Original Article

The Effect of Pender's Health Promotion Model Interventions on Colorectal Cancer Preventive Nutritional Behaviors in First-degree Relatives of Patients with Colorectal Cancer: A Randomized Controlled Trial

Negar Keshavarz[1], MSc; Marziyeh Hosseini[2], PhD; Mohsen Shams[2], PhD; Janmohamad Malekzadeh[3], PhD; Nazafarin Hosseini[2], PhD; Hajar Zamani Habibabad[4], PhD candidate

[1]Student Research Committee, Yasuj University of Medical Sciences, Yasuj, Iran;
[2]Social Determinants of Health Research Center, School of Nursing, Yasuj University of Medical Sciences, Yasuj, Iran;
[3]Department of Nutrition, School of Health and nutrition, Yasuj University of Medical Sciences, Yasuj, Iran;
[4]Student Research Committee, Shiraz University of Medical Sciences, Shiraz, Iran

Corresponding Author:
Nazafarin Hosseini, PhD; Social Determinants of Health Research Center, School of Nursing, Yasuj University of Medical Sciences, Postal Code: 75919-94799, Yasuj, Iran
Tel/Fax: +98 74 33235144; **Email:** hosseinichenar@yahoo.com

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Abstract

Background: Colorectal cancer in relatives with a positive family history is more common than in other people, probably due to environmental factors, genetics, and lifestyle. Education based on Pender's Health Promotion Model (HPM) on nutritional behavior may be helpful. This study was conducted to determine the effect of interventions based on Pender's HPM on preventive nutritional behaviors of colorectal cancer and other constructs of the model in first-degree relatives of individuals with colorectal cancer.

Methods: This is a randomized controlled trial study conducted on 136 first-degree family members of colorectal cancer patients (68 in each intervention and control groups) who were referred to Nemazee, Faghihi, and Amir Hospitals affiliated with Shiraz University of Medical Sciences, Shiraz, Iran, from March 2017 to August 2019. An educational intervention (four sessions weekly) based on the Pender model was designed and implemented. The data collection instrument was a nutritional behaviors inventory based on Pender's HPM for colorectal cancer prevention. It was a researcher-made inventory that was filled in before (week 0) and 12 weeks after 4 weeks of the intervention (week 16), by the participants. The data were analyzed using SPSS software version 19.0; we used independent sample t-test, Paired t-test, ANCOVA, Pearson correlation, and Chi-square tests. A P value < 0.05 was considered statistically significant.

Results: There was significant improvement in the mean score of nutritional behavior and other constructs of the model in the intervention group compared to the control (P=0.001) exception to the positive affection, which showed no significant between-group difference (P=0.453). Within-group comparison of the mean score of nutritional behavior in the intervention group showed a significant increase after completion of the follow-up (P=0.001), but the effect was not observed in the control group (P=0.788).

Conclusion: The intervention based on Pender's HPM can improve nutritional behavior in first-degree family members of patients with colorectal cancer. This model is recommended to be used by

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Keywords: Colorectal; Cancer; Health promotion; Nutrition; Prevention

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Introduction

Colorectal cancer is the world's third most common cancer and second leading cause of cancer death, with 2024 estimates reaching 2.0 million new cases and 918,000 deaths.[1] United States projections for 2026 further estimate 158,850 new cases.[2] In Iran, the annual incidence rate of this cancer is about 6-9.7 per 100,000 individuals, with an estimated mortality rate of 1.198 per 100,000 individuals.[3] The incidence of colorectal cancer is associated with obesity; environmental factors; lifestyle factors such as smoking, alcohol drinking, low physical activity, consumption of high-fat red meat, sugar-sweetened beverages, and low fiber; and a positive family history.[4, 5] In a meta-analysis study, family history of colorectal cancer in one of the first-degree relatives increases the relative risk of colon cancer by 1.92 (95% CI, 1.53–2.41) and 1.37 (95% CI, 0.76–2.46) for cohort studies that increased with more relatives.[6] Economic status, income, knowledge, level of education, level of health-related responsibilities, interpersonal relationships, and cancer risk perception are all regarded as effective determinants in disease prevention behaviors.[7] It is estimated that the probability of colorectal cancer is 62% lower in people who adhere to 5 factors of a healthy lifestyle compared to two factors of a healthy lifestyle.[8] The number of patients diagnosed with colorectal cancer in Iran has shown a substantial growth in recent years.[9] Consumption of fat and fast foods has increased in Iran, and there is no adequate level of preventive nutritional behaviors.[10] Therefore, the necessity to change nutritional behavior concerning colorectal cancer is obvious.[11]

A healthy eating pattern, defined by low intake of animal proteins, processed foods, and alcohol, and a high intake of fiber and unsaturated fatty acids, fruits and vegetables, provides the foundation for nutritional interventions.[12] The mechanism by which diet affects cancer is probably through a direct effect on immune system response and inflammation, an indirect effect with overeating and obesity, as well as an effect on intestinal microorganisms.[13] Many types of cancer are considered preventable to a significant extent, particularly when individuals adopt healthier lifestyles that include not smoking, keeping a healthy weight, exercising regularly, avoiding alcohol use, and eating nutritiously.[14] Greater health and nutrition awareness is positively correlated with dietary behaviors.[15] A study in Turkey found that 56.3% of the patient's family had little knowledge of the disease and how to prevent it, which indicated the need to increase awareness of healthy lifestyle behaviors among first-degree relatives of individuals with colorectal cancer.[7] Previous studies indicated that nutritional education and intervention could be helpful if they focused on behavior.[15-17] Pender's Health Promotion Model (HPM) is one of the most widely used models for planning and changing unhealthy behaviors, promoting healthy behaviors.[18-20] Several studies have indicated the effectiveness of HPM in encouraging healthy behaviors.[15, 21-23]

Pender's HPM increases motivation, which improves people's health behaviors. This model includes three areas that nurses can use to evaluate health promotion behavior

of participants. The first is Experiences and individual characteristics, including previous related behaviors and personal factors (e.g., biological, psychological, and sociocultural). The second is behavior-specific cognitions and affect, such as perceived benefits of action, perceived barriers to action, perceived self-efficacy, activity-related affect (positive or negative), perceived interpersonal influences, situational influences, immediate competing demands and preferences, and commitment to a plan of action. The third is Health-promoting behavior or behavioral outcome, which encompasses both health-promoting and desired behavioral outcomes.[24] Pender's HPM is an integrative nursing framework that identifies personal, motivational, and interpersonal factors influencing health decisions, providing a comprehensive basis for adopting a healthy lifestyle through behavioral change.[25]

Pender's HPM has some advantages. This model is not limited to specific health behaviors and has been found useful in many different settings, including the workplace, home, and healthcare settings. In addition, Pender's HPM is useful in reducing disease risk factors, especially preventing chronic diseases and promoting healthy lifestyles. This model has unique characteristics in health behaviors and prevention of diseases. In this model, nurses should consider "strengthening resources, potentials, and capabilities" of individuals, families, and societies to acquire a better quality of life. In this model, clarity, feasibility, and consistency have been defined.[26] The constructs of HPM have a logical structure. It considers the interaction between the nurse and the environment, and the role of the political, social and individual environment in promoting health. Given these environmental factors, this study clarifies the role of nurses in delivering healthcare services across all age groups.[27]

Instruction based on Pender model enhanced self-efficacy and a healthy lifestyle in patients with diabetic foot ulcers.[28] The effect of health promotion education on healthy behaviors of patients with heart attack has been revealed.[29] Pender's model has increased nutritional behavior and some constructs of the model in obese women.[15] Therefore, considering the high risk of the first-degree relatives of patients with colorectal cancer to develop this cancer and the role of diet in changing their lifestyle, as well as the limited studies on this subject, the present study was conducted to determine the effect of interventions based on Pender's HPM on preventive nutritional behaviors of colorectal cancer and other constructs of the model in first-degree relatives of individuals with colorectal cancer.

Materials and Methods

The present randomized controlled trial study was conducted on the first-degree relatives of patients with colorectal cancer who had referred to Nemazee, Faghihi, and Amir Hospitals affiliated with Shiraz University of Medical Sciences (Shiraz, Iran) from March 2017 to August 2019. Participants were required to meet the following inclusion criteria: being first-degree relatives (parents, siblings, or children) of patients with colorectal cancer aged 18 to 60 years; being literate; having no history of participation in any similar educational intervention within the past 6 months; and reporting no chronic diseases (such as diabetes, cardiovascular disease, thyroid disorders, or kidney and liver diseases) or debilitating conditions, including mental retardation. Lack of willingness of participants to take part in the study and absence in more than one session of educational intervention were considered the exclusion criteria.

According to the study by Dehdari et al.,[30] based on the construct of Commitment to plan of action (commitment to planning for breakfast eating) with $\mu1=17.80$, $\sigma1=3.88$, $\mu2=19.98$, $\sigma2=3.53$, $\alpha=0.05$, $\beta=0.10$, $1-\beta=0.90$, $Z_{1-\alpha/2}=1.96$, the required number of samples was equal to 62. However, due to the high possibility of dropping samples, approximately 10% attrition rate was considered, so the

minimum required sample in each group was estimated 68 participants. The formula used was as follows:

$$n = \frac{\left[\left(z_{1-\frac{\alpha}{2}} + z_{1-\beta}\right)^2\right] \times (\sigma_1^2 + \sigma_2^2)}{(\mu_1 - \mu_2)^2}$$

The participants were first recruited using the convenience sampling method and then assigned into two intervention and control groups by the randomized block allocation method. Considering 136 participants as the total sample size for two groups, 22 blocks of 6 and one block of 4 participants with different arrangements were created with two letters, A and B. Letter A was assigned to the control group and letter B to the intervention group. Then, the participants were placed in these arrangements in order of their entry into the study. Randomization continued until 68 participants were placed in each group (Figure 1).

The present study was conducted in two stages. In the first stage, since no existing instrument met the study objectives, the research team developed and validated a new instrument based on the constructs of Pender's model; the researchers made an inventory for needs assessment of the participants. The constructs of Pender's model were discussed with 14 participants utilizing the focus group method (3 sessions of 90 minutes) under the supervision of the researcher (the first author). At that point, the interviews were transcribed, and the meaning associated with each construct was extracted using the qualitative

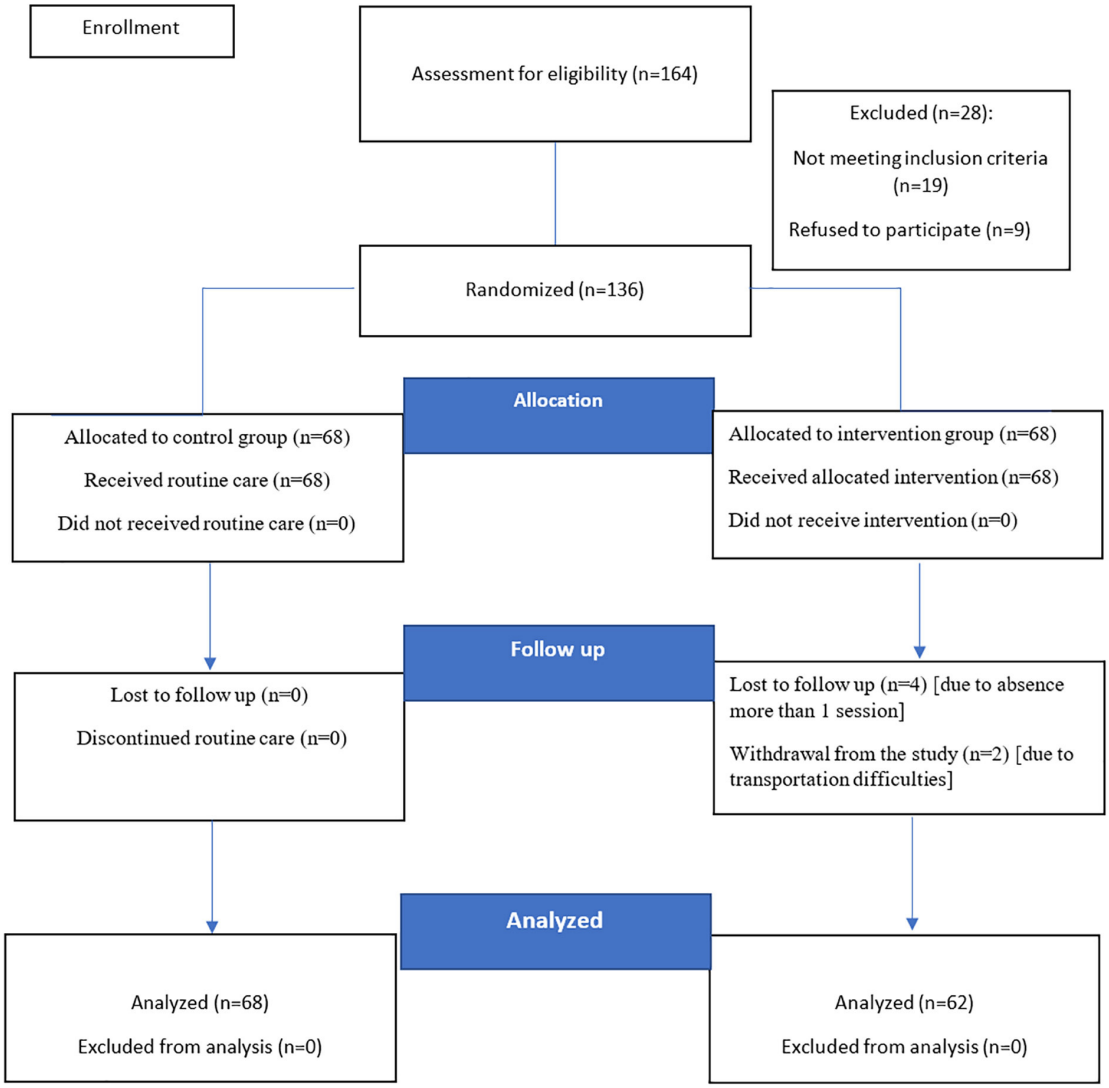


Figure 1: Consort diagram of participants

content analysis method. Moreover, by using textbooks and the extracted needs, a needs assessment inventory based on Pender's health promotion model was designed to evaluate and analyze the nutritional behaviors of first-degree relatives of patients with colorectal cancer. The needs assessment inventory was also discussed and evaluated in two sessions by a panel including a nutritionist, a health education expert, a community health nurse, and an oncologist. Afterwards, the inventory was validated and confirmed.

This inventory had 70 items, including 3 parts. The first part included personal or demographic factors (1-16 items) such as age, weight, height, body mass index (BMI), sex, occupation, education, marital status, ethnicity, first-degree relatives, cancer family history, cancer site, diagnostic tests, smoking hookah, smoking cigarettes, and physical activity.

The second part of the inventory consisted of the Construct of Nutritional Behaviors (Health- promoting behavior) as the behavioral outcome that measured the primary outcome of the study. The nutritional behavior construct consisted of 12 items (items 17–28). For items 17–23, responses were scored on a 5-point scale from 0 (no consumption) to 4 (the best consumption). Items 24–25 were scored from 0 to 2 according to the healthiness of the selected option. Items 26-28 were scored dichotomously (0/1(. Thus, the total score ranged from 0 to 35, with higher scores indicating more favorable nutritional behavior.

The third part of the inventory evaluated behavior-specific cognitions and affect, which served as the secondary outcomes of the study, comprising 42 items (items 29–70). Items 29 to 66 were scored on a five-point Likert scale, with the scoring direction determined by the nature of each construct. Specifically, items assessing perceived benefits (4 items, 29–32; score: 4–20), perceived self-efficacy (4 items, 42–45; score: 4–20), positive activity-related affect (4 items, 50–53; score: 4–20), and commitment to a plan of action (4 items, 63–66; score: 4–20) were scored directly (strongly agree=4 to strongly disagree=0). In contrast, reverse scoring (strongly agree=1 to strongly disagree=5) was applied to constructs of perceived barriers (9 items, 33–41; score: 9–45), negative activity-related affect (4 items, 46–49; score: 4–20), situational influences (5 items, 54–58; score: 5–25), and immediate competing demands and preferences (4 items, 59–62; score: 4–20). Additionally, interpersonal influences were measured using four dichotomous items (items 67–70; yes=1, no=0; score: 0–4). Consequently, across all constructs, higher scores reflect a more favorable status.

The validity of the questionnaire was examined using face and content validity. For face validity, the questionnaire was given to 14 first-degree relatives of patients with colorectal cancer. Afterwards, the participants were interviewed face-to-face regarding the level of difficulty, appropriateness, and ambiguity of all the items. Based on the opinions and suggestions of the participants, the questionnaire was revised.

The content validity is ensured through a Content Validity Index (CVI) and Content Validity Ratio (CVR). For this purpose, the researcher prepared a table containing the questionnaire items based on the CVR and CVI indices and sent it via email to ten faculty members including, four experts in health education, three in community health nursing, and three in nutritional sciences**.** Therefore, the opinions of them were used to evaluate the content validity of the inventory, and then the items were modified based on their feedback.

To determine the CVR, we asked ten faculty members to rate each item on the questionnaire, and Lavoshi's CVR table based on 10 people, a value of 0.62 and above was acceptable.[31] In this questionnaire, the CVR value of all questions was between 0.66 and 1, so all questions of the inventory were confirmed. In this study, CVI was 0.94. Therefore, the validity of inventory was confirmed.

Additionally, the reliability coefficient

of the questionnaire was obtained using Cronbach's alpha test. Moreover, test-retest reliability was assessed, and Spearman's correlation coefficient ranged from 0.73 to 0.98 for all the constructs of Pender's HPM including nutritional behavior: 0.80, perceived benefits: 0.73, perceived barriers: 0.90, perceived self-efficacy: 0.97, affect related to behavior: 0.89, situational influences: 0.98, commitment to behavior: 0.88, competitive demand and preferences: 0.85, and interpersonal influences: 0.85. Therefore, reliability of the inventory was confirmed.

In the second stage of the study, according to the needs assessment in the first stage, educational goals and interventions for each construct were determined based on Pender's HPM.[15] Educational interventions such as group discussion, problem-solving methods, role play, educational videos, and presentation of lectures along with the presentation of educational pamphlets were designed to change the participants' behavior. Moreover, some educational videos were provided by WhatsApp. The instructional content was selected based on textbooks,[32-35] valid references, the participants' interests, as well as its relevance to daily real-world concerns. This content was approved by 2 oncologists and 2 nutritionists.

The intervention group participants were divided into five groups (each group including 13-14 participants), and each group received four two-hour sessions, one session per week for 4 weeks face to face including lecture with PowerPoint, group discussion, question and answer, and virtual sources such as demonstration of video by WhatsApp, as shown in Table 1. A community health nurse (first author) carried out the interventions under the supervision of some faculty members including a community health nursing, a health education specialist, a nutritionist, and an oncologist according to educational content based on Pender's HPM (Table 1). The control group received only the routine education which was provided by the healthcare personnel. The inventory was filled out by all participants in two groups before intervention (week 0) and 12 weeks after the end of 4 weeks of the research interventions (week 16). Blinding in the present study was not possible for participants and researchers; however, statistician was blinded to thethe nature of groups.

The primary outcome variable was nutritional behaviors in first-degree relatives of patients with colorectal cancer. The secondary outcome was to determine the other constructs of Pender's HPM including perceived benefits of action, perceived barriers to action, negative activity-related affect, positive activity-related affect, situational influences, Immediate competing demands and preferences, perceived self-efficacy, commitment to a plan of action, and perceived interpersonal influences.

Data were analyzed using SPSS software,

Table 1: Educational content of the intervention based on Pender's health promotion model for promoting colorectal preventive nutrition in first-degree relatives of patients with colorectal cancer

Session	Subjects	Educational methods
1	The nature of the disease, pathophysiology, etiology or risk factors and clinical manifestations, and prevention of the colorectal cancer.	Lecture with PowerPoint, group discussion, video by WhatsApp
2	The participants' interests and their positive and negative affection, situational influences, immediate competing demands and preferences, the benefits of and barriers to eating healthy diet for prevention of colorectal cancer such as life style especially nutritional behaviors.	Lecture with PowerPoint, group discussions
3	Giving the information about healthy nutrition and its benefits, discussion about ways using healthy nutritional for increasing self-efficacy	Lecture with PowerPoint, problem solving, role play, video by WhatsApp
4	Review all sessions and process evaluation	Question and answer, group discussion, pamphlets, video by WhatsApp

version 19.0 (IBM, USA). The Chi-square test was used to compare the qualitative data between the groups. To compare the variables between the groups, the independent sample t-test was used; paired t-tests were used for intra-group comparisons and ANCOVA for controlling the effect of significant difference between groups before the intervention. Pearson's correlation test was used for determining the correlation of preventive nutritional behavior with other constructs of Pender's model among the participants. P<0.05 was considered statistically significant.

The study was conducted following the Declaration of Helsinki and approved by the Ethics Committee of Yasuj University of Medical Sciences (Ethical code: IR.SUMS.REC.1394.141). The participants were informed about the goals of the research and written informed consent was obtained from them. In addition, they were assured that their personal information would remain confidential and not be disclosed. Withdrawal from the study at any stagewas preserved for all participants without any penalties or effects on the treatment process of their patients. At the end of the study, educational booklets and pamphlets were given to the participants in the control group. No expenses were imposed on the participants.

Results

The present study included 68 participants in the intervention group and 68 in the control group. At the end of the study, 62 participants remained in the intervention group and 68 in the control group. Dropout in the intervention group was due to absence more than 1 session (4 person), and withdrawal from the study (2 person) due to transportation difficulties (Figure 1).

In the present study, the percentages of families with colorectal cancer patients included 45(33.1%) fathers, 41(30.1%) mothers, 26(19.1%) sisters, 21(15.4%) brothers, and only 3(2.2%) of the children. The mean age of the participants in the intervention group (40.58±11.91) was significantly higher than the control group (35.97±8.80) (P=0.006). Moreover, there was a statistically significant difference in occupation between the two groups (P=0.046). However, using analysis of covariance (ANCOVA) for age, cancer family history, and occupation indicated that three of them were not confounding variables. There were no statistically significant differences in other basic characteristics between the two groups (P>0.05) (Table 2).

There was no statistically significant difference between the mean score of the control and intervention groups in the construct of nutritional behavior before the intervention (P=0.685). Nonetheless, a statistically significant improvement was observed in the mean score of this construct in the intervention group compared to the control group after the intervention (P=0.001). The within-group comparison revealed that the mean score of nutritional behavior in the intervention group increased after the intervention compared to before (P=0.001). However, no significant difference in the mean score of nutritional behavior was observed in the control group after the intervention compared to before (P=0.788) (Table 3).

Before the intervention, except for the construct of negative affect (P=0.003), no statistically significant difference was observed in the mean score of other constructs of Pender's model (P>0.05). After the intervention, there was a significant improvement in the intervention group compared to the control group in the mean score of the constructs of Pender's model including perceived benefits of action (P=0.001), perceived barriers to action (P=0.001), negative affection related to the behavior (P=0.001), situational influences (P=0.001), competitive demand and preferences (P=0.001), perceived self-efficacy (P=0.001), commitment to behavior (P=0.001), and interpersonal influences (P=0.001). Although the positive affect improved in the intervention group after the intervention compared to the control group, this difference was not statistically significant (P=0.453) (Table 3).

The within-group comparison showed that

Table 2: Comparing the individual factors between intervention and control groups

Variables	Intervention (N=68) Mean±SD	Control (N=68) Mean±SD	P value
Age	40.58±11.91	35.97±8.80	0.006*
Weight	69.76±11.39	68.35±11.58	0.938*
BMI[a]	25.30±3.29	24.58±3.97	0.115*
	N (%)	N (%)	
Sex			
Female	36 (52.94)	39 (57.35)	0.605**
Male	32 (47.06)	29 (42.65)	
Occupation			
Employee	18 (26.47)	32 (47.06)	0.046**
Manual worker	6 (8.82)	6 (8.83)	
Student	6 (8.82)	10 (14.71)	
Uunemployed	17 (25.00)	8 (11.76)	
Tradesman	9 (13.24)	8 (11.76)	
Other	12 (17.65)	4 (5.88)	
Education			
Elementary	4 (5.96)	2 (2.94)	0.321**
Middle school	5 (7.46)	6 (8.82)	
High school	30 (44.79)	22 (32.35)	
University Degree	28 (41.79)	38 (55.89)	
Marital status			
Single	17 (25)	24 (35.29)	0.417**
Married	47 (69.12)	41 (60.30)	
Divorced	4 (5.88)	3 (4.41)	
Ethnicity			
Fars	62 (91.18)	60 (88.24)	0.480**
Other	6 (8.82)	8 (11.76)	
First Degree Relatives			
Father	27 (39.70)	18 (26.47)	0.790**
Mother	23 (33.82)	18 (26.47)	
Sister	11 (16.19)	15 (22.06)	
Brother	7 (10.29)	14 (20.59)	
Children	0 (0)	3 (4.41)	
Cancer Family History			
Yes	32 (47.05)	20 (29.42)	0.011**
No	36 (49.25)	48 (70.58)	
Cancer Site in family			
Breast	7 (21.88)	4 (20.00)	0.09**
Stomach	11 (34.37)	5 (25.00)	
Lung	4 (12.50)	2 (10.00)	
Blood	4 (12.50)	5 (25.00)	
Other	6 (18.75)	4 (20.00)	
Diagnostic tests			
Stool OB	8 (11.76)	7 (10.30)	0.132**
Colonoscopy	9 (13.24)	4 (5.88)	
None	51 (75.00)	57 (83.82)	
Smoking hookah			
Yes	5 (7.35)	7 (10.29)	0.545**
No	63 (92.65)	61 (89.71)	
Smoking cigarette			
Yes	6 (8.82)	11 (16.18)	0.195**
No	62 (91.18)	57 (83.82)	
Physical Activity			
Walking 30minute	20 (29.41)	23 (33.83)	0.474**
Other Exercise	8 (11.77)	5 (7.35)	
None	40 (58.82)	40 (58.82)	

*Independent t-test; **Chi-square test; [a]BMI: Body mass index

Table 3: Within- and between-group comparison of preventive nutritional behaviors from colorectal cancer and other constructs based on Pender's health promotion model

Variable	Time	Control (Mean±SD)	Intervention (Mean±SD)	95% CI		P value*
				Lower	Upper	
Nutritional behavior	Before	18.95±6.61	18.77±6.22	-2.47	2.12	0.685
	After	18.82±5.54	29.66±2.95	9.29	12.36	0.001
P value**		0.788	0.001			
Perceived benefits	Before	15.30±2.50	15.22±2.86	-1.00	0.82	0.849
	After	15.30±2.14	18.16±1.57	2.20	3.50	0.001
P value**		0.763	0.001			
Perceived barriers	Before	22.09±5.35	23.13±5.36	-0.71	2.92	0.232
	After	21.88±4.96	26.60±5.03	2.97	6.46	0.001
P value**		0.819	0.001			
Negative activity-related affect	Before	11.91±2.66	13.52±3.52	0.55	2.67	0.003
	After	12.22±2.56	15.76±2.27	2.69	4.38	0.001
P value***		0.07	0.001			
Positive activity-related affect	Before	15.27±2.20	15.41±2.63	-0.69	0.95	0.751
	After	15.53±2.05	15.83±2.20	-0.45	1.06	0.453
P value**		0.443	0.001			
Situational influences	Before	11.26±2.83	12.07±3.76	-0.32	1.93	0.160
	After	11.24±2.62	15.16±2.20	3.08	4.75	0.001
P value**		0.459	0.001			
Immediate competing demands and preferences	Before	13.91±3.43	14.48±4.31	-0.74	1.89	0.393
	After	14.70±7.61	18.14±3.13	1.44	5.42	0.001
P value**		0.207	0.001			
Perceived self-efficacy	Before	16.15±2.15	16.84±2.31	-0.66	1.803.67	0.426
	After	15.15±2.12	18.14±3.13	3.67	5.55	0.001
P value**		0.050	0.001			
Commitment to plan of action	Before	14.56±2.94	14.85±3.56	-0.82	1.38	0.619
	After	15.53±1.76	18.19±1.65	2.04	3.25	0.001
P value**		0.001	0.001			
Interpersonal influences	Before	1.76±1.25	2.09±1.52	-0.15	0.80	0.192
	After	2.05±1.24	3.94±0.38	1.57	2.21	0.001
P value**		0.001	0.001			

*Independent t-test; **Pair t-test; *** ANCOVA

Table 4: Correlation between preventive nutritional behavior for colorectal cancer and the other constructs of Pender's health promotion model in all participants in pre-intervention

Variable	Correlation coefficient	P value*
Perceived benefits	0.41	0.001
Perceived barriers	0.45	0.001
Perceived self-efficacy	0.66	0.001
Negative affection	0.26	0.042
Positive affection	0.38	0.003
Situational influences	0.48	0.001
Interpersonal influences	0.31	0.001
Competitive demand and preferences	0.49	0.001
Commitment to behavior	0.29	0.024

*Pearson's correlation test. Perceived barriers, negative activity-related affect, situational influences, and competing demands were reverse-scored; therefore, higher scores indicate a more favorable status (i.e., fewer obstacles and negative influences). Thus, positive correlation coefficients reflect a negative association between these barriers and dietary behavior

the mean scores of Pender's model constructs, including perceived benefits, perceived barriers, negative and positive affects related to behavior, situational influences, competitive demand and preferences, perceived self-efficacy, commitment to behavior, and interpersonal influences, in the intervention group indicated a statistically significant improvement after the intervention (P=0.001). In the control group, the mean scores of most Pender's model constructs did not show significant differences from baseline to post-intervention (P>0.05); however, significant within-group improvements were observed in two constructs: 'Commitment to a plan of action' and 'Interpersonal influences' (P=0.001) (Table 3).

Before the intervention, Pearson's correlation analysis revealed that colorectal cancer preventive nutritional behavior in first-degree relatives was significantly associated with all constructs of Pender Health Promotion Model. Among these, perceived self-efficacy demonstrated the strongest positive correlation with nutritional behavior (r=0.66, P<0.001) (Table 4).

Discussion

The findings of the present study showed that an educational intervention based on Pender's HPM significantly improved nutritional behavior, as the primary outcome, among first-degree relatives of patients with colorectal cancer. Most constructs of the model, including perceived benefits of action, perceived barriers to action, perceived self-efficacy, interpersonal and situational influences, commitment to a plan of action, immediate competing demands and preferences, and negative activity-related affect also improved after the intervention; however, positive activity-related affect did not change significantly.

In the present study, nutritional behavior, as the primary outcome, improved significantly after the HPM-based intervention. Given the study context, this improvement may reflect greater adherence to dietary practices relevant to colorectal cancer prevention and may be interpreted as the behavioral expression of concurrent changes in several HPM constructs, including perceived self-efficacy, perceived benefits of action, interpersonal and situational influences, perceived barriers to action, and negative activity-related affect. Rather than operating through a single pathway, the intervention likely influenced nutritional behavior by addressing both motivational and contextual determinants of dietary change. This interpretation is consistent with previous HPM-based studies reporting improvements in nutritional or related health-promoting behaviors.[15, 23, 36-39] However, differences across studies in target populations, intervention content, follow-up duration, and outcome measures suggest that the effectiveness of HPM-based interventions is context-dependent. In the present study, first-degree relatives of patients with colorectal cancer may have been particularly responsive because perceived familial risk and concern about cancer could have increased the personal relevance of dietary recommendations. Nevertheless, because mediating pathways were not directly tested, this explanation should be interpreted cautiously.

The HPM-based intervention significantly increased perceived benefits of action, a construct that showed a baseline association with colorectal cancer–preventive nutritional behavior. This finding is theoretically plausible because, in Pender's model, perceived benefits provide motivational value for initiating and sustaining health-promoting behaviors. Rather than merely increasing knowledge, the intervention may have strengthened this construct by linking specific dietary changes—such as increasing fruits, vegetables, and whole grains and reducing dietary fat—to personally meaningful cancer-preventive benefits. This mechanism is consistent with previous HPM-based evidence showing associations between perceived benefits and healthier dietary or other health-promoting behaviors.[23, 36-39] However, the effect of this construct may

depend on whether benefits are presented as concrete, relevant, and achievable outcomes rather than general health messages.

In the present study, the mean score of the perceived barriers to action construct increased following the intervention; given the reverse scoring of the construct, it demonstrated a negative correlation with nutritional behavior before the intervention. Although some theory-based interventions have reported similar reductions in dietary barriers,[36, 38] others improved nutritional behaviors without changing perceived barriers.[37, 40] These differences may be related to variation in intervention approaches and the extent to which the targeted barriers were amenable to change. The barriers, including food cost, limited time for vegetable preparation, concerns about legume-related bloating, and preference for fatty foods, were addressed through education, group discussions, videos, and affordable dietary alternatives. Discussing perceived benefits and barriers and strengthening self-efficacy may also have supported the improvement in reduction of these barriers.

In the present study, negative activity-related affect improved significantly after the intervention, whereas positive activity-related affect did not. At baseline, both constructs were associated with colorectal cancer–preventive nutritional behaviors. This pattern suggests that the intervention may have been more effective in reducing aversive responses than in creating positive emotional experiences. For example, group discussions and cooking modifications addressed common dislikes, such as the odor of fish or reluctance toward legumes and vegetables, and may have reduced emotional resistance to these foods. However, developing enjoyment, satisfaction, or pleasure in cancer-preventive eating may require repeated exposure, habit formation, and culturally acceptable recipes beyond the duration of the intervention. This may explain why simpler behaviors, such as breakfast consumption, showed improvement in both positive and negative affect in a previous study,[39] whereas broader dietary change in the present study produced only partial affective change. Consistent with prior evidence,[41] these findings suggest that reducing negative affect may be an early mechanism of dietary change, while enhancing positive affect may require longer follow-up and more enjoyment-oriented strategies.

In the present study, situational influences were associated with colorectal cancer preventive dietary behaviors at baseline and improved significantly after the intervention. In Pender's HPM, this construct reflects how environmental and contextual cues can facilitate or hinder health-promoting behavior. The improvement may be explained by the intervention's emphasis on recognizing high-risk eating situations, such as restaurants and social gatherings, and replacing unhealthy options with feasible alternatives. Group discussion and peer modeling may also have helped the participants reinterpret these situations as manageable contexts rather than unavoidable barriers. Although this finding is consistent with some HPM-based studies,[23, 36] other interventions did not improve situational influences.[20, 37] This inconsistency suggests that situational influences may be responsive only when interventions directly address the environments in which the behavior occurs. Among first-degree relatives of patients with colorectal cancer, perceived familial risk may have further increased motivation to modify food choices across everyday settings.

In the present study, competing demands and preferences were associated with colorectal cancer–preventive nutritional behaviors, and its mean score improved significantly after the intervention. Within Pender's HPM, this construct reflects the extent to which immediate alternatives interfere with planned health-promoting actions. The observed improvement may be explained by the intervention's focus on helping participants overcome and manage unhealthy competing preferences, specifically by encouraging them to choose healthier alternatives rather than red meat, fatty foods, and high-fat

sauces. By combining risk-related nutritional information with practical substitution strategies, the intervention might have helped the participants reframe healthy eating not as a restriction but as a feasible choice within everyday food situations. Consistent with previous HPM-based studies,[20] this suggests that competing preferences are more likely to change when education addresses both the cognitive understanding of risk and the practical management of tempting or habitual food choices.

In the present study, perceived self-efficacy improved significantly after the intervention and showed a baseline correlation with colorectal cancer–preventive nutritional behaviors among all HPM constructs. This finding is theoretically important as self-efficacy in Pender's HPM reflects individuals' confidence in their ability to initiate and maintain health-promoting behaviors. The intervention might have enhanced this construct by using interactive strategies such as group discussion, role-playing, experience sharing, and social encouragement, which provided the participants with opportunities to practice decision-making, observe successful behavioral examples, and receive reinforcement. Although previous HPM-based interventions have generally reported improvements in self-efficacy,[21, 23, 28, 37] some studies found dietary improvement without a significant change in this construct.[15, 38] Such inconsistency suggests that self-efficacy may be more responsive when interventions go beyond information delivery and include confidence-building techniques. However, the absence of an immediate increase in positive activity-related affect indicates that confidence in performing preventive nutritional behaviors may develop earlier than positive emotional experiences associated with those behaviors.

In the present study, Commitment to a Plan of Action improved following the HPM-based intervention and showed a significant, positive baseline correlation with colorectal cancer preventive nutritional behavior. Our finding was consistent with previous studies,[20, 27, 29] although differences in participants, intervention duration, and follow-up periods should be considered. In contrast, an HPM-based intervention among women with overweight and obesity did not improve Commitment to a Plan of Action.[15] This discrepancy may partly reflect differences in perceived health risk: first-degree relatives of patients with colorectal cancer may have been more receptive to information and more attentive to translating it into dietary action than individuals with overweight or obesity. This improvement may be related to the intervention's emphasis on concerns about colorectal cancer and weight gain and the benefits of fruit and vegetable consumption.

At baseline, interpersonal influences were correlated with colorectal cancer–preventive nutritional behaviors and improved significantly following the intervention. This improvement may be attributed to the explicit targeting of social influences within the intervention through discussion of family and peer roles in food choices, involvement of significant others in action planning, peer modeling, and repeated reinforcement. From the perspective of Pender's HPM, these strategies may strengthen social support and interpersonal norms, thereby facilitating healthier choices within shared meals and family food routines. This mechanism may be particularly relevant to first-degree relatives of patients with colorectal cancer, for whom preventive nutrition may be perceived as a shared family concern. Although the finding is broadly consistent with previous evidence linking interpersonal support to health-promoting behaviors,[15, 23, 36, 42] other HPM-based interventions found no significant improvement in this construct.[20, 37, 38] This inconsistency suggests that interpersonal influences may change only when social support is directly activated and may also depend on family engagement, perceived familial risk, cultural food practices, and intervention delivery. However, as these mechanisms were not directly assessed, this interpretation should be considered tentative.

Although the control group did not receive any structured educational intervention, a significant within-group improvement was observed in Commitment to a plan of action and Interpersonal influences. This finding can be justified by several reasonable mechanisms. First, witnessing the patient's illness, combined with professional medical advice on preventing recurrence, likely increased the perceived vulnerability and risk awareness among first-degree relatives. This awareness likely strengthened their commitment to preventive measures. Second, the diagnosis of colorectal cancer in a family member naturally creates a shared familial crisis that stimulates intra-family communication and mutual support, consequently enhancing interpersonal influences. Finally, this change may simply be a testing effect, where the initial survey acted as a reminder for participants to think about their health and independently research cancer prevention strategies during the study.

The main strength of the present study was the participants' active participation in group discussions and interventions. One of the limitations of the present study was the short follow-up period. Dropout of six participants in the intervention group may decrease external validity. Although all HPM constructs were significantly associated with colorectal cancer–preventive nutritional behaviors, their independent predictive effects were not examined. Future studies should use multivariable analyses to identify the most influential predictors.

Conclusion

In the present study, colorectal cancer preventive nutritional behaviors improved in the first-degree relatives of patients with colorectal cancer after the intervention based on the Pender's HPM. These findings suggest that the intervention might have facilitated dietary change by targeting multiple motivational, affective, interpersonal, and contextual determinants emphasized in the model. It is recommended that healthcare professionals should pay attention to all these constructs of Pender's HPM in educational and psychological interventions for relatives of patients with colorectal cancer. It is suggested to design and implement virtual educational interventions in prospective studies, and it is also recommended that the participants' follow-up time should extend to six months.

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Authors' Contribution

N.K., N.H. and H.ZH. were responsible for the study conception and design. N.K. developed educational intervention and conducted the trial. M.H. contributed to participant recruitment, clinical coordination, and data collection. JM.M. performed the statistical analyses and data management. N.K. and JM.M. contributed to the operationalization of the theoretical framework and tool validation. H.ZH. and M.H. authored the initial draft of the manuscript. N.H. supervised the project and critically revised the manuscript for important intellectual content. All authors reviewed and approved the final manuscript; they accept responsibility for its content and integrity. The corresponding author affirms that all individuals listed fulfill the authorship criteria and that no eligible contributors have been omitted.

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Conflict of Interest

None declared.

Declaration on the use of AI

The authors used an AI-assisted language tool (GapGPT 5.6) solely to improve language, clarity, conciseness, and organization of selected sections of the manuscript. All conceptual content, study design, data analysis, interpretation, and final revision were conducted solely by the authors.

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