Research Square

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Effect of mobile health application-based training on chemotherapy side effects and quality of life in colorectal cancer patients: a randomized controlled trial

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Abstract

Purpose Mobile health applications offer a transformative approach to colorectal cancer care by integrating proactive patient self-management with continuous, home-based nursing support. This study investigates the impact of education delivered through mobile health applications on chemotherapy side effects and the quality of life of colorectal cancer patients.

Methods This randomized controlled trial utilized a pretest-post-test experimental design. The study included 70 colorectal cancer outpatients (35 per group) receiving chemotherapy at a training and research hospital. Data were collected using a Patient Information Form, the Functional Assessment of Cancer Therapy-Colorectal *(FACT-C)* scale, the Nightingale Symptom Assessment *(N-SAS*) Scale, a Self-Care Needs Assessment Form, and a Mobile Health Application Training Evaluation Form.

Results No statistically significant differences were found between the groups regarding baseline socio-demographic characteristics. Post-test scores indicated that the intervention group experienced better quality of life and symptom management as measured by the FACT-C and N-SAS compared to the control group. Additionally, the mean post-test score of the Self-Care Needs Assessment Form showed an increase from the mean pre-test score.

Conclusions These findings indicate that education provided through mobile health applications positively affects the quality of life for colorectal cancer patients. We recommend assessing educational needs regarding chemotherapy side effects, which could inform the development of targeted educational interventions using mobile health applications.

Clinical Trial Registration ClinicalTrials.gov, NCT05940740, Registered on July 12, 2023.

Introduction

Colorectal cancer is the third most common cancer globally, following lung and breast cancers, characterized by high incidence and mortality rates [1]. The American Cancer Society reports an incidence rate of 8% and a mortality rate of 9% among all cancers [2]. In Turkey, 34,207 new colorectal cancer cases were diagnosed in 2025, representing a 9.1% incidence among all cancer cases [3].

Both environmental and genetic factors significantly contribute to the development of colorectal cancer [4]. Increased risk factors include a sedentary lifestyle, chronic alcohol and tobacco use, high consumption of red or processed meat, inadequate calcium intake, low fruit and vegetable consumption, and rising obesity rates [5]. Genetic predispositions include a family history of colorectal cancer, genetic syndromes (like Lynch syndrome), chronic inflammatory bowel diseases (such as ulcerative colitis or Crohn's disease), and diabetes mellitus. Regular use of non-steroidal anti-inflammatory drugs (NSAIDs), such as aspirin, may lower the risk of colorectal cancer, but these medications can also have serious side effects, including gastrointestinal bleeding [2, 6].

Chemotherapy is a key treatment for colorectal cancer but often leads to numerous side effects [7]. Major barriers to managing chemotherapy-related side effects include inadequate symptom assessment and insufficient ongoing patient education [8]. Technological advancements can be leveraged to improve

symptom management and patient education with mobile health applications proving particularly effective in this regard [9, 10].

Research on symptom monitoring through mobile health applications is growing, focusing on various cancer diagnoses and treatments. Putranto and Rochmawati [7] highlight the importance of mobile health applications in enhancing cancer patient education and symptom reporting. These applications can empower patients and their families to manage symptoms effectively and support palliative care through evidence-based resources such as modules, videos, avatars, and culturally integrated features [7]. Santin et al. [11] found mobile health applications effective in managing cancer treatment symptoms and reducing their incidence [11].

Advancements in communication technology have made health information more accessible through mobile platforms compared to traditional printed materials [12]. Today, cancer screening programs reach wider communities via mobile health applications, like e-nabız in Turkey. Various modules within these applications are increasingly used for diverse health purposes [9]. More communication technology tools are necessary to enhance public awareness and provide access to reliable health education information [12].

Comprehensive symptom assessment is crucial for effective symptom control and improved quality of life. Mobile health applications allow patients to report symptoms from home, eliminating the need for hospital visits [7, 9]. These tools promote efficient data recording, save time, and reduce hospitalizations [12]. This study aimed to evaluate the effectiveness of a mobile health application based on self-care deficit theory in assisting colorectal cancer patients with managing chemotherapy-related symptoms.

Research objectives

This study explored how colorectal cancer patients' quality of life changed after receiving education about chemotherapy side effects through a mobile health application.

Hypotheses

1. Education delivered via a mobile health application based on self-care theory improves the quality of life in colorectal cancer patients.
2. Education delivered via a mobile health application based on self-care theory alleviates chemotherapy side effects in colorectal cancer patients.
3. Training using a mobile health application based on self-care theory increases self-care behaviours in colorectal cancer patients.

Methods

Design

This study employed a randomized controlled trial design with a pre-test/post-test format. To avoid selection bias, the intervention and control groups were formed using a simple random sampling method.

Setting

On average, between 80 and 100 colorectal cancer patients were admitted to the outpatient clinic for chemotherapy each month in 2022.

Population and sample

The study sample consisted of patients diagnosed with colorectal cancer who received chemotherapy in the internal medicine medical oncology outpatient clinic of a training and research hospital from March 2023 to April 2024, meeting the inclusion criteria.

Sample size calculation

The sample size was determined based on previous studies and the standard effect size accepted in the field. Power analysis indicated that a minimum of 35 participants per group was required to achieve a statistical power of 90% (1-β) = 0.90.

Randomization

Seventy patients meeting the inclusion criteria were randomly assigned to either the intervention group (n = 35) or the control group (n = 35) at a 1:1 allocation ratio. Randomization was performed using a computer-generated random number list via Research Randomizer (www.randomizer.org). This ensured that every participant had an equal chance of being assigned to either group, preventing selection bias. The allocation flow is detailed in Fig. 1.

Due to the nature of the intervention involving a mobile application and educational training, it was not possible to blind the participants and the researcher providing the training. However, to minimize detection bias, the data analysis was conducted by a researcher who was blinded to the group assignments.

Data collection tools

The Patient Information Form comprises 19 questions related to individual, disease, and treatment characteristics. The first section *addresses* sociodemographic information, the second covers health history, and the third focuses on the patient's diagnosis and treatment.

The Functional Assessment of Cancer Therapy-Colorectal (FACT-C) (4th version) is a tool designed to evaluate the quality of life in patients with colorectal cancer. Developed by Ward et al. (1999) as part of the Functional Assessment of Chronic Illness Therapy (FACIT) Measurement System in the United States, the FACT-C scale consists of five sub-dimensions: Physical Well-Being, Social/Family Well-Being, Emotional Well-Being, Functional Well-Being, and Additional Concerns [13, 14].

When using the FACT-C scale, individuals respond to statements based on their experiences over the past seven days. Each item is rated on a 5-point Likert-type scale: “not at all” = 0, “very little” = 1, “a little” = 2, “quite a bit” = 3, and “very much” = 4 [14].The Cronbach's alpha internal consistency coefficient for the post-test assessment of this study was 0.89.

The Nightingale Symptom Assessment Scale (N-SAS) was developed by Can and Aydıner (2009) specifically for cancer patients. This scale includes 38 reported side effects, categorized into three sub-dimensions: Physical Well-Being, Social Well-Being, and Psychological Well-Being [15, 16]. The Physical Well-Being sub-dimension includes items 1–4, 6–15, 23–27, and 37; Social Well-Being consists of items 5 and 16–22; and Psychological Well-Being encompasses items 28–36 and 38 [17].

Higher scores on the N-SAS indicate an increased experience of symptoms related to the disease or treatment. Responses are rated as follows: “No” = 0, “Very little” = 1, “A little” = 2, “Quite a bit” = 3, and “Very much” = 4 [15, 17]. The Cronbach's alpha internal consistency coefficient for the post-test assessment in this study was 0.92.

The Self-Care Needs Assessment Form contains 28 statements regarding the self-care needs of patients with colorectal cancer. Created by the researchers based on evidence-based care standards and literature reviews, this form submitted for expert opinion. Patients are asked to respond to the statements by selecting from “Yes,” “Sometimes,” or “No.” The form has undergone expert review, and the Cronbach's alpha internal consistency coefficient for the post-test assessment in this study was 0.92.

The Mobile Health Application Training Evaluation Form was developed by the researchers to assess the impact of training provided through a mobile health application on users. This scale aims to identify changes in participants' self-care skills, determine if their training needs are met, and measure the frequency of application usage, along with overall satisfaction on a scale of 1 to 10.

Procedure

Phase I: application development

The research was conducted in two stages. The initial phase involved designing the mobile health application training and subjecting it to expert evaluation. The development process included planning, analysis, design, implementation, testing and merging, and expert evaluation.

1. *Planning*: Patients with colorectal cancer who used smart devices (cell phones and tablets) were included in the study. The application was designed to be user-friendly, featuring clear language, logos, animations, videos, and audio readings.
2. *Analysis*: The researcher completed a certified software programming training course on the Xamarin platform. MySQL was used to develop the mobile application for Android and iOS operating systems.
3. *Design*: The mobile health application was named Kolorektali-M, and its logo was designed. The content menu and educational modules on managing chemotherapy side effects were organized using clear headings and figures.
4. *Application*: During development, assistance was provided by a computer engineer, with costs covered by the researcher. The Xamarin infrastructure was used in the software development phase, allowing for cross-platform functionality between Android and iOS.
5. *Testing and Consolidation*: Usability, compatibility, interface, service, and installation tests were conducted to verify the functionality of the application on mobile devices.
6. *Expert Evaluation*: Fourteen experts reviewed the application, providing feedback on its usefulness, clarity, aesthetics, inclusion of up-to-date information, colour choices, visuals, font size, and navigation between screens. Their suggestions were incorporated into the final version of the application (Fig. 2).

Phase II: intervention and data collection

Pre-implementation phase: A pilot study was conducted with seven patients using data collection tools and the mobile health application. The data from this pilot were not included in the final study.

Data collection phase: Patients who met the inclusion criteria were identified. Those who agreed to participate were informed about the study through face-to-face interviews during chemotherapy premedication visits. Participants were assigned to either the intervention or control group.

1. Control group

Data were collected from patients in the control group using the Control Group Informed Consent Form, Patient Information Form, FACT-C, N-SAS, and Self-Care Needs Assessment Form. In the control group, post-test data were collected using FACT-C, N-SAS, and Self-Care Needs Assessment Forms after 12 weeks. At the end of the study, the Kolorektali-M application was made available to the control group with ethical consent.

2. Intervention group: implementation of the study

Pre-test (week 1)

Written and verbal consent was obtained from the intervention group using the Intervention Group Informed Consent Form when patients visited the unit for chemotherapy. Data were collected using FACT-C, N-SAS, and Self-Care Needs Assessment Form. Patients were instructed on how to use the Kolorektali-M application installed on their smartphones.

Providing education using the mobile health application (week 1)

The researcher provided training through the Kolorektali-M application installed on a 9.7-inch iOS tablet for better visibility. The intervention group received verbal explanations during sessions lasting approximately 20–30 minutes throughout their chemotherapy course. Questions from patients were addressed and information was repeated as needed. Symptoms affecting the quality of life of the intervention group patients were evaluated at the end of the first cycle using the data collection tools.

Follow-up (week 4 and week 8)

The researcher remotely monitored the intervention group's use of the Kolorektali-M application via the mobile health application usage manager platform. Weekly reminder SMS messages about the application were sent to the intervention group (10 reminders in total).

Throughout the two-week chemotherapy administration period, the intervention group’s questions about the Kolorektali-M training were answered. Symptoms impacting the quality of life of the intervention group patients were assessed at the end of the first and second cycles using data collection tools.

Final test (week 12)

After the training provided through the Kolorektali-M application, data were collected

using FACT-C, N-SAS, and Self-Care Needs Assessment Form. Training effectiveness was evaluated using the Mobile Health Application Training Evaluation Form. The Kolorektali-M application was made actively available for use by the intervention group (Fig. 3).

Ethical issues

Ethics committee approval was obtained from the Health Sciences University Hamidiye Clinical Research Ethics Committee on 13.10.2022 (Decision No: 2022.10.13-34). The study was registered at ClinicalTrials.gov (Registry: ClinicalTrials.gov, Identifier: NCT05940740, Date of Registration: July 12,

2023). During the mobile health application development process, support was received from the software company, with costs covered by the researcher.

Statistical analysis

The data from the study were analysed using the Statistical Package for Social Sciences (SPSS) for Windows version 25.0. Descriptive statistical methods, including number, mean ± standard deviation, median (min–max), and frequency (percentage), were employed to evaluate the data. Before analysis, the data were tested for normal distribution conformity, which was assessed through Q-Q plot analysis. A normal distribution was confirmed when skewness and kurtosis values fell within ± 3. Outliers and extreme observations from all measurement tools were identified and removed from the dataset. The study was conducted using a per-protocol analysis. Patients who did not complete the 12-week follow-up or could not receive the intervention due to technical reasons (e.g., insufficient smartphone memory or health complications) were excluded from the final statistical analysis. The analysis was performed on the data of 70 patients (35 in the intervention group and 35 in the control group) who fully complied with the study protocol.

For comparing quantitative data that followed a normal distribution, an independent t-test was employed to assess differences between two independent groups, while a dependent sample t-test was used for two dependent groups. Differences among more than two dependent measurements were analysed using a repeated measures ANOVA test, with the Bonferroni multiple comparison test applied to identify differences across measurement times.

Results

Demographic data

The mean age of participants in the intervention group was 44.20 ± 13.34 years, with 42.9% being high school graduates and 51.4% single. Socio-demographic characteristics were similar between the intervention and control groups, with no significant differences noted (Table 1).

Table 1
Sociodemographic characteristics of intervention and control groups

Variables	Intervention (n = 35)		Control (n = 35)		Test	p
	n	%	*n*	%		
Age group						
≤ 35 years	10	28.5	8	22.9	0.562 P	0.91
36–45 years	8	22.9	10	28.5		
46–55 years	9	25.7	8	22.9		
56–64 years	8	22.9	9	25.7		
Marital status						
Single	18	51.4	15	42.9	0.516 P	0.47
Married	17	48.6	20	57.1		
Education Status						
Literate	1	2.8	3	8.6	4.869 FE	0.44
Primary education	7	20.0	11	31.4		
Middle school	3	8.6	2	5.7		
High school	15	42.9	15	42.9		
University	7	20.0	2	5.7		
Postgraduate	2	5.7	2	5.7		
Economic situation						
Income is low compared to expenses	17	48.6	18	51.4	0.206 FE	1.00
Balances income and expenses	16	45.7	15	42.9		
Income is more than expenditure	2	5.7	2	5.7		
Cancer Diagnosis						
Colon cancer	23	65.7	25	71.4	0.265 P	0.61
Rectum cancer	12	34.3	10	28.6		
Colorectal cancer stage						

FE Fisher Exact chi-square test, P Pearson chi-square test, t: Independent sample t test, *p < 0.05

Variables	Intervention (n = 35)		Control (n = 35)		Test	p
	n	%	*n*	%		
Stage I	1	2.9	4	11.4	2.141 [P]	0.54
Stage II	6	17.1	5	14.3		
Stage III	9	25.7	7	20.0		
Stage IV	19	54.3	19	54.3		
Status of receiving training in management of chemotherapy side effects						
No, didn't	31	88.6	27	77.1	1.609 [P]	0.21
Yes, did	4	11.4	8	22.9		
	Mean ± SD		*Mean ± SD*		**t-test**	**p**
Average age	44.20 ± 13.34		45.30 ± 11.99		-0.396	0.69

[FE] Fisher Exact chi-square test, [P] Pearson chi-square test, t: Independent sample t test, *p < 0.05

Comparison of intervention FACT-C scale and N-SAS scores

In the intervention group, statistically significant differences were observed among the pre-test, follow-up, and post-test scores of the FACT-C subscales: Physical Well-Being, Social/Family Well-Being, Emotional Well-Being, Functional Well-Being, and Additional Concerns, as well as the total FACT-C scale (p = 0.000, p = 0.001, p = 0.000, p = 0.000, p = 0.000, p = 0.000, respectively) (Table 2). The mean scores for these sub-dimensions, along with the post-test scores of the total FACT-C scale, were higher than those from the pre-test and both follow-ups. Improvements in these mean scores were noted over the three-month period between the pre-test, two follow-ups, and post-test (Table 2).

Table 2
Pre-test, follow-up and post-test evaluations of FACT-C Scale, N-SAS and Self-Care Needs Assessment Form scores in the intervention group

Variables	Intervention (n = 35)				
	Mean ± SD	F value	p	η^2	Post hoc #
Functional Assessment of Cancer Therapy-Colorectal (FACT-C) Scale					
Physical Well-Being					
Pre-test (1st measurement)	11.57 ± 6.54	28.034	**0.000***	0.452	1.2.3 < 4
1st monitoring (2nd measurement)	14.63 ± 5.31				
2nd follow-up (3rd measurement)	13.54 ± 5.82				
Post-test (4th measurement)	18.51 ± 4.82				
Social/Family Well-Being					
Pre-test (1st measurement)	20.86 ± 4.89	8.357	**0.001***	0.197	1.2.3 < 4
1st monitoring (2nd measurement)	21.63 ± 4.25				
2nd follow-up (3rd measurement)	21.46 ± 4.37				
Post-test (4th measurement)	22.89 ± 3.63				
Emotional Well-Being					
Pre-test (1st measurement)	7.60 ± 3.55	30.148	**0.000***	0.470	1.2.3 < 4
1st monitoring (2nd measurement)	10.37 ± 3.07				
2nd follow-up (3rd measurement)	9.69 ± 3.67				
Post-test (4th measurement)	14.00 ± 4.57				
Functional Well-Being					
Pre-test (1st measurement)	10.60 ± 5.50	31.995	**0.000***	0.485	1.2.3 < 4
F: Repeated measures ANOVA test, *p < 0.05, η^2: Eta squared					
# 1: Pretest (1st measurement), 2: 1st follow-up (2nd measurement), 3: 2nd follow-up (3rd measurement), 4: Posttest (4th measurement)					
Pre-test (1st measurement) was performed at 0 months, 1st follow-up (2nd measurement) at 1 month, 2nd follow-up (3rd measurement) at 2 months and post-test (4th measurement) at 3 months.					

Variables	Intervention (n = 35)				
	Mean ± SD	F value	p	η^2	Post hoc #
1st monitoring (2nd measurement)	13.97 ± 5.49				
2nd follow-up (3rd measurement)	12.46 ± 5.83				
Post-test (4th measurement)	17.51 ± 5.39				
Additional Concerns					
Pre-test (1st measurement)	14.66 ± 4.53	21.814	**0.000***	0.391	1.2.3 < 4
1st monitoring (2nd measurement)	16.86 ± 3.72				
2nd follow-up (3rd measurement)	16.66 ± 4.08				
Post-test (4th measurement)	19.63 ± 4.58				
FACT-C total scale					
Pre-test (1st measurement)	65.29 ± 14.81	41.901	**0.000***	0.552	1.2.3 < 4
1st monitoring (2nd measurement)	77.46 ± 14.21				
2nd follow-up (3rd measurement)	73.80 ± 15.52				
Post-test (4th measurement)	92.54 ± 16.48				
Nightingale Symptom Assessment Scale (N-SSS)					
Physical Well-Being					
Pre-test (1st measurement)	1.76 ± 0.79	16.354	**0.000***	0.325	1.2.3 > 4
1st monitoring (2nd measurement)	1.28 ± 0.65				
2nd follow-up (3rd measurement)	1.35 ± 0.70				

F: Repeated measures ANOVA test, *p < 0.05, η^2: Eta squared

1: Pretest (1st measurement), 2: 1st follow-up (2nd measurement), 3: 2nd follow-up (3rd measurement), 4: Posttest (4th measurement)

Pre-test (1st measurement) was performed at 0 months, 1st follow-up (2nd measurement) at 1 month, 2nd follow-up (3rd measurement) at 2 months and post-test (4th measurement) at 3 months.

Variables	Intervention (n = 35)				
	Mean ± SD	F value	p	η^2	Post hoc #
Post-test (4th measurement)	0.93 ± 0.49				
Social Well-Being					
Pre-test (1st measurement)	1.42 ± 0.66	14.410	**0.000***	0.298	1.2.3 > 4
1st monitoring (2nd measurement)	1.00 ± 0.59				
2nd follow-up (3rd measurement)	0.96 ± 0.63				
Post-test (4th measurement)	0.66 ± 0.44				
Psychological Well-Being					
Pre-test (1st measurement)	2.17 ± 0.83	22.976	**0.000***	0.403	1.2.3 > 4
1st monitoring (2nd measurement)	1.69 ± 0.66				
2nd follow-up (3rd measurement)	1.79 ± 0.81				
Post-test (4th measurement)	1.22 ± 0.64				
N-SAS total scale					
Pre-test (1st measurement)	1.77 ± 0.63	24.078	**0.000***	0.415	1.2.3 > 4
1st monitoring (2nd measurement)	1.31 ± 0.53				
2nd follow-up (3rd measurement)	1.37 ± 0.62				
Post-test (4th measurement)	0.94 ± 0.45				
Self-Care Needs Assessment Form					
Pre-test (1st measurement)	52.80 ± 5.61	0.717	0.48	----	----
1st monitoring (2nd measurement)	54.60 ± 8.38				

F: Repeated measures ANOVA test, *p < 0.05, η^2: Eta squared

1: Pretest (1st measurement), 2: 1st follow-up (2nd measurement), 3: 2nd follow-up (3rd measurement), 4: Posttest (4th measurement)

Pre-test (1st measurement) was performed at 0 months, 1st follow-up (2nd measurement) at 1 month, 2nd follow-up (3rd measurement) at 2 months and post-test (4th measurement) at 3 months.

Variables	Intervention (n = 35)				
	Mean ± SD	**F value**	**p**	**η^2**	**Post hoc [#]**
2nd follow-up (3rd measurement)	53.71 ± 10.65				
Post-test (4th measurement)	55.57 ± 11.57				
F: Repeated measures ANOVA test, *p < 0.05, η^2: Eta squared					
[#] 1: Pretest (1st measurement), 2: 1st follow-up (2nd measurement), 3: 2nd follow-up (3rd measurement), 4: Posttest (4th measurement)					
Pre-test (1st measurement) was performed at 0 months, 1st follow-up (2nd measurement) at 1 month, 2nd follow-up (3rd measurement) at 2 months and post-test (4th measurement) at 3 months.					

There was no statistically significant difference in the pre-test, follow-up, and post-test scores of the Self-Care Needs Assessment Form for the intervention group (p > 0.05) (Table 2).

Comparison of FACT-C scale scores

A statistically significant difference was observed between the groups regarding post-test scores for the FACT-C Functional Well-Being sub-dimension (p = 0.014), the Social/Family Well-Being subscale (p = 0.003), and the Emotional State subdimension (p = 0.000). Additionally, a significant difference was noted in the post-test scores of the FACT-C Functional Well-Being subscale (p = 0.001) and the Additional Concerns sub-dimension related to colorectal cancer treatment (p = 0.002). Differences in the post-test scores of the total FACT-C scale also reached statistical significance (p = 0.000) (Table 3).

Table 3
Comparison of pre-test and post-test scores of Functional Assessment of Cancer Therapy-Colorectal (FACT-C) Scale in intervention and control groups

Total scale and its sub-dimensions	**Groups**	**Pre-test**	**Post-test**	***t-test***	**p**
		Mean ± SD	***Mean ± SD***		
Physical Well-Being	**Intervention** (n = 35)	11.57 ± 6.54	14.63 ± 5.31	[a] -3.772	**0.001***
	Control (n = 35)	14.06 ± 6.45	11.03 ± 6.61	[a] 2.851	**0.007***
t-test		-1.601	b2.510		
p		0.11	**0.014***		
Social/Family Well-Being	**Intervention** (n = 35)	20.86 ± 4.89	21.63 ± 4.25	[a] -1.650	0.11
	Control (n = 35)	18.40 ± 6.22	18.14 ± 5.09	[a] 0.282	0.77
t-test		1.837	b3.108		
p		0.07	**0.003***		
Emotional Well-Being	**Intervention** (n = 35)	7.60 ± 3.55	10.37 ± 3.07	[a] -5.795	**0.000***
	Control (n = 35)	9.83 ± 3.98	7.49 ± 3.14	[a] 2.740	**0.010***
t-test		[b] -2.472	b3.890		
p		**0.016***	**0.000***		
Functional Well-Being	**Intervention** (n = 35)	10.60 ± 5.50	13.97 ± 5.49	[a] -4.986	**0.000***
	Control (n = 35)	12.31 ± 5.80	10.06 ± 4.11	[a] 2.307	**0.027***
t-test		**[b]** -1.269	b3.377		
p		0.21	**0.001***		
Additional Concerns	**Intervention** (n = 35)	14.66 ± 4.53	16.86 ± 3.72	[a] -3.208	**0.003***
	Control (n = 35)	14.34 ± 4.47	13.71 ± 4.53	[a] 0.782	0.44

[a] Dependent sample t-test, [b] Independent sample t-test, *p < 0.05

Total scale and its sub-dimensions	Groups	Pre-test	Post-test	*t-test*	p
		Mean ± SD	***Mean ± SD***		
t-test		**b0.292**	b3.170		
p		0.77	**0.002***		
FACT-C total scale	**Intervention** (n = 35)	65.29 ± 14.81	77.46 ± 14.21	to 5.470	**0.000***
	Control (n = 35)	68.94 ± 17.33	60.43 ± 13.08	[a] 2.909	**0.006***
t-test		-0.949	b5.216		
p		0.35	**0.000***		

[a] Dependent sample t-test, [b] Independent sample t-test, *p < 0.05

Comparison of N-SAS scores

Significant differences were found between the groups for post-test scores in the Physical Well-Being (p = 0.000) and Social Well-Being (p = 0.001) subscales, as well as in the Psychological Well-Being sub-dimension (p = 0.000) and the N-SAS total scale (p = 0.000) (Table 4).

Table 4
Comparison of pre-test and post-test scores of the Nightingale Symptom Assessment Scale (N-SAS) in the intervention and control groups

Total scale and its sub-dimensions	**Groups**	**Pre-test**	**Post-test**	**t-test**	**p**
		Mean ± SD	***Mean ± SD***		
Physical Well-Being	**Intervention** (n = 35)	1.76 ± 0.79	1.28 ± 0.65	[a] 6.771	**0.000***
	Control (n = 35)	2.49 ± 0.76	2.69 ± 0.91	[a] 2.146	**0.039***
t-test		[b] -3.992	[b] -4.290		
p		**0.000***	**0.000***		
Social Well-Being	**Intervention** (n = 35)	1.42 ± 0.66	1.00 ± 0.59	[a] 6.045	**0.000***
	Control (n = 35)	2.32 ± 0.88	2.70 ± 0.97	[a] 2.755	**0.009***
t-test		[b] -4.838	[b] -3.665		
p		**0.000***	**0.001***		
Psychological Well-Being	**Intervention** (n = 35)	2.17 ± 0.83	1.69 ± 0.66	[a] 7.880	**0.000***
	Control (n = 35)	2.77 ± 0.85	2.86 ± 0.87	[a] 1.653	0.11
t-test		[b] -2.978	[b] -4.133		
p		**0.004***	**0.000***		
N-SAS total scale	**Intervention** (n = 35)	1.77 ± 0.63	1.31 ± 0.53	[a] 8.233	**0.000***
	Control (n = 35)	2.51 ± 0.70	2.09 ± 0.82	[a] 2.475	**0.018***
t-test		[b] -4.630	[b] -4.701		
p		**0.000***	**0.000***		

[a] Dependent sample t-test, [b] Independent sample t-test, *p < 0.05

Although a significant difference was observed between the groups in the N-SAS pre-test scores ($p < 0.05$), the focus of the analysis was shifted to the mean change within groups and the effect size (η^2) to

accurately evaluate the impact of the mobile application intervention over time.

Responses to the mobile health application training evaluation form

Participants in the intervention group were surveyed regarding the impact of the mobile health application, Kolorektali-M, on their self-care. Overall, 31.4% reported that the application helped them manage their disease and treatment side effects, while 25.7% noted it facilitated their learning during treatment. The average satisfaction score of the intervention group regarding the training on the mobile health application was 8.32 ± 1.09 (indicating a high level of satisfaction) (Table 5).

Table 5
Evaluation of the Mobile Health Application: User Feedback and System Log Data

Mobile Health Application Training Evaluation Form	**Answers**	
	n	**%**
The impact of mobile health application on patients' self-care		
“It helped me cope with the disease and treatment side effects.”	11	31.4
“It helped me learn during the illness and treatment.”	9	25.7
“He corrected my incorrect information about the disease and treatment”	8	22.9
“Thanks to the application, I did not feel alone during the illness process”	7	20.0
Self-Reported Frequency of Use		
Once a day	11	31.4
Two or three times a day	11	31.4
Once every two days	8	22.9
Two or three times a week	5	14.3
Most Frequently Visited Modules (based on clicks)		
Side Effect Management Module	350	42.5
Nutrition Module	210	25.5
General Information Module	155	18.8
Other	108	13.2
	Mean ± SD	
Objective System Log Data (Recorded by App)		
Average Total Logins per Patient (over 12 weeks)	45.2 ± 5.6	
Average Session Duration (minutes)	12.4 ± 3.2	
Average satisfaction with the mobile health application [#]	8.32 ± 1.09	
[#] 0 points → Not satisfied at all, 5 points → Satisfied, 10 points → Very satisfied		

Limitations of the research

The findings of this research are limited to the colorectal cancer patient group included in the sample, and generalizations should not be applied to all patients undergoing treatment for colorectal cancer. Additionally, the mobile health application is available only in Turkish.

Discussion

Recent studies indicate that evidence-based care and practices can promote lifestyle changes and symptom management in patients with colorectal cancer. Previous research demonstrates that nurse-led strategies positively influence quality of life [18–22]. Successfully integrating technology into nursing practices is essential for managing patient care [21]. This study aimed to provide training and support for patients with colorectal cancer through the mobile health application Kolorektali-M, expecting a positive impact on their physical, social, emotional, functional well-being, and overall quality of life.

In a study assessing the effects of mobile health applications and wearable smart wristbands on the quality of life of colorectal cancer patients, Kim et al. (2023) found that the intervention group's overall quality of life score was significantly higher than that of the control group ($p < 0.05$) [23]. Alfayyad et al. (2022) evaluated the effect of education on the health-related quality of life of patients with colorectal cancer receiving chemotherapy treatment and their caregivers [24]. Their study showed that the post-test FACT-C Scale total score of the colorectal cancer intervention group after the education applied to the patient and caregiver was higher than the control group, and a statistically significant difference was found ($p < 0.001$) [24]. Almohammadi et al. (2020) evaluated the effects of chemotherapy side effects on quality of life, and the results showed that the training patients received on side effect management made a statistically significant difference in their quality of life ($p < 0.05$) [25].

Nurses typically develop personalized care plans that address the unique needs of their patients [23]. Mobile health applications created by nurses can enhance this process by providing tailored education and support. This approach can improve the quality of life for patients with cancer during chemotherapy. Our findings confirm the effectiveness of mobile health applications and training in enhancing the quality of life for patients with colorectal cancer. Our results indicate that chemotherapy side effect management training provided via the ‘Kolorektali-M’ mobile application significantly enhances Physical Well-Being, Social/Family Well-Being, Emotional Well-Being, Functional Well-Being, and overall quality of life, thereby supporting hypothesis H1.

In this study, the total post-test score of the N-SAS was lower (indicating a better quality of life) in the intervention group compared to the control group. This finding suggests that the education and support provided to colorectal cancer patients for managing chemotherapy side effects through mobile health applications positively impact their physical, psychological, social well-being, and overall quality of life.

Im et al. (2024) conducted a study on the effects of e-health applications on symptom management in colorectal cancer treatment. They reported that the total scores of the European Organization for Research and Treatment of Cancer Quality of Life Scale were higher in the intervention group after receiving education and support [26]. Similarly, Toni et al. (2024) examined the effects of videoconferencing and telephone interviews on colorectal cancer patients during the COVID-19 pandemic [27]. They found a statistically significant improvement in physical, psychological, and social health subscales, as well as overall quality of life scores three months later, with the intervention group performing better than the control group [27]. These results indicate that digital and remote health

interventions can significantly enhance the overall quality of life for patients with colorectal cancer, aligning with findings from other studies in the literature.

These results indicate that the training provided on managing chemotherapy side effects through the mobile health application, developed based on self-care theory for colorectal cancer patients, positively impacts their ability to manage side effects, supporting hypothesis H2. According to Orem's self-care theory, individuals' capacity to identify and meet their self-care needs is crucial for maintaining health and coping with illness [28, 29]. Although this study did not find a statistically significant difference in post-test responses to the Self-Care Needs Form between pre-test and post-test scores in the intervention group, the mean post-test score did increase compared to the pre-test score. This suggests that education and support provided through mobile health applications may positively influence self-care behaviours in colorectal cancer patients. It is essential to regularly monitor the self-care needs of patients diagnosed with colorectal cancer during treatment, considering their universal, developmental, and disease state needs.

Kim et al. (2023) found that using a mobile health application and a wearable smart bracelet improved the quality of life for colorectal cancer patients, as evidenced by an increase in the Patient Activation Measure score from a mean pre-test of 50.20 ± 6.15 to a post-test score of 54.80 ± 4.90 [23]. They concluded that telemedicine technologies enhance self-care behaviours and, consequently, the quality of life for patients [23]. Additionally, Marzuki et al. (2019) reported that education provided through the mobile health application (ColorApp) raised the mean self-care level score of the intervention group from 51.30 ± 5.20 to 56.75 ± 3.80 [12]. These findings suggest that mobile health applications and wearable smart bracelets can effectively enhance patients' self-care skills and assist in managing chemotherapy side effects.

In our study, although the post-test scores for the Self-Care Needs Assessment Form showed a numerical increase in the intervention group, this change did not reach statistical significance ($p = 0.48$), and thus hypothesis H3 was not supported. However, the high satisfaction score of 8.32 ± 1.09 and the fact that 31.4% of patients reported the application helped them cope with side effects suggest a clinical benefit in patient empowerment. The lack of statistical significance may be attributed to the 12-week study period being insufficient to solidify long-term behavioral changes in self-care. These results imply that the education and support provided to colorectal cancer patients managing chemotherapy side effects through a mobile health application positively influence their quality of life and aid in effective symptom management and self-care.

Marzuki et al. (2019) found that 79.2% of colorectal cancer patients believed the mobile health application (ColorApp) was helpful in managing symptoms and coping with the disease during treatment [12]. Additionally, in a study by Putranto and Rochmawati (2020) examining mobile health applications for symptom management at home, 70.8% of participants reported that the training helped them cope with side effects, and 79.2% felt it reduced feelings of loneliness [7]. These findings support our

conclusion that the Kolorektali-M mobile health application positively impacts the quality of life and self-care skills of colorectal cancer patients.

Conclusion

Unmanaged symptoms related to chemotherapy can adversely affect the quality of life for cancer patients, potentially leading to treatment discontinuation, dose reduction, or termination. Conducting comprehensive symptom evaluations throughout the treatment process and planning interventions based on evidence-based practices are crucial. Training programs and mobile health applications developed by nurses can significantly improve side effect management and enhance the quality of life for patients with colorectal cancer. Our findings indicate that the mobile health application developed according to self-care theory positively influences symptom control related to chemotherapy side effects and improves the quality of life for colorectal cancer patients.

Limitations

This study has several limitations that should be acknowledged. First, the research was conducted at a single center with a specific sample size, which may limit the generalizability of the findings to all colorectal cancer populations. Second, the Kolorektali-M application is currently only available in Turkish, restricting its use in diverse cultural and linguistic settings. Additionally, although the 12-week follow-up period provided significant insights into symptom management, a longer monitoring period might be necessary to observe permanent changes in self-care behaviors and long-term survival rates.

Declarations

Funding The author(s) received no financial support for the research, authorship, and/or publication of this article.

Conflict of interest The author(s) declared no potential conflicts of interest concerning the research, authorship, and/or publication of this article.

Ethics approval* Written approval (decision number: 2020.144.06.06, dated: 18/06/2020) was received from the Health Sciences University Hamidiye Clinical Research Ethics Committee to implement the study. Institutional permission was obtained for data collection. All participants were informed about the research and their informed consent was received. All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Participants were informed about the purpose of the research, and their written and verbal consent was received prior to data collection. The study was registering with clinicaltrial.gov. The clinical trial registry number is NCT05940740, Registered on July 12, 2023.

Consent to Participate / Publish: Informed consent was obtained from all individual participants included in the study. The participants provided informed consent for the publication of the study results

Data Availability A data set on all patients is provided in the supplementary material. Further requests for data sharing may be submitted to Neslisah Yasar Kartal (neslisahysr@gmail.com).

Author's Contributions

Neslisah Yasar Kartal Conceptualization, Methodology, Investigation, Formal analysis, Writing – original draft, Project administration. **Semiha Akın Eroglu** Conceptualization, Methodology, Formal analysis, Writing – original draft, Supervision. *All authors read and approved the final manuscript.*

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During the preparation of this work, the author(s) used DeepL and ChatGPT in order to translate, improve readability, and language. After using this tool/service, the author(s) reviewed and edited the content as needed and takes) full responsibility for the content of the publication.

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Figures

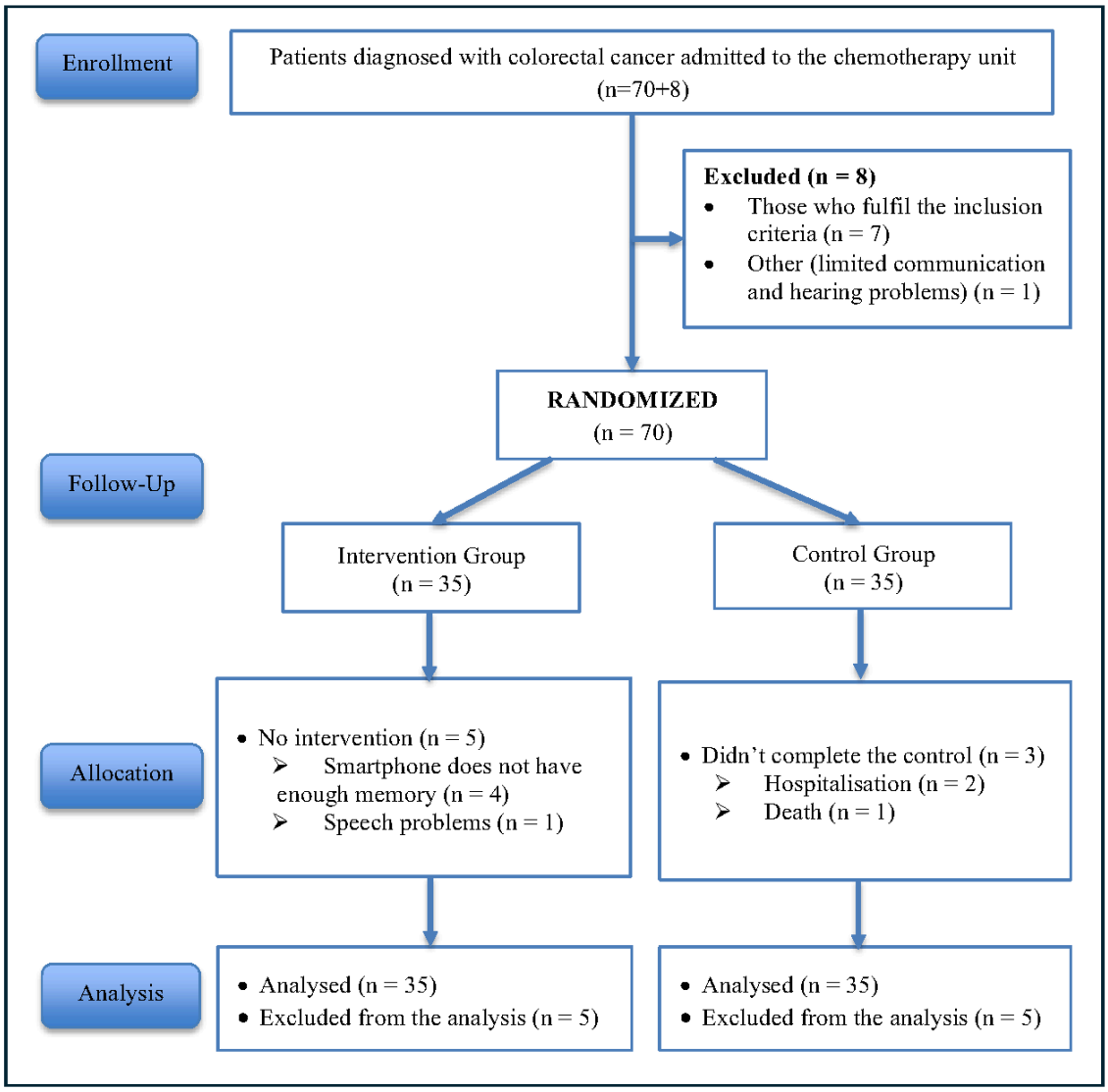


Figure 1 Consort diagram

Figure 1

See image above for figure legend



Figure 2 Kolorektali-M application context menu, main and intermediate screen views

Figure 2

See image above for figure legend

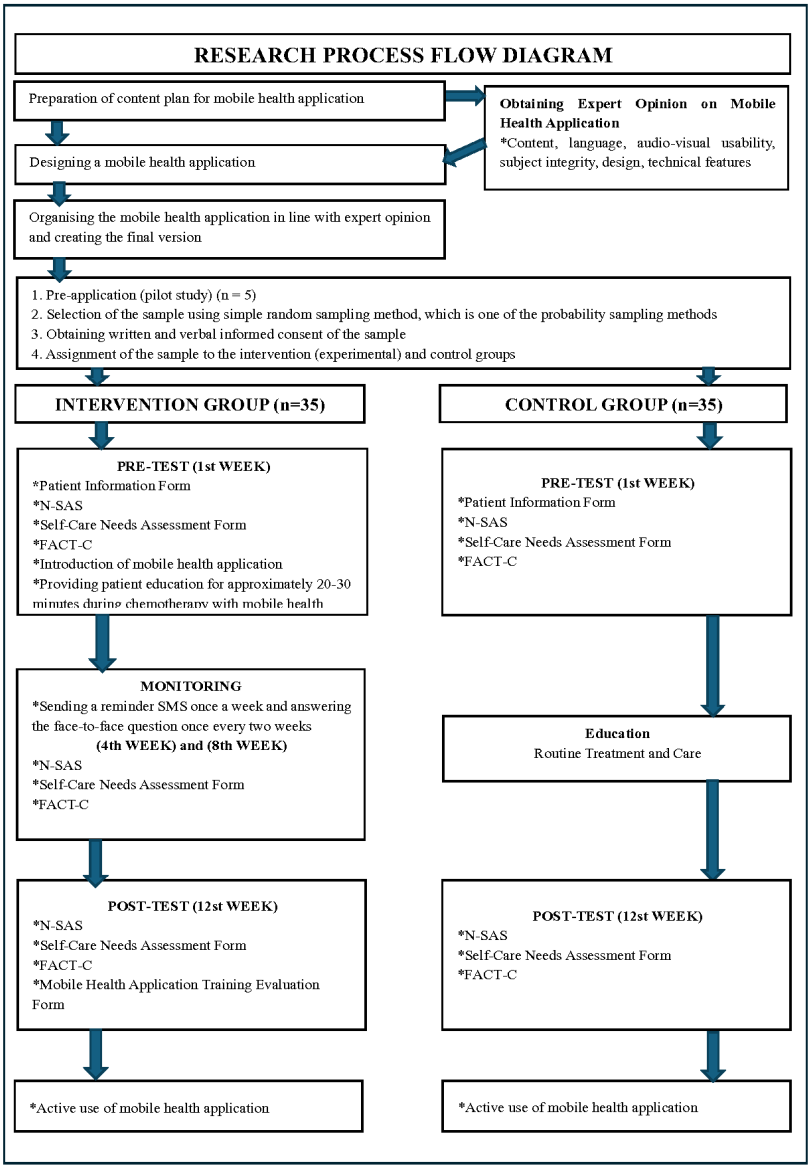


Figure 3 Flow diagram

* FACT-C : Functional Assessment of Cancer Therapy-Colorectal
* N-SDS : Nightingale Symptom Assessment Scale

Figure 3

See image above for figure legend

Supplementary Files

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