consumption of red and processed meats and a higher consumption of fiber, fruits, vegetables, and whole grains may have a significant influence on CRC preventative efforts. Through public health initiatives and nutritional interventions, the population should be informed about the benefits of a healthy diet rich in plant-based foods and low in processed and red meats.

Limitations and Future suggestion

Notwithstanding its advantages, this research has a number of drawbacks. 'The limited generalizability of the results might be attributed to the comparatively small sample size of 84 individuals'. Self-reporting of dietary consumption raises the possibility of recollection bias. Furthermore, it is not possible to conclusively demonstrate causation due to the observational character of the research. To improve the generalizability of the results, bigger and more varied populations should be the focus of future research. In order to prove

causation and get a deeper comprehension of the processes by which food habits affect the risk of colorectal cancer, longitudinal studies are required. Research on the relationship between food and genetic variables in the development of CRC should also be conducted.

Conclusion

This research emphasizes how important eating habits are in determining one's risk of colon cancer. Increasing your intake of processed & red meats was linked to a higher risk; increasing consumption of 'whole grains, fiber, fruits, and vegetables' was linked to a reduced risk. The significance of dietary changes as a prophylactic against colorectal cancer is emphasized by these results. To assist lower the prevalence of this illness and enhance general health outcomes, public health campaigns should emphasize the promotion of diets high in "plant-based foods and low in red and processed meats".

Conflict of interest

The authors state no conflict of interest.

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