RESEARCH ARTICLE

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Factors Associated with Positive Fecal Immunochemical Test Results for Colorectal Cancer Screening among At-Risk Populations in Southern Thailand: A Cross-Sectional Analytic Study

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Abstract

Background: Colorectal cancer (CRC) is a leading cause of cancer-related morbidity and mortality globally. Early detection through Fecal Immunochemical Test (FIT) screening is essential, particularly among at-risk populations. However, evidence linking dietary consumption behavior to FIT test outcomes remains limited in Thailand, especially in the southern region. This study aimed to determine the prevalence of positive FIT results and to examine the association between dietary consumption behavior and sociodemographic factors with positive FIT results among at-risk individuals in Southern Thailand. **Materials and Methods:** A cross-sectional analytic study was conducted among participants aged 50–70 years who underwent FIT screening in primary healthcare units in Nakhon Si Thammarat Province between October 2023 and August 2024. Totally, 382 participants were included, 191 cases with positive- and 191 controls with negative-FIT results. The case-control ratio was 1:1. Data were collected using structured questionnaires assessing demographic characteristics, health risk factors, and dietary consumption behaviors. Crude and multivariate logistic regression analyses were performed to identify factors associated with a positive FIT result. **Results:** The prevalence of positive FIT results was 13.77% (95% CI: 12.04–15.66). Multivariate analysis showed low dietary consumption behavior was prevalent (83.77%), it was not significantly associated with FIT positivity (AOR = 1.10, 95%CI: 0.71-1.68), after adjusting for confounders. However, lower education level (AOR = 0.50, 95%CI: 0.32-0.78), agricultural occupation (AOR = 0.45, 95%CI: 0.25-0.82), and monthly income between 3,000–8,000 Baht (AOR = 2.11, 95%CI: 1.27-3.49) were significantly associated with a positive FIT result. **Conclusion:** Education, occupation, and income were significantly associated with positive FIT results. Targeted education and risk-reduction strategies are recommended to improve CRC screening outcomes in at-risk populations.

Keywords: Health equity- rural population- socio-demographic determinants- cancer screening behavior- primary care

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Introduction

Colorectal cancer (CRC) originates from the uncontrolled growth of epithelial cells lining the colon and rectum, often beginning as benign polyps that can progress to malignancy over time [1]. The development of CRC is influenced by both non-modifiable and modifiable risk factors [2]. Non-modifiable risks include advancing age [3], with individuals over 50 accounting for more than 90% of cases, and a family history of CRC [4] or inherited syndromes such as Lynch syndrome and familial adenomatous polyposis (FAP) [5]. Modifiable risk factors encompass lifestyle choices like diets high in red and processed meats, low physical activity, obesity, smoking, and excessive alcohol consumption [6]. The impact of CRC extends beyond individual health, affecting families emotionally and financially [7], burdening national healthcare systems, and contributing significantly to global cancer mortality [8].

Globally, CRC is the third most commonly diagnosed cancer, with significant incidence and mortality rates [9]. In Asia, rapid socioeconomic and lifestyle changes have led to a notable increase in CRC cases [10]. In Southeast Asia, CRC has become a significant health concern, with

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varying incidence rates across countries. In Thailand, CRC is the third most common cancer, accounting for 11% of the cancer burden [11], with over 10,000 new cases annually [12, 13]. CRC has become an increasing public health concern in Nakhon Sri Thammarat Province, reflecting national and regional trends [14]. Over the past five years, CRC screening using the Fecal Immunochemical Test (FIT) has expanded significantly across primary healthcare units [15]. Data from provincial health reports indicate a rising trend in the number of individuals with positive FIT results, particularly among those aged 50 years and older [16]. This increase aligns with lifestyle-related risk factors prevalent in the area, such as high consumption of grilled and processed meats and low intake of fruits and vegetables [17]. Projections suggest continued growth through 2026. Nakhon Si Thammarat, a southern Thai province with a large rural population, has seen rising rates of colorectal cancer screening using FIT tests. The area's aging population [18], dietary patterns rich in processed and grilled foods, and limited access to early diagnostic services contribute to increasing colorectal cancer risks and detection rates.

Geographically, Lansaka District is situated in Nakhon Si Thammarat Province in Southern Thailand. It is characterized by a rural landscape and a predominantly agricultural economy, with most residents engaged in rubber and fruit cultivation, reflecting the district's traditional livelihoods [19]. Healthcare services are primarily delivered through Lansaka Hospital and its affiliated primary care units, emphasizing community-based health initiatives [20]. Although industrial development is limited, Lansaka is rich in cultural heritage and natural attractions, which contribute to local tourism. Despite its unique local identity, studies focusing on Lansaka's socio-economic and health-related conditions remain limited, highlighting the need for context-specific research to inform effective public health strategies.

Despite growing evidence that diet influences CRC risk, limited studies have explored its association with positive FIT results. A previous study [21] found low fruit and vegetable intake linked to increased colorectal polyps in Thai adults, yet direct links to FIT outcomes remain unclear. Rising early-onset CRC cases suggest possible dietary influences not fully understood [12]. Moreover, while fiber-rich diets are protective, the effect of specific dietary behaviors on FIT positivity across populations is under-researched [22]. Although previous cross-sectional studies in Northeastern Thailand [23, 24] examined the relationship between food consumption and FIT results, both reported no significant association. However, these findings may not be generalizable to other regions of Thailand due to distinct differences in dietary habits, lifestyle, and cultural practices. In particular, Southern Thailand presents unique dietary patterns such as higher consumption of spicy foods, fermented products, and seafood—as well as differing socioeconomic and health service contexts. To date, limited evidence exists on the association between dietary behavior and FIT results in Southern Thailand, highlighting the need for region-specific research to better inform targeted public health interventions and colorectal cancer screening strategies.

This gap highlights the need for context-specific research linking diet and FIT outcomes to improve screening strategies. The FIT is a non-invasive screening tool designed to detect hidden blood in the stool, an early indicator of CRC. A positive FIT result suggests the presence of blood, warranting further diagnostic procedures like colonoscopy to confirm the presence of cancer or precancerous lesions. The benefits of FIT include its simplicity, cost-effectiveness, and ability to reduce CRC mortality through early detection. However, gaps in knowledge exist regarding the factors influencing positive FIT results, particularly dietary behaviors in specific populations. This study aims to determine the prevalence of positive FIT and to examine whether dietary consumption behaviors and other sociodemographic and health-related factors are associated with positive FIT results among at-risk individuals in Southern Thailand.

Materials and Methods

Study Design

This study employed a cross-sectional analytic design and was conducted between November 2024 and February 2025. Although this study was designed as cross-sectional analytic, the use of retrospective FIT results and matched controls aligns closely with a case-control methodology. The research was carried out across nine primary healthcare facilities affiliated with Lansaka Hospital, located in Lansaka District, Nakhon Si Thammarat Province, Southern Thailand.

Study Samples

The target population included individuals aged 50–70 years who underwent colorectal cancer screening using the FIT between October 2023 and August 2024 (fiscal year). All participants were registered in the FIT screening registry at Lansaka Hospital. A total of 1,445 individuals received FIT screening during the study period, according to data from the Health Data Center (HDC), Ministry of Public Health [25].

Participants were categorized into two groups: cases with a positive FIT result and controls with a negative FIT result. A case-control analytic design with Fleiss correction for continuity was used to calculate the sample size [26, 27]. The sample size estimation was based on a two-sided significance level of 95% ($Z\alpha/2 = 1.96$) and a statistical power of 85% ($Z\beta = 0.84$), using the proportion of alcohol consumption reported in a previous study—59% in the case group and 40% in the control group [24]. With a 1:1 case-to-control ratio, the required minimum sample size was 134 participants per group.

To enhance statistical power and account for missing data, all eligible cases (n = 199) with positive FIT results were included. An equal number of controls (n = 199) were systematically selected from the FIT registry. Both groups were drawn from the same healthcare settings to minimize selection bias. Exclusion criteria included individuals who had relocated, were unable to communicate or complete the interview, or had died during the study period.

Additionally, a post-hoc power analysis was conducted using education level as the reference variable, which was found to be significant in the final model [28, 29]. The proportion of individuals with secondary or vocational education was 42.26% among cases and 57.74% among controls. With 191 participants per group and $\alpha = 0.05$, the estimated power was 86%.

Variables

Data were collected using a structured questionnaire developed by the research team. The questionnaire comprised three sections: (1) demographic characteristics, (2) health risk factors, and (3) dietary consumption behavior. Demographic characteristics included five items: gender, age, education level, occupation, and average monthly income. Health risk factors consisted of twelve items: body mass index (BMI), presence of underlying diseases, history of annual physical examinations, history of gastrointestinal diseases, history of rectal bleeding or abnormal bowel movements, history of CRC screening, family history of CRC, history of genetic disorders, exercise behavior, smoking status, frequency of smoking, alcohol consumption, frequency of drinking, and type of alcoholic beverage consumed. Dietary consumption behavior was assessed using 11 items: frequency of consumption of red meat, processed foods, vegetables and fruits, fermented foods, canned foods, drinking less than 8 glasses of water per day (approximately four 500 ml bottles), tea or coffee, spicy foods, snacks, dried foods, and grilled, fried, smoked, or charred foods. Participants were asked to recall their frequency of consumption over the past month, rated on a three-point scale: rarely (≤1 time/week = score 3), occasionally (1–4 times/week = score 2), and regularly (5–7 times/week = score 1).

In this study, the content validity of the questionnaire was assessed using the Index of Item-Objective Congruence (IOC). Three experts—specialized in family medicine, nursing, and public health methodology—independently evaluated each item for its relevance and alignment with the study objectives. Each item was rated on a scale from –1 (not congruent) to +1 (clearly congruent), and IOC scores were calculated by averaging these ratings. An IOC score of 0.50 or higher is generally considered acceptable in exploratory research. In our study, the IOC values ranged from 0.66 to 1.00, indicating moderate to high agreement among experts and confirming the clarity and appropriateness of the questionnaire items.

Overall dietary consumption behavior scores were classified into three levels using the minimum–maximum range divided into tertiles: high adherence to recommended dietary behaviors (score 2.34–3.00), moderate adherence (score 1.67–2.33), and low adherence (score 1.00–1.66). Additionally, higher scores indicated healthier dietary behaviors, where ‘rare’ consumption of risk-related items (e.g. red meat, processed food) received the highest score, reflecting greater adherence to dietary recommendations aimed at reducing colorectal cancer risk.

Data Collection

The study protocol was approved by the Human Research Ethics Committee of Thaksin University. An official letter of approval was issued, allowing data collection to be conducted under the supervision of Lansaka Hospital. Access to the list of participants registered in the FIT for colorectal cancer screening program was granted by the hospital director.

Prior to data collection, all researchers were trained on the standardized use of the questionnaire to ensure consistency and accuracy in data gathering. During the data collection process, eligible participants were approached individually. The researchers explained the study’s objectives, procedures, and confidentiality measures, and informed consent was obtained. Participants who agreed to take part in the study were then asked to complete the structured questionnaire.

Statistical Methods

Descriptive statistics were used to summarize participants’ demographic characteristics, health information, and dietary consumption behavior. The primary outcome of interest was the result of the FIT for CRC screening, a dichotomous variable coded as positive (Yes = 1) or negative (No = 0). To examine associations between independent variables and a positive FIT result, a crude analysis using simple logistic regression was initially performed. This included variables from the domains of demographic characteristics, health information, and dietary consumption behavior. Variables with a p-value less than 0.25 based on Wald’s test were considered for inclusion in the multivariate analysis.

Subsequently, multiple logistic regression was employed to identify factors independently associated with a positive FIT result. In addition, a multivariate model was used to assess both the overall and subscale dietary consumption behavior in relation to FIT outcomes, using both categorical and continuous variable formats. For categorical analysis, dietary consumption behavior was dichotomized into high and low adherence groups based on the median cut-off score (≥ 2.63 for high adherence), due to non-normal distribution (Kolmogorov-Smirnov Test, p-value ≥ 0.05). Sensitivity analysis was conducted using both the enter and backward elimination methods to validate the stability of the model identifying factors associated with positive FIT results.

All findings were reported using odds ratios (OR) and adjusted odds ratios (AOR) with 95% confidence intervals (95% CI). An OR > 1 indicated a risk factor, OR < 1 indicated a protective factor, and OR = 1 indicated no association with a positive FIT result.

Ethical Considerations

The study was approved by the Human Research Ethics Committee of Thaksin University (COA No. TSU 2024_330, REC No. 0762). It was conducted in full compliance with international ethical guidelines for human research, including the Declaration of Helsinki, The Belmont Report, the CIOMS Guidelines, and the International Conference on Harmonisation – Good Clinical Practice (ICH-GCP). All participants were informed about the study objectives, procedures, confidentiality, and their rights to withdraw at any time. Written informed consent was obtained from all participants prior to data collection.

Results

Prevalence and Demographic Characteristics among Participants With and Without Positive FIT Results

The prevalence of positive FIT results among the at-risk population over the past two years (2023–2024) was 13.77% (95% CI: 12.04–15.66).

Among cases, approximately two-thirds were female (63.35%). About half were aged 61–70 years (51.31%), with a mean age of 61.53 years (SD = 5.63). Around 60.73% had a normal BMI, with a mean BMI of 23.99 kg/m² (SD = 3.65). More than half had completed primary education or less (55.50%), and 63.87% were agriculturists. Nearly half (45.55%) reported a monthly income of 3,000–8,000 Baht, with an average income of 6,346.28 Baht (SD = 4,852.10).

Among controls, 65.97% were female, and 54.45% were aged 50–60 years, with a mean age of 59.46 years (SD = 5.73). 59.16% had a normal BMI, with a mean BMI of 24.04 kg/m² (SD = 3.55). About half (50.79%) had completed high school or vocational education. The majority were agriculturists (75.39%), and 39.27% reported earning less than 3,000 Baht per month, with a mean income of 6,363.09 Baht (SD = 4,991.90).

Health Risk Factors among Participants With and Without Positive FIT Results

Among cases, 58.64% had underlying conditions, with the three most common being hypertension (29.32%), hyperlipidemia (25.65%), and diabetes mellitus (14.14%). Approximately 51.83% had undergone annual health checkups, while only 12.57% reported a history of gastrointestinal disease, and 8.38% had experienced rectal bleeding or abnormal bowel movements. The majority (92.67%) had previously undergone colorectal cancer screening, and only 3.66% had a family history of colorectal cancer. Around 26.18% had a history of genetic disorders, and 39.79% reported exercising 2–3 times per week. 18.85% were smokers, with 8.90% smoking every other day. 11.66% reported alcohol consumption, and 15.18% drank alcohol every other day.

Among controls, 51.83% had underlying diseases, mainly hypertension (21.47%), hyperlipidemia (20.94%), and diabetes mellitus (9.95%). 50.26% had annual health checkups. 13.61% had gastrointestinal diseases, and 14.14% reported rectal bleeding or abnormal bowel movements. Most had undergone colorectal cancer screening (86.91%), and only 4.71% reported a family history of colorectal cancer. 19.90% had genetic disorders, and about half exercised 2–3 times per week. 16.75% were smokers, with 2.62% smoking every other day. 17.28% consumed alcohol, and 15.18% drank every other day.

Dietary Behavior of Participants With and Without Positive FIT Results

Among cases, most participants showed low adherence to dietary recommendations (83.77%), with a mean score of 2.54 (SD = 0.25). Subscale analysis revealed regular consumption of red meat (11.52%), processed foods (0.52%), vegetables and fruits (4.71%), fermented food (2.09%), canned food (2.62%), less than 8 glasses of water per day (59.69%), tea or coffee (46.60%), spicy food (8.90%), snacks (2.09%), dry food (2.09%), and grilled, fried, smoked, or charred food (3.66%) as shown in Table 1.

Among controls, 83.25% had low adherence to dietary recommendations, with a mean score of 2.56 (SD = 0.27). Regular consumption was reported for red meat (10.99%), processed foods (1.05%), vegetables and fruits (8.38%), fermented food (2.09%), canned food (1.05%), less than 8 glasses of water per day (55.50%), tea or coffee (46.07%), spicy food (8.90%), snacks (1.57%), dry food (2.62%), and grilled, fried, smoked, or charred food (3.14%) as shown in Table 1.

Crude Analysis of Factors Associated With Positive FIT Results among Participants

The crude analysis revealed significant associations between several demographic factors and positive FIT results. Participants over 60 years old were 1.56 times more likely to test positive compared to younger participants (OR = 1.56, 95% CI: 1.04–2.33). Those who completed junior high or vocational education were 44% less likely to test positive than those with primary education or lower (OR = 0.56, 95% CI: 0.37–0.85). Participants working in agriculture were 52% less likely to test positive compared to those in private business, sales, or government jobs (OR = 0.48, 95% CI: 0.28–0.84). Those with a monthly income of 3,000–8,000 Baht were 1.79 times more likely to test positive than those earning less than 3,000 Baht (OR = 1.79, 95% CI: 1.12–2.87) as shown in Table 2.

Crude Analysis of Health Risk Factors Associated With Positive FIT Results among Participants

There were no significant associations between health risk factors and positive FIT results, including sex, BMI, underlying conditions, annual checkups, gastrointestinal diseases, rectal bleeding, history of screening, family history of colorectal cancer, genetic disorders, exercise, smoking, and alcohol consumption (all p-values > 0.05) as shown in Table 3.

Crude Analysis of Subscale and Overall Dietary Consumption Behavior Associated With Positive FIT Results among Participants

No significant associations were found between either overall dietary consumption behavior or any subscale variables and positive FIT results. This included intake of red meat, processed foods, vegetables and fruits, fermented foods, canned foods, water intake, tea/coffee, spicy foods, snacks, dry foods, and grilled/fried/smoked/charred foods. Additionally, both categorical and continuous measures of dietary behavior were not significantly associated with FIT test outcomes (p = 0.759 and p = 0.454, respectively) as shown in Table 4.

Multivariate Analysis of Factors Associated With Positive FIT Results among Participants

A multivariate logistic regression analysis (enter

Table 1. Dietary Consumption Behavior among Participants with and without Positive FIT Results for Colorectal Cancer Screening (n = 382)

Dietary consumption behavior	Cases (n = 191)	Controls (n = 191)
Red meat		
Rarely	91 (47.64)	107 (56.02)
Occasionally	78 (40.84)	63 (32.98)
Regularly	22 (11.52)	21 (10.99)
Processed foods		
Rarely	165 (86.39)	164 (85.86)
Occasionally	25 (13.09)	25 (13.09)
Regularly	1 (0.52)	2 (1.05)
Vegetables and fruits		
Rarely	134 (70.16)	125 (65.44)
Occasionally	48 (25.13)	50 (26.18)
Regularly	9 (4.71)	16 (8.38)
Fermented foods		
Rarely	160 (83.77)	155 (81.15)
Occasionally	27 (14.14)	32 (16.75)
Regularly	4 (2.09)	4 (2.09)
Canned foods		
Rarely	152 (79.58)	154 (80.63)
Occasionally	34 (17.80)	35 (18.32)
Regularly	5 (2.62)	2 (1.05)
Drinking less than 8 glasses of water per day (approximately four 500 ml bottles)		
Rarely	31 (16.23)	52 (27.23)
Occasionally	46 (24.08)	33 (17.28)
Regularly	114 (59.69)	106 (55.50)
Tea or coffee		
Rarely	83 (43.46)	91 (47.64)
Occasionally	19 (9.95)	12 (6.28)
Regularly	89 (46.60)	88 (46.07)
Spicy foods		
Rarely	125 (65.45)	125 (65.45)
Occasionally	49 (25.65)	49 (25.65)
Regularly	17 (8.90)	17 (8.90)
Snacks		
Rarely	155 (81.15)	155 (81.15)
Occasionally	32 (16.75)	33 (17.28)
Regularly	4 (2.09)	3 (1.57)
Dried foods		
Rarely	165 (86.39)	166 (86.39)
Occasionally	22 (11.52)	20 (10.47)
Regularly	4 (2.09)	5 (2.62)
Grilled, fried, smoked, charred foods		
Rarely	161 (84.29)	164 (85.56)
Occasionally	23 (12.04)	21 (10.99)
Regularly	7 (3.66)	6 (3.14)

Table 1. Continued

Dietary consumption behavior	Cases (n = 191)	Controls (n = 191)
Dietary consumption behavior		
High	0 (0.00)	1 (0.52)
Moderate	31 (16.23)	31 (16.23)
Low	160 (83.77)	159 (83.25)
Mean ± SD	2.54 ± 0.25	2.56 ± 0.27
Median (Min-Max)	2.64 (1.82-3.00)	2.64 (1.64-3.00)

method) revealed that education, occupation, income, and history of rectal bleeding or abnormal bowel movements were significantly associated with positive FIT results. Participants with secondary or vocational education were 50% less likely to test positive (AOR = 0.50, 95% CI: 0.32-0.78), and those in agriculture were 55% less likely than those in other occupations (AOR = 0.45, 95% CI: 0.25-0.82). Participants who had previously undergone colorectal cancer screening were 54% less likely to test positive (AOR = 0.46, 95% CI: 0.23-0.94), while those with monthly incomes of 3,000-8,000 Baht were 2.11 times more likely to test positive (AOR = 2.11, 95% CI: 1.27-3.49) as shown in Table 5.

A sensitivity analysis using the backward method confirmed the final model, showing that education ($p = 0.012$), occupation ($p = 0.014$), income ($p = 0.014$), and rectal bleeding ($p = 0.033$) were significantly associated with positive results. Screening history ($p = 0.062$) and smoking ($p = 0.056$) were not significant in the final model (data not shown).

When analyzing dietary behavior using logistic regression, participants with low dietary behavior had slightly higher odds of testing positive (AOR = 1.10, 95% CI: 0.71-1.68) in categorical analysis. In contrast, the continuous dietary score showed a 36% reduced likelihood of a positive result (AOR = 0.74, 95% CI: 0.36-1.68), though neither association was statistically significant as shown in Table 6.

Finally, subscale analysis of dietary behavior found that frequent consumption of red meat, canned food, water <8 glasses/day, tea/coffee, and spicy food appeared to increase the risk of a positive result, while processed foods, vegetables/fruits, fermented foods, snacks, and dry foods appeared to be protective. However, none of these associations were statistically significant after adjusting for confounders as shown in Table 7.

Discussion

In summary, the prevalence of positive FIT results among at-risk individuals from 2023 to 2024 was 13.77% (95% CI: 12.04-15.66). Most participants in both the case (83.77%) and control (83.25%) groups exhibited low adherence to dietary recommendations. Multivariate logistic regression revealed significant associations between positive FIT results and socio-demographic factors. Participants with secondary or vocational education, agricultural occupations, or prior CRC screening were significantly less likely to test

Table 2. Crude Analysis of Demographic Characteristic Factors Associated with Positive FIT Results for Colorectal Cancer Screening among Participants (n = 382)

Factors	Cases (n = 191)	Controls (n = 191)	OR	95%CI	p-value
Sex					0.593
Male	70 (51.85)	65 (48.15)	Ref.		
Female	121 (48.99)	126 (51.01)	0.89	0.58-1.36	
Age (year)					0.032
60	83 (44.39)	104 (55.61)	Ref.		
>60	108 (55.38)	87 (44.62)	1.56	1.04-2.33	
Education					0.025
Primary school or lower	106 (56.68)	81 (43.32)	Ref.		
Secondary school, high school or professional vocation	71 (42.26)	97 (57.74)	0.56	0.37-0.85	
Certificate, higher professional vocation or higher	14 (51.85)	13 (48.15)	0.82	0.37-1.85	
Occupaiton					0.034
Private business / sales / governmental officers	42 (63.64)	24 (36.36)	Ref.		
Employees	26 (53.06)	23 (46.94)	0.65	0.30-1.37	
Agriculturists	122 (45.86)	144 (54.14)	0.48	0.28-0.84	
Average monthly income (Baht)					0.046
<3,000	57 (43.18)	75 (56.82)	Ref.		
3,000-8,000	87 (57.62)	64 (42.38)	1.79	1.12-2.87	
>8,000	47 (47.47)	52 (52.53)	1.19	0.07-2.01	
Average monthly income (Baht, continuous)	-	-	1.00	1.00-1.00	0.976

Note: OR, Odds ratio; 95% CI, 95 Percent confidence interval, Ref., Reference group; FIT, Fecal Immunochemical Test. "–" indicates that the variable is continuous and not applicable for presentation as n (%).

positive. In contrast, those with monthly incomes between 3,000–8,000 Baht were over twice as likely to have a positive result. Dietary behavior showed no significant association with FIT positivity.

Our study found no significant association between overall or subscale dietary consumption behaviors and positive FIT results for CRC screening. In our study, although dietary consumption behaviors both overall and by subscale were not significantly associated with positive FIT results, participants who regularly consumed red meat showed a higher likelihood of FIT positivity, though not statistically significant (AOR = 1.42, 95%CI: 0.93-2.17). This may be explained by the underlying demographic characteristics among cases and controls. Most participants had similar dietary habits, low dietary diversity (83.77% VS 83.25%), and low educational attainment (55.50% VS 42.41%), particularly among older agriculturists with limited health literacy (64.21% VS 75.39%). These factors may have masked the potential effects of dietary risks. Moreover, the dominant low adherence to dietary recommendations profile in both groups likely reduced variability, limiting the detection of significant associations.

This aligns with a study conducted in northeastern Thailand, which reported no significant association between red meat consumption and positive FIT results [23,24]. However, other studies have identified links between certain dietary patterns and CRC risk. For instance, a Canadian study found that meat-based and sugary dietary patterns increased CRC risk, with odds ratios of 1.84 and 2.26, respectively, for individuals in the highest intake quintiles compared to the lowest [30]. Additionally, a review of 17 years of studies indicated that adherence to a Mediterranean dietary pattern is associated with a lower risk of CRC [31]. The lack of association in our study may be due to the homogeneity of dietary behaviors among participants or the influence of other factors such as genetics, lifestyle, or environmental exposures. Further research is needed to elucidate the complex interactions between diet and CRC risk.

In our study, socio-demographic factors were significantly associated with positive FIT results. Participants with secondary or vocational education were 50% less likely to test positive compared to those with primary education or less, while those engaged in agricultural occupations had a 55% lower likelihood of testing positive. These findings may reflect the influence of educational attainment and occupational context on health behaviors, awareness, and access to preventive services. Prior CRC screening was also associated with a reduced likelihood of FIT positivity, highlighting the benefit of routine screening in early detection. Conversely, participants with monthly incomes of 3,000–8,000 Baht were more than twice as likely to test positive, possibly due to limited health literacy or reduced access to timely care. Lower education and occupational categories may reflect reduced access to preventive care and limited dietary options, consistent with structural and economic barriers commonly observed in rural Thai populations.

These findings are consistent with a meta-analysis [32], which found that individuals with higher socioeconomic status had significantly better CRC screening uptake.

Table 3. Crude Analysis of Health Risk Factors Associated with Positive FIT Results for Colorectal Cancer Screening among Participants (n = 382)

Factors	Cases (n = 191)	Controls (n = 191)	OR	95%CI	p-value
Body mass index (kg/m2)					0.667
<25.00	127 (50.80)	123 (49.20)	Ref.		
≥25.00	64 (48.48)	68 (51.52)	0.91	0.60-1.39	
Underlying diseases					0.181
No	79 (46.20)	92 (53.80)	Ref.		
Yes	112 (53.08)	99 (46.92)	1.32	0.88-1.97	
Hypertension	56 (57.73)	41 (42.27)	1.52	0.95-2.42	0.079
Diabetes	27 (58.70)	19 (41.30)	1.49	0.80-2.78	0.211
Hyperlipidemia	49 (55.06)	40 (44.94)	1.30	0.81-2.10	0.277
Others (heart diseases, ulcerative colitis, ischemic stroke, thyroid, cancer, asthma, allergy, etc.)	32 (51.61)	30 (48.39)	1.08	0.63-1.86	0.781
History of annual physical exams					0.759
No	92 (49.20)	95 (50.80)	Ref.		
Yes	99 (50.77)	96 (49.23)	1.06	0.71-1.59	
History of gastro-intestinal diseases					0.762
No	167 (50.30)	165 (49.70)	Ref.		
Yes	24 (48.00)	26 (52.00)	0.91	0.50-1.65	
History of rectal bleeding / abnormal bowel movement					0.078
No	175 (51.62)	164 (48.38)	Ref.		
Yes	16 (37.21)	27 (62.79)	0.56	0.29-1.07	
History of colorectal cancer screening					0.066
No	14 (35.90)	25 (64.10)	Ref.		
Yes	177 (51.60)	166 (48.40)	1.90	0.96.3.79	
History of family illness with colorectal cancer					0.610
No	184 (50.27)	182 (49.73)	Ref.		
Yes	7 (43.75)	9 (56.25)	0.77	0.28-2.11	
History of genetic disorders					0.146
No	141 (47.96)	153 (52.04)	Ref.		
Yes	50 (56.82)	38 (43.18)	1.43	0.88-2.31	
Exercise behavior					0.279
Everyday	43 (59.72)	29 (40.28)	Ref.		
Every other day	11 (73.33)	4 (26.67)	1.85	0.54-6.39	
2-3 Times a week	76 (47.20)	85 (52.80)	0.60	0.34-1.06	
Once a week	25 (50.00)	25 (50.00)	0.64	0.33-1.40	
Less than once a week	20 (40.00)	30 (60.00)	0.45	0.22-0.94	
1-3 Days a month	16 (47.06)	18 (52.94)	0.60	0.26-1.36	
Smoking					0.075
No	137 (47.40)	152 (52.61)	Ref.		
Yes	54 (58.06)	39 (41.93)	1.54	0.96-2.46	
Alcohol drinking					0.801
No	152 (50.33)	150 (49.67)	Ref.		
Yes	39 (48.75)	41 (51.25)	0.94	0.57-1.54	

Note: OR, Odds ratio; 95% CI, 95 Percent confidence interval; Ref., Reference group; FIT, Fecal Immunochemical Test.

Similarly, the study in southeast Texas, the United State [33] observed that low education levels were associated with higher CRC risk. In contrast, a study in a large German population did not find significant associations between income and positive FIT results [34], suggesting that contextual factors may influence these associations. These findings emphasize the need for targeted health education and equitable access to screening services.

Table 4. Crude Analysis of Dietary Consumption Behavior Associated with Positive FIT Results for Colorectal Cancer Screening among Participants (n = 382)

Food consumption behavior	Cases (n = 191)	Controls (n = 191)	OR	95%CI	p-value
Red meat					0.102
Rarely	91 (45.96)	107 (54.04)	Ref.		
Occasionally / Regularly	100 (54.35)	84 (45.56)	1.40	0.94-2.10	
Processed food					0.882
Rarely	165 (50.15)	164 (49.85)	Ref.		
Occasionally / Regularly	26 (49.06)	27 (50.94)	0.96	0.54-1.71	
Vegetable and fruit					0.325
Rarely	134 (51.74)	125 (48.26)	Ref.		
Occasionally / Regularly	57 (46.34)	66 (53.66)	0.81	0.52-1.24	
Fermented food					0.501
Rarely	160(50.79)	155 (49.21)	Ref.		
Occasionally / Regularly	31 (46.27)	36 (53.73)	0.83	0.49-1.42	
Canned food					0.798
Rarely	152 (49.67)	154 (50.33)	Ref.		
Occasionally / Regularly	39 (51.31)	37 (48.70)	1.07	0.65-1.77	
Drinking water less than 8 glasses a day					0.408
Rarely	77 (47.53)	85 (52.50)	Ref.		
Occasionally / Regularly	114 (51.82)	106 (48.18)	1.19	0.79-1.78	
Tea or coffee					0.411
Rarely	83 (47.70)	91 (52.30)	Ref.		
Occasionally / Regularly	108 (51.92)	100 (48.10)	1.18	0.79-1.77	
Spicy foods					1.00
Rarely	125 (50.00)	125 (50.00)	Ref.		
Occasionally / Regularly	66 (50.00)	66 (50.00)	1.00	0.66-1.53	
Snacks					1.00
Rarely	155 (50.00)	155 (50.00)	Ref.		
Occasionally / Regularly	36 (50.00)	36 (50.00)	1.00	0.60-1.67	
Dried food					0.880
Rarely	165 (49.85)	166 (50.15)	Ref.		
Occasionally / Regularly	26 (50.10)	25 (49.01)	1.05	0.58-1.89	
Grilled/fried/smoked and burnt foods					0.667
Rarely	161 (49.54)	164 (50.46)	Ref.		
Occasionally / Regularly	30 (52.63)	27 (47.40)	1.32	0.64-1.99	
Dietary consumption behavior					0.759
High (≥2.63)	98 (49.25)	101 (50.75)	1.00		
Low (<2.63)	93 (50.82)	90 (49.18)	1.07	0.71-1.59	
Dietary consumption behavior (score, continuous variable)	-	-	0.74	0.34-1.61	0.454

Note: OR, Odds ratio; 95% CI, 95 Percent confidence interval; Ref., Reference group; FIT, Fecal Immunochemical Test. "–" indicates that the variable is continuous and not applicable for presentation as n (%).

Advantage and limitation of the study

This study offers several notable advantages. It is among the first to examine the association between dietary consumption behavior and positive FIT results for CRC screening in Southern Thailand, particularly within a rural context like Lansaka District. The use of a community-based, population registry allowed for a representative sample, enhancing the generalizability of the findings to similar settings. The structured questionnaire was validated by experts, ensuring content validity, and multivariate analysis was applied to control for potential confounders, strengthening the internal validity of the results. Furthermore, the inclusion of both crude and adjusted models, along with sensitivity analysis, added robustness to the analytical approach.

However, the study also has limitations. Its cross-sectional design precludes establishing causal relationships between risk factors and FIT results. The reliance on self-reported dietary behavior may have introduced recall or social desirability bias, with a potential for underreporting,

Table 5. Multivariate Analysis of Factors Associated with Positive FIT Results for Colorectal Cancer Screening among Participants (n = 382)

Factors	n (%)	OR (95%CI)	AOR (95%CI)	p-value
Red meat				0.109
Rarely	91 (45.96)	Ref.	Ref.	
Occasionally / Regularly	100 (54.35)	1.40 (0.94-2.10)	1.42 (0.93-2.17)	
Education				0.010
Primary school or lower	106 (56.68)	Ref	Ref.	
Secondary school, high school or professional vocation	71 (42.26)	0.56 (0.37-0.85)	0.50 (0.32-0.78)	
Certificate, higher professional vocation or higher	14 (51.85)	0.82 (0.37-1.85)	0.75 (0.31-1.81)	
Occupation				0.019
Private bussiness	42 (63.64)	Ref.	Ref.	
Employees	26 (53.06)	0.65 (0.30-1.37)	0.72 (0.33-1.61)	
Agriculturists	122 (45.86)	0.48 (0.28-0.84)	0.45 (0.25-0.82)	
Average income (Baht per month)				0.014
<3,000	57 (43.18)	Ref.	Ref.	
3,000-8,000	87 (57.62)	1.79 (1.12-2.87)	2.11 (1.27-3.49)	
≥8,000	47 (47.47)	1.19 (0.07-2.01)	1.32 (0.75-2.33)	
History of rectal bleeding / abnormal bowel movement				0.032
No	175 (51.62)	Ref.	Ref.	
Yes	16 (37.21)	0.56 (0.29-1.07)	0.46 (0.23-0.94)	
History of colorectal cancer screening				0.085
No	14 (35.90)	Ref.	Ref.	
Yes	177 (51.60)	1.90 (0.96-3.79)	1.91 (0.91-4.02)	
Smoking				0.054
No	137 (47.40)	Ref.	Ref.	
Yes	54 (58.06)	1.54 (0.96-2.46)	1.65 (0.99-2.74)	

Note: OR, Odds ratio; AOR, Adjusted odds ratio; 95% CI, 95 Percent confidence interval; Ref. , Reference group; FIT, Fecal Immunochemical Test. Model goodness-of-fit tested using Hosmer-Lemeshow test (χ^2 = 9.854, df = 8, p = 0.275; -2 Log likelihood = 490.978 , Cox and Snell R^2 = 0.093, Nagelkerke R^2 = 0.124)

Table 6. Multivariate Analysis of Overall Dietary Consumption Behavior and Positive FIT Results for Colorectal Cancer Screening among Participants (n = 382)

Factors	n (%)	OR (95%CI)	AOR (95%CI)	p-value
Dietary consumption behavior				0.675*
High (≥2.63)	98 (49.25)	Ref.	Ref.	
Low (<2.63)	93 (50.82)	1.07 (0.71-1.59)	1.10 (0.71-1.68)	
Dietary consumption behavior (score, continuous variable)	-	0.74 (0.34-1.61)	0.74 (0.36-1.68)	0.472**

Note: OR, Odds ratio; AOR, Adjusted odds ratio; 95% CI, 95 Percent confidence interval; Ref., Reference group; FIT, Fecal Immunochemical Test. Model goodness-of-fit tested using Hosmo-Lemeshow test for categorical variable* (χ^2 = 20.873, df = 8, p = 0.007); -2 log likelihood = 490.203; Cox & Snell R^2 = 0.095, Negelkerke R^2 = 0.126) and continuous variable** (χ^2 = 18.482, df = 8, p = 0.018; -2 log likelihood = 489.862, Cox & Snell R^2 = 0.096; Negelkerke R^2 = 0.128). "–" indicates that the variable is continuous and not applicable for presentation as n (%).

particularly among older adults. Additionally, the relatively homogeneous dietary patterns among participants may have limited variability, reducing the ability to detect significant associations. Residual confounding cannot be ruled out, as unmeasured factors may have influenced the observed relationships. Additionally, the findings may not be generalizable beyond the local context due to cultural and regional differences. Lastly, the absence of colonoscopy confirmation for FIT-positive cases limits the ability to link findings directly to confirmed colorectal cancer diagnoses.

Implication of the study

This study provides valuable insights into the socio-demographic and behavioral factors associated with positive FIT results for CRC screening among at-risk populations in Southern Thailand. The findings highlight the importance of addressing socioeconomic disparities-particularly education, occupation, and income-in the design and implementation of CRC screening programs. Tailored health communication strategies are essential to improve awareness, especially among individuals with lower educational attainment or income, who may have limited access to health information or preventive

Table 7. Multivariate Analysis of Dietary Consumption Behavior Subscales Associated with Positive FIT Results for Colorectal Cancer Screening among Participants (n = 382)

Factors	n (%)	OR (95%CI)	AOR (95%CI)	p-value*
Red meat				0.142
Rarely	91 (45.96)	Ref.	Ref.	
Occasionally / Regularly	100 (54.35)	1.40 (0.94-2.10)	1.40 (0.89-2.21)	
Processed food				0.769
Rarely	165 (50.15)	Ref.	Ref.	
Occasionally / Regularly	26 (49.06)	0.96 (0.54-1.71)	0.90 (0.44-1.83)	
Vegetable and fruit				0.399
Rarely	134 (51.74)	Ref.	Ref.	
Occasionally / Regularly	57 (46.34)	0.81 (0.52-1.24)	0.81 (0.51-1.31)	
Fermented food				0.754
Rarely	160 (50.79)	Ref.	Ref.	
Occasionally / Regularly	31 (46.27)	0.83 (0.49-1.42)	0.90 (0.48-1.69)	
Canned food				0.774
Rarely	152 (49.67)	Ref.	Ref.	
Occasionally / Regularly	39 (51.31)	1.07 (0.65-1.77)	1.09 (0.61-1.95)	
Drinking water less than 8 glasses a day				0.750
Rarely	77 (47.53)	Ref.	Ref.	
Occasionally / Regularly	114 (51.82)	1.19 (0.79-1.78)	1.14 (0.72-1.82)	
Tea or coffee				0.682
Rarely	83 (47.7)	Ref.	Ref.	
Occasionally / Regularly	108 (51.92)	1.18 (0.79-1.77)	1.10 (0.70-1.73)	
Spicy food				0.824
Rarely	125 (50.00)	Ref.	Ref.	
Occasionally / Regularly	66 (50.00)	1.00 (0.66-1.53)	1.06 (064-1.74)	
Snack				0.620
Rarely	155 (50.00)	Ref.	Ref.	
Occasionally / Regularly	36 (50.00)	1.00 (0.60-1.67)	0.85 (0.46-1.59)	
Dry food				0.948
Rarely	165 (49.85)	Ref.	Ref.	
Occasionally / Regularly	26 (50.10)	1.05 (0.58-1.89)	0.98 (0.48-1.98)	
Grilled, fried, smoked, burnt food				1.000
Rarely	161 (49.54)	Ref.	Ref.	
Occasionally / Regularly	30 (52.63)	1.32 (0.64-1.99)	1.00 (0.50-2.00)	

Note: OR, Odds ratio; AOR, Adjusted odds ratio; 95% CI, 95 Percent confidence interval; Ref., Reference group; FIT, Fecal Immunochemical Test. Model goodness-of-fit tested using Hosmer-Lemeshow test (χ^2 = 14.097, df = 8, p = 0.079; -2 Log likelihood = 485.594; Cox and Snell R^2 = 0.106; Nagelkerke R^2 = 0.141).

care services [32]. Furthermore, the association between prior screening and reduced FIT positivity underscores the role of regular screening in early detection and CRC prevention. Despite the lack of a significant association between dietary behaviors and FIT results, the prevalence of low dietary quality suggests the need for ongoing nutritional education in the community. Policymakers and healthcare providers should prioritize integrated screening strategies that combine FIT with community-based education, especially in rural and underserved areas. This approach may enhance CRC screening coverage, improve early detection rates, and ultimately reduce CRC morbidity and mortality [34].

In conclusion, this study investigated factors associated with positive FIT results for CRC screening among at-risk populations in Southern Thailand. The findings revealed that socio-demographic factors including education, occupation, income, and history of prior CRC screening were significantly associated with FIT positivity. Participants with higher education, agricultural occupations, and previous screening were less likely to test positive, while those with moderate income had increased odds. Interestingly, overall and subscale dietary consumption behaviors showed no significant association with FIT results, despite a higher proportion of low dietary quality across the sample. These findings suggest that socio-economic and behavioral factors may play a more critical role in CRC risk than diet alone in this population. Public health strategies should emphasize targeted education and screening outreach, especially for socioeconomically disadvantaged groups. Future studies are recommended to explore these associations longitudinally and examine other contributing lifestyle and environmental factors.

Author Contribution Statement

EB, SB, BC and SW conceptualized and designed the study. EB, SB, B.C. SW, and SP. contributed to drafting the research proposal and conducting the literature review. Data collection and verification were carried out by EB, SB, SK and PA. Data analysis and interpretation were performed by EB, SB, BC, SW and SM. The initial manuscript was drafted by EB and SB under the supervision of BC and SW. All authors reviewed and approved the final manuscript prior to submission.

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Ethics Approval

Approved by Human Research Ethics Committee, Thaksin University (COA No. TSU 2024_330, REC No. 0762).

Availability of Data

Permission was obtained from the director of Lansaka Hospital, Nakhon Sri Thammarat, Thailand to access and utilize the hospital's database containing the FIT screening registry of participants aged 50–70 years at risk for CRC.

Conflicts of interest

There are no conflicts of interest.

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