

STUDY PROTOCOL

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Efficacy of an app for self-efficacy of patients with cancer through tailored information delivery and coaching: protocol for a randomized controlled trial

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Abstract

Background Though numerous mobile apps have been developed to support patients with cancer, there is no comprehensive app that integrates evidence-based medical information, schedule management, lifestyle modification tools, psychological support, and access to appropriate community resources, to address the needs of patients with cancer. This paper presents a protocol for a randomized controlled trial to evaluate the efficacy of a newly developed app designed specifically for patients with cancer.

Methods This prospective, multicenter, matched-pairs, randomized control trial is designed to evaluate the efficacy of a digital app called Cancer Manager Plus (CAMA+)[®] (HuDIT, Seoul, Korea). Two hundred patients will be stratified based on cancer type (colorectal, lung, breast, and thyroid) and treatment stage (diagnosis, chemotherapy, surgery, radiation, and after treatment). Patients will be randomized to an intervention group that uses the developed app or a control group that will undergo standard treatment for eight weeks. We hypothesize that self-efficacy, measured by the Korean version of the Cancer Survivor Self-Efficacy Scale, will significantly improve in the intervention group, as will cancer survivors' mental adjustment, measured by the Korean Mini-Mental Adjustment to Cancer Scale. We will also assess other outcomes, such as physical health, mental health, cancer treatment adherence, and the experience of using the app. All measurements will be evaluated at baseline and eight weeks follow-up.

Discussion The app being evaluated is designed to be tailored to each user and provide information and services on four types of cancer, including evidence-based treatment information and appropriate mental and physical support according to the user's treatment stage. This app is the first to offer comprehensive features such as personalized information based on cancer type and treatment stage, mental and physical coaching, medication management and appointment scheduling, and links to appropriate resources related to wellness. This study will help understand how the app affects the self-efficacy of patients with cancer and type of adaptation to cancer, and assess the app's feasibility.

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Trial registration The clinical trial was registered with the Clinical Research Information Service, a part of the WHO International Clinical Trials Registry Platform, on March 5, 2024 (approval number: KCT0009219).

Keywords Digital health, Mobile application, Cancer, Information services, Lifestyle

Background

Cancer is one of the most prevalent diseases worldwide, with a substantial burden of unmet needs among patients [1]. Advances in treatments, diagnostic methods, and screening schedules have significantly improved survival rates, with the five-year survival rate for all cancers increasing from 49% to 68% over the past 40 years [2, 3]. Cancer mortality rates have also steadily declined since the 1990s [3]. As of 2022, cancer survivors accounted for 5.4% of the U.S. population, a figure that is expected to rise by 24% by 2032 [4]. This growing population underscores the importance of addressing the complex challenges associated with cancer care and survivorship [5].

Mobile health (mHealth) apps have emerged as a promising solution for cancer care, offering a range of functionalities to support patients throughout treatment and survivorship [5]. These apps cater to diverse patient needs, including survivorship care, symptom management, sleep disturbances, nutrition, general health education, emotional support, physical activity, and motivation [6]. By enabling continuous monitoring, real-time feedback, and access to resources, the apps help manage the complexities of cancer care [7]. Studies indicate that mHealth interventions improve symptom management, enhance patient engagement, and foster self-efficacy, all of which are critical for achieving positive long-term outcomes [8–10]. Additionally, these tools have been shown to improve quality of life (QOL), reduce stress, and support treatment adherence by empowering patients to report symptoms and treatment-related side effects, thereby promoting effective self-management [11, 12].

Despite these advancements, significant gaps remain in the development and implementation of mHealth apps for patients with cancer. Many apps are limited in scope, addressing only one or two functions—such as information delivery, adherence support, or psychological assistance—without integrating these features into a comprehensive platform [13–15]. Furthermore, most apps lack personalized recommendations tailored to individual patient data, and users often encounter usability challenges, especially among diverse populations [16, 17]. The psychological support features of these apps are frequently inadequate, and the unique needs of patients with different cancer subtypes are underexplored [18, 19]. Research on mHealth apps has predominantly focused on improving QOL, with limited attention given to other critical clinical outcomes or the cost-effectiveness of these technologies in healthcare settings [20].

As the paradigm shifts from perceiving cancer as an acute disease to recognizing it as a chronic condition, frameworks like Bandura's self-efficacy theory are becoming increasingly relevant in cancer management [21, 22]. The theory suggests that individuals with higher self-efficacy are more likely to engage in self-management behaviors, contributing to improved health outcomes [22]. Active patient participation in treatment and self-care is essential for achieving long-term success. Enhancing self-efficacy enables patients to manage the physical and psychological challenges of cancer more effectively, ultimately improving overall QOL. Low self-efficacy, however, is often correlated with poorer outcomes and higher symptom severity [23]. In contrast, higher self-efficacy is associated with better pain management [23, 24], higher cancer screening rates [25], improved self-examinations [26], healthier behaviors, lower depression levels, reduced support needs, and better psychosocial and functional outcomes [27]. Many patients with cancer struggle with the initial responsibility of managing their health [16], which emphasizes the need for interventions that enhance self-efficacy.

Numerous efforts have been conducted to improve self-efficacy in patients with cancer. Online interventions, such as Springboard Beyond Cancer, have shown significant improvements in self-efficacy in randomized controlled trials [16]. A meta-analysis of online self-management programs revealed lower symptom distress in intervention groups compared to controls, although most evaluated programs were outdated, and only one was adapted for smartphone use [28]. Limitations in these programs include difficulty in delivering interventions at the optimal time [29] and the need for tailored approaches [16]. Despite these challenges, mHealth solutions hold promise for addressing self-efficacy and other survivorship needs, particularly when combined with scientifically validated interventions, like psychological therapy, exercise, and nutritional guidance, as exercise has been shown to alleviate treatment-related symptoms [30], and certain nutritional factors may impact mortality and recurrence risk [31].

In many countries, access to professional medical staff is limited, prompting cancer survivors to seek information from communities or online platforms. Unfortunately, much of the online information is unverified and potentially harmful. For example, 70% of bladder cancer-related content on social media is of moderate to poor quality [32], and 32.5% of popular articles on breast, prostate, colorectal, and lung cancers contain

false information, with 30.5% deemed harmful [33]. This underscores the importance of providing accurate, evidence-based resources to patients with cancer.

To address these challenges, we created a digital app to provide personalized, evidence-based information appropriate to the type of cancer (colorectal, lung, breast, thyroid) and stage of cancer treatment (diagnosis, surgery, chemotherapy, radiation, end of treatment, etc.). The app also provides coaching and training for lifestyle modifications and psychological coping, and assists in matching patients' needs with appropriate community resources. The current clinical trial has been designed to validate the clinical efficacy of this app.

Hypotheses

To address the research objective, the following hypotheses will be tested:

- (1) Cancer survivors' self-efficacy (primary endpoint) significantly improves in the group using the app for eight weeks in combination with conventional treatment (intervention), compared with the group receiving only conventional treatment (control).
- (2) Mental adjustment to cancer (secondary endpoint) significantly improves in the intervention group, compared with the control group.
- (3) The newly developed app will show efficacy in improving cancer survivors' health outcomes, and its feasibility and usability will be confirmed.

Methods

Study design

This study is a prospective, multicenter, matched-pairs, randomized controlled trial designed to evaluate the efficacy of the developed app (Fig. 1). Two hundred survivors of prevalent cancers—colorectal, lung, breast, and thyroid—will be selected, with 50 individuals representing each type of cancer. To assess the effectiveness of the app throughout the cancer treatment cycle, participants will be evenly distributed across the treatment stages—diagnosis, before and after chemotherapy, before and after surgery, before and after radiation, and after all treatments have been completed. From the pairs of patients matched based on cancer type, sex, age group, and treatment stage, one will be randomly assigned to the intervention group and the other to the control group. Randomization will be done by a separate researcher, independent of the study researchers. The intervention group will use the app in combination with their standard treatment for eight weeks, whereas the control group will receive only the standard treatment for the same duration. Outcomes will be evaluated at the beginning of the trial (baseline) and eight weeks after using the program (endpoint).

Study setting

The participants will be recruited from three hospitals located in three different regions in the Republic of Korea: Chung-Ang University Hospital in Seoul, Chung-Ang University Gwangmyeong Hospital in Gyeonggi-Do, and Chungbuk National University Hospital in Chungcheongbuk-Do. Although participants will be recruited from three hospitals, the app-based intervention will be managed by researchers at the principal investigator's institution, Chung-Ang University Hospital. Additionally, researchers from all three hospitals will receive training at Chung-Ang University Hospital on the app, administrator program, and standardization of outcome

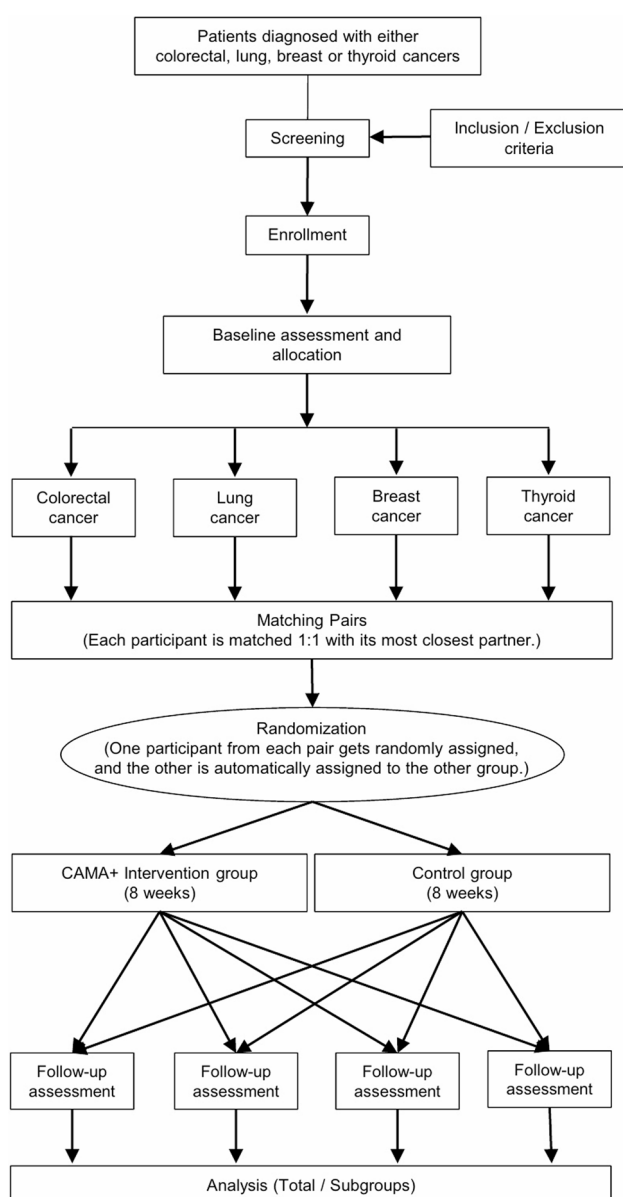


Fig. 1 Study design

measurement to ensure homogeneity of the interventions and assessments. The participants will be recruited through posters and information booklets on the trial. Written consent will be gathered before participants begin the study, and they will have the option to opt out of the study for any reason whatsoever, whenever they wish.

Eligibility criteria

The inclusion criteria will be as follows:

- (1) Primary diagnosis of colorectal, lung, breast, or thyroid cancer.
- (2) Aged 20 years or older.
- (3) Has access to an Android or IOS-based smartphone or similar device.

The exclusion criteria will be as follows:

- (1) Does not voluntarily consent to the study.
- (2) Has difficulty in communication.
- (3) Diagnosed with a psychiatric disorder or has significant cognitive impairment.
- (4) Has limited digital literacy skills.

Pilot analysis on feasibility and usability

To assess if CAMA+[®] could show acceptable feasibility and usability, we conducted a two-week pilot test with ten participants from September to November 2024 [34]. The mean age of the participants was 50.2 years (SD = 10.82), with one male and nine female participants. After using the app for two weeks, participants completed surveys and interviews to evaluate how the application affected their mental state, as well as their satisfaction and user experience. Feasibility was assessed using a questionnaire that measured how much the application supported users' mental health, with each of the four modules evaluated separately. Satisfaction was also measured through a dedicated survey. Usability was assessed using another ten-question user experience survey, which evaluated participants' experience with the app's functionality, structure, and design. All items evaluating feasibility and usability were rated on a 6-point Likert scale, ranging from 1 (strongly disagree) to 6 (strongly agree). Additionally, qualitative research was conducted through interviews, primarily using open-ended questions to explore users' experiences in depth. More details on the pilot study are provided in the supplementary materials (Additional File 1).

The results showed that participants were highly satisfied with CAMA+[®], with most ratings averaging 5 or higher on a 6-point Likert scale. User feasibility analysis of the app's modules indicated that participants found it helpful for cancer treatment and lifestyle management,

with average ratings of 5.45 for schedule management, 5.40 for tailored medical information, 5.57 for coaching programs, and 4.95 for connection to well-being-related resources. Participants also reported positive experiences with the app's functionality, structure, and design, with an overall satisfaction rating of 5.33 and an average usability score of 5.39. The lowest-rated aspect was difficulty in correcting errors during input, which received an average score of 4.89. The following key themes emerged from the qualitative data: a sense of connection to healthcare services, recognition of shared experiences, ease of information acquisition, and self-management. These findings suggest that CAMA+[®] demonstrates acceptable feasibility and usability in the healthcare management and treatment process for cancer survivors, warranting a more rigorous and detailed study.

Interventions

Participants of the intervention group will be provided with an app developed by the authors of the study called "Cancer Manager Plus (CAMA+)[®] (HuDIT, Seoul, Korea)." This digital app is designed to be customizable to each user, providing relevant information and services regarding colorectal, lung, breast, and thyroid cancer. It also provides evidence-based information based on when the participant was diagnosed with cancer, assists with mental and physical training for a healthier lifestyle, manages a scheduled program for better health, and matches the user with other resources related to well-being.

The CAMA+[®] can be accessed from the patient-side app and the administrator-side homepage. The patient app comprises four modules: schedule management, individually tailored evidence-based medical information, a coaching program for the self-promotion of healthy activities, and matching to well-being-related resources. The administrator website can control the digital information database, add and update information to the patient app, and assist in patient management. The homepage and app are interlinked, and the patient information can only be accessed through the administrator's homepage to protect patient privacy (Fig. 2).

The CAMA+[®] app is designed based on the Chronic Care Model (CCM) and the Health Belief Model (HBM) to enhance self-efficacy, mental adjustment to cancer, and QOL. By integrating key elements from these models, CAMA+[®] aims to support sustained self-management and health-promoting behaviors among cancer survivors.

CCM is a widely used framework for improving chronic disease management by strengthening patients' self-management capabilities and establishing a network of medical, psychological, and social resources [35]. CAMA+[®] incorporates CCM principles through features, such as schedule management (clinical information system & self-management support), personalized medical



Fig. 2 Brief overview of “Cancer Manager Plus (CAMA+)”[®] (A) Patients can see how far they have progressed in the individual care tracks (B) Information such as the type of cancer, phase of treatment, specific type of cancer, other variables to be considered, and areas of interest were collected (C) Overview of the daily tasks provided by the application: The patients can check what they are required to do each day and how far they have progressed (D) Various educational materials are provided based on the patient’s status and areas of interest (E) The patient’s important medical schedules, such as doctor visits or medication and test schedules, can be viewed here (F) Coaching for lifestyle modifications and psychological coping is provided based on the patient’s preferences and lifelog data

information (self-management support & decision-making), coaching programs (self-management support), and connections to well-being resources (community resources) [36]. These functions enable a comprehensive support system, empowering patients to take an active role in managing their health.

HBM explains health-related behaviors by focusing on individuals’ perceptions of health threats, benefits and barriers to action, and self-efficacy [37]. In line with HBM, CAMA+[®] reduces perceived health threats by providing reliable medical information and psychological coaching [38]. It also motivates behavior change through schedule management and personalized coaching, helping patients assess symptom severity and engage in health-promoting behaviors. By addressing barriers with tailored interventions and resource connections, CAMA+[®] encourages sustained behavior change and enhances self-efficacy.

By integrating CCM’s focus on long-term health system sustainability and HBM’s emphasis on individual motivation, CAMA+[®] provides core modules that enable cancer survivors to actively manage their health. These features help reduce uncertainty related to cancer treatment, foster psychological adaptation, and support lifestyle modifications. Furthermore, reminders and notifications serve as continuous cues to action, reinforcing long-term engagement in health behaviors.

In summary, CAMA+[®] is a digital health solution that bridges CCM and HBM principles to empower cancer survivors. We propose that utilizing CAMA+[®] will enhance self-management capabilities and improve self-efficacy (Hypothesis 1), facilitate the sustained practice of

health behaviors and psychological adaptation (Hypothesis 2), and provide a valuable health management tool with a positive user experience (Hypothesis 3). Ultimately, CAMA+[®] is expected to improve both the mental and physical well-being of cancer survivors while contributing to a sustainable health management system.

A study evaluating the efficacy of CAMA[®], the predecessor to CAMA+[®], in breast cancer survivors revealed that the experimental group utilizing the app exhibited improvements in self-efficacy, psychological well-being, and positive attitudes toward cancer, as well as reductions in depressed mood and anxiety, compared to the control group [39]. Additionally, self-efficacy plays a crucial role in changing and maintaining health-related behaviors, and enhancing self-management through the improvement of self-efficacy may yield long-term benefits for patients with chronic diseases [40, 41]. These findings emphasize the importance of strategies to improve self-efficacy in mobile interventions for patients with cancer.

The app modules are described as follows:

(1) Module 1: Schedule management.

Module 1 provides cancer survivors with appropriate daily schedules based on when they were diagnosed with cancer and pop-up alarms for important activities. Pop-up alarms remind users of their medication regimens, hospital schedules, and daily missions, and provide important information, educational advice on developing healthy habits, and motivational support.

Schedule management is a crucial component in promoting self-management and aligns with the clinical

information system and self-management support elements of the CCM. The alarm function, an important part of schedule management, maintains and reinforces the patient's behavior by reminding patients of important activities such as medication adherence and appointments. Previous studies have demonstrated that the alarm function improves patient adherence to medication and enhances exercise performance. Furthermore, these interventions are effective at increasing self-efficacy [13, 42].

- (2) Module 2: Individually tailored evidence-based medical information based on an algorithmic approach.

The digital information database will comprise guidelines from reputable organizations and evidence-based content developed by doctors specializing in the relevant boards, psychologists specializing in psycho-oncology, exercise experts, and nutritionists. The content will be tailored to each cancer survivor's current general health status and treatment phase (e.g., after diagnosis, before surgery, or during chemotherapy). This information will also include a range of topics, including cancer symptoms, treatment,

treatment side effects, management of symptoms, exercise, nutrition, and psychological support. Since the content will be tailored to the individual's needs, this will enhance user immersion in the program, increase app usage, and reduce the need to separately search for relevant information.

This module encompasses the key components of the CCM's decision-making and self-management support, by giving people access to accurate information. Providing reliable information to patients enhances their decision-making capabilities by increasing their health-related knowledge [43]. Furthermore, it addresses the perceived benefits and barriers to engaging in health-promoting behaviors of the HBM by providing content that meets patients' needs. For example, in the case of a patient who has undergone chemotherapy, information regarding potential side effects and management strategies may be provided. These interventions reduce distress and improve QOL by alleviating uncertainty regarding treatment and management [44]. Tailored educational interventions can also facilitate continuous changes in patients' health behaviors and improve self-efficacy in healthcare management [45, 46].

- (3) Module 3: Coaching program for self-promotion of healthy lifestyles.

Table 1 Example coaching programs for self-promotion of healthy lifestyles

Program	Coaching methods
Coaching based on coping strategies for cancer	○ Session 1: Coping with cancer (Cancer adaptation test) ○ Session 2: Balancing your thoughts ○ Session 3: Relaxing your body (breathing exercises) ○ Session 4: Calming the mind (meditation) ○ Session 5: Expressing your thoughts ○ Session 6: Summary ○ Session 7 (Supplementary): Managing distress by cancer type The order of each session may differ depending on the type of cancer adaptation.
Self-management coaching based on lifestyles	○ All patients: Coaching based on motivation enhancement for lifestyle modification. ○ Patients with a low level of physical activity: Coaching based on behavioral activation. ○ Patients with insomnia: Coaching based on cognitive behavioral methods such as sleep hygiene and sleep restriction. ○ Dietary habits: Suitable dietary guidelines based on cancer type, general health status or side effects of treatment.
Rehabilitation exercise	○ Rehabilitation exercise will be assigned at an appropriate level based on cancer type and assessment of daily physical activity performance. ○ Beginner: Range of Motion (ROM) ○ Intermediate: Active Assistive ROM (AAROM) ○ Advanced: Strengthening and stretching exercises ○ Aerobic exercise ○ Rehabilitation training by cancer type (e.g., breathing exercises, lymphedema massage, vocal rehabilitation)

A coaching program for lifestyle modifications and mental coping strategies will be provided based on the questionnaire responses. The lifestyle modification programs will be based on motivational enhancement and positive psychological principles (Table 1). They will focus on forming healthy habits through 16-day programs for each of the three themes: physical activity/exercise, diet, and sleep. Programs focused on psychological well-being will target distress management and comprise six sessions and one supplementary session. The five types of cancer adaptation—combative, compliant, repressed, resigned, and worried—determine the order in which each session is presented. The sessions will be based on mindfulness and cognitive behavioral therapy methods and focus on skill-building to help manage distress and increase adaptive coping strategies for cancer. If needed, data on the cancer survivors' activity level (number of steps per day), sleep patterns (bedtime, wake-up time), diet, etc. that have been collected by the app can be used to provide more individualized coaching content.

This module is designed to integrate the CCM's self-management support by facilitating patient's improvement in their physical and psychological health through a systematic coaching program. Patients can address perceived barriers to and enhance the perceived benefits of engaging in health-promoting treatment through participation in coaching programs. The assessment in this

module identifies the patient's cancer adaptation type and provides information on the appropriate level of exercise, thereby enabling the patient to recognize health-related threats. Suitable exercises are provided for each individual according to their cancer type and daily physical activity performance level. All exercises were designed by experts with a medical degree in rehabilitation medicine or doctorate in healthcare-related exercise fields, and were overseen by psychiatrists and oncologists. Psychological training for distress management encompasses techniques such as diaphragmatic breathing, meditation, and cognitive restructuring, based on cognitive behavioral therapy and mindfulness principles. These programs were designed based on previous studies that have shown that cognitive behavioral therapy and mindfulness-based interventions are effective in alleviating depression and anxiety and enhancing the QOL of cancer survivors [47, 48]. All interventions in this module are built on prior research that demonstrated that healthy lifestyle habits influence the physical and psychological health and QOL of cancer survivors [49–51].

(4) Module 4: Connection to well-being–related resources.

This module provides information on various service organizations that can help cancer survivors with lifestyle changes and overall well-being. The resources consist of organizations that provide services related to diet, exercise, physical activity, and psychological support. Examples of resources include exercise centers that can provide evidence-based exercises for cancer survivors, research teams or organizations that can provide appropriate diets based on the type and stage of cancer treatment, counseling centers that have experience working with cancer survivors, and knowledge of various symptoms.

The connection to well-being-related resources provides cancer survivors with the opportunity to utilize reliable external information and services in the community. This module extends the continuity of healthcare beyond the mobile app, creating a more holistic approach to cancer management. Moreover, it emphasizes the integrated aspects of cancer treatment and management, enhances patient experiences, and motivates individuals to maintain health-promoting behaviors [52].

Primary outcome

To assess self-efficacy in patients with cancer, we will employ the Korean version of the Cancer Survivor Self-Efficacy Scale [53, 54]. This self-report instrument consists of two subscales covering ten items: the managing health problems subscale (5 items) and the seeking help and support subscale (5 items). The respondents will rate these items on a scale ranging from 1 (not at all

confident) to 10 (completely confident). The total scores will be obtained by aggregating the scores for each item, with higher scores indicating higher self-efficacy. In a previous study, Cronbach's α for the original tool and the Korean version was 0.92 [54].

Secondary outcome

The Korean Mini-Mental Adjustment to Cancer Scale (K-Mini-MAC) will be used to evaluate psychological responses to cancer [55]. The reliability of this tool for assessing coping methods related to cancer is well documented [56].

Tertiary outcomes

Tertiary outcomes will include various patient-reported outcomes (PRO), medical service utilization, physical state, and laboratory findings. PRO will be evaluated using various self-reported scales to assess physical health, psychological state, and QOL, among other outcomes. QOL will be measured using the EuroQol-5D (EQ-5D), which evaluates quality of life using five questions [57]. Although it is a short form questionnaire, it is an effective way to predict QOL in the Korean population [58]. The Memorial Symptom Assessment Scale-Short Form (MSAS-SF) will also be used; it is a self-report scale used to evaluate pain during the past week based on 28 physical and 4 psychological symptoms [59]. The Korean MSAS-SF comprises three subscales: the physical symptom distress score, psychological symptom distress score, and global distress index. The psychological state will be assessed using various scales. Depression will be measured using the Patient Health Questionnaire-9 [60], while anxiety will be measured using the Generalized Anxiety Disorder-7 (GAD-7) [61]. Both tools are widely used and have been validated in the Korean population [62, 63]. The Distress Thermometer (DT) was chosen to evaluate distress because of its wide utility [64]. Treatment satisfaction will also be evaluated on a five-point scale, with 5 denoting “most satisfied.”

Medical service utilization will be evaluated based on factors such as medical costs, the number of unplanned outpatient ward visits, and emergency room visits. Treatment adherence will be assessed using both medication and outpatient visit adherence. Medication adherence will be checked by counting pills, whereas outpatient visit adherence will be based on whether the patient visited their scheduled outpatient ward within a one-week window. Test adherence will also be evaluated by checking whether the patient correctly participated in cancer-related and other scheduled tests.

Patients' physical state will be assessed using the body mass index, skeletal muscle mass, blood pressure, and pulse rate. Laboratory findings will include tumor markers/genes, serum glucose, lipid panel, liver function test,

serum creatinine, estimated glomerular filtration rate, blood urea nitrogen, and complete blood count.

Lifelog data, which can be collected via smartphone or input directly via the CAMA+® program, will also be evaluated. These data will include activity level (steps), sleep patterns (bedtime, wake-up time), diet, content usage time and frequency, related content, and search terms. The severity of side effects will be evaluated using the Common Terminology Criteria for Adverse Events version 5.0 [65] and the performance of everyday activities will be measured using the Eastern Cooperative Oncology Group Performance Status Scale [66]. Changes in lifestyle after the intervention will be assessed using the Global Physical Activity Questionnaire, which contains questions on daily activities such as time spent walking or sitting and the intensity of workouts [67]. Diet will be evaluated using the food diary maintained by patients, where they will be asked to write about what, when, and how much they ate during the past week. They will be asked to record food-related data for three days (two weekdays and one day on a weekend). Finally, service satisfaction will be evaluated using a survey developed by the Korean Cancer Survivor Healthcare Research and Development Project of the Korean National Cancer Center (KOCAS). The survey consists of five questions: one required and four optional, selected by the researchers. The optional questions covered convenience, perceived usefulness, willingness to use, and willingness to recommend. Table 2 presents the detailed summary table of all outcomes that will be evaluated and when the data will be acquired.

Sample size and recruitment methods

The minimum required sample size was calculated using G*Power 3.1.9.7 (Faul, Universität Kiel). Using the mixed model analysis of variance method (ANOVA), a sample size of 38 participants was determined based on the effect size from a prior study evaluating the impact of digital interventions on self-efficacy of patients with cancer [68, 69], with a significance level of 0.05, power of 0.85, and an effect size of 0.25 (moderate). Assuming a 20–25% dropout rate, we aim to recruit 200 participants, 50 for each of the four types of cancer (colorectal cancer, lung cancer, breast cancer, and thyroid cancer).

Adherence assessment methods and criteria for the app

Adherence to the app intervention will be monitored and evaluated using specific usage metrics during the 8-week study period. Participants in the intervention group will be required to use the CAMA+® digital healthcare service in addition to receiving standard cancer care. Adherence will be assessed every two weeks through the administrator system by monitoring module utilization, with a particular focus on progress in viewing evidence-based

medical information tailored to the patient (Module 2) and completing the coaching programs related to healthy lifestyle behaviors—such as exercise, dietary habits, and sleep hygiene, as well as psychological coping (Module 3). All participants will be required to complete at least one coaching session in Module 3. Phone reminders will be provided by researchers if the average content progress in Module 2 is $\leq 50\%$ or if none of the coaching programs in Module 3 have been initiated during the biweekly monitoring period. Participants will be classified as non-adherent and dropped out if the average content progress in Module 2 remains $\leq 30\%$ over the 8-week study period or if none of the coaching programs in Module 3 are completed. These measures are designed to ensure consistent monitoring of adherence, provide proactive support to encourage participation and minimize dropout rates.

Data collection and management methods

Qualified members of the research team will perform data collection. Researchers who collect data will have training in psychology, social welfare, nursing, or psychiatry, and have experience with patients with cancer. Data will be managed using the KOCAS ecosystem, an electronic system developed using government funds, designed to support multicenter clinical trials and data management. It is designed to support the entire research process, from electronic consent acquisition to clinical data collection, management, and analysis. Moreover, it has been developed in a public cloud environment that offers robust security services.

Statistical methods

A mixed model ANOVA will be performed using IBM SPSS Statistics to compare changes in the outcome measures between baseline and post-assessment. The statistical analysis will assess the effectiveness of the app by checking whether the difference between pre- and post-utilization values is statistically significant. For continuous data, values that deviate abnormally from the distribution will be defined as outliers and excluded from the analysis. A per-protocol analysis, which excludes dropouts and analyzes only patients who completed the study according to the protocol, will be conducted. When comparing the mean change of each outcome from baseline to eight weeks after intervention, a p -value of 0.05 will be considered statistically significant.

Discussion

With advancements in technology, digital health interventions utilizing software and mobile apps have emerged as pivotal tools in modern patient care. The official approval by government bodies of select digital therapeutics as medical treatments has significantly elevated

Table 2. Study schedule and methods to evaluate outcomes

		STUDY PERIOD		
		Enrolment (Screening)	Allocation (Baseline)	Post- allocation (Close out)
TIMEPOINT**		$-t_1$	0	t_1 (8 weeks $\pm$ 1 week)
ENROLMENT				
	Eligibility screen	X		
	Informed consent	X		
	Allocation		X	
INTERVENTIONS				
	[Intervention group]			
	[Control group]			
ASSESSMENTS				
Basic	Demographic information	X	X	
Patient- Reported Outcome	Self-Efficacy (CS-SES-K)		X	X
	Adjustment to cancer (K-Mini-MAC)		X	X
	Physical and psychological symptoms (MSAS-SF)		X	X
	Health-related quality of life (EQ-5D)		X	X
	Distress (Distress Thermometer)		X	X
	Depression (PHQ-9)		X	X
	Anxiety (GAD-7)		X	X
	Survey on lifestyle habits (smoking, drinking)		X	X
	Physical activity (GPAQ)		X	X
	Dietary survey		X	X
	Overall treatment satisfaction		X	X
Medical Service Utilization	Treatment adherence (Medication/medical visit)		X	X
	Test adherence (Cancer-related/scheduled)		X	X
	Medical costs		X	X
	Unplanned medical visits		X	X
Physical State	Physical measurements (weight, BMI, SMM, etc.)		X	X
	Blood pressure/Pulse		X	X
	Laboratory findings (tumor markers/genes)		X	X
Others	Clinical data (cancer type, staging, etc.)	X	X	X
	Comorbidities/medical history	X	X	X
	Medication history	X	X	X
	Adverse drug events/postoperative complications (CTCAEs)		X	X
	Performance level (ECOG PSS)		X	X
	Lifelog data*		X	X
	Satisfaction with CAMA+® app services			X

CS-SES-K Korean version of the Cancer Survivor Self-Efficacy Scale, K-Mini-MAC Korea Mini-Mental Adjustment to Cancer Scale, MSAS-SF Memorial Symptom Assessment Scale - Short Form, EQ-5D EuroQoL-5D, PHQ-9 Patient Health Questionnaire-9, GAD-7 Generalized Anxiety Disorder-7, GPAQ Global Physical Activity Questionnaire, BMI Body mass index, SMM Skeletal muscle mass, CTCAE Common Terminology Criteria for Adverse Events, ECOG PSS Eastern Cooperative Oncology Group Performance Status Scale. *Lifelog data: Data such as activity level (steps), sleep patterns (bedtime, wake-up time), diet, content usage time and frequency, related content, and search terms that can be inputted directly through the CAMA+® app or by other smart devices

the potential of digital health [70]. This progress extends to the field of oncology, in which various digital solutions have been developed to support patients with cancer and improve treatment outcomes [71]. For example, online self-management programs have shown effectiveness in reducing immediate distress among patients with early-stage breast cancer [72]. Similarly, mobile game-based approaches have improved self-management and QOL in patients with breast cancer undergoing chemotherapy [73]. Studies involving patients with head and neck cancers have demonstrated improved communication and outcomes through PRO apps [74], while telehealth-based interventions have yielded comparable results [75]. Additional programs have improved post-operative symptom management [76], addressed treatment-related events more effectively [47], and enhanced care for chemotherapy-related symptoms [77, 78].

Despite these advances, most digital health services for cancer treatment focus on specific cancer types or limited treatment phases, such as chemotherapy or post-operative management. CAMA+® seeks to address these limitations by providing continuous support for patients with cancer across their survivorship journey—from diagnosis to long-term care. The app personalizes the delivery of evidence-based digital information to meet the needs of patients with cancer for high-quality, timely information [79]. Additionally, it stores patient-specific digital data, which could be used to develop machine-learning algorithms in the future, further advancing its precision and utility.

The CAMA+® app is designed based on CCM and HBM and is expected to enhance self-efficacy, mental adjustment to cancer, and QOL [36, 38]. CAMA+® expands upon the prior CAMA® for patients with breast cancer by incorporating additional modules that support lifestyle modification and psychological adaptation, thus extending its scope to include a broader range of patients with cancer. These enhancements are designed to promote healthy lifestyles and coping strategies, improve health-related QOL, boost physical and mental health, and increase treatment adherence. Ultimately, these benefits are expected to lead to better long-term disease outcomes [23, 27, 80]. Furthermore, it is anticipated that CAMA+® will reduce psychological distress, depression, and anxiety among cancer survivors, providing substantial emotional and psychological support throughout their cancer journey.

This study, while adopting a randomized controlled trial (RCT) design, also carries the characteristics of a more rigorous feasibility study. Feasibility studies are inherently exploratory, aiming to assess usability, acceptability, and preliminary effects [81]. Their primary purpose is to provide foundational data and insights to inform the design and implementation of larger, more

definitive studies [82]. Consistent with this objective, this study will focus on evaluating the practicality and initial impact of the app, rather than drawing definitive conclusions. As a feasibility study, this study includes multiple outcome variables to explore meaningful ones for future research. Specifically, based on previous findings [21–23, 27], self-efficacy has been designated as the primary endpoint, with additional outcome variables broadly included. However, it may be challenging to achieve statistical significance across all variables or to predefine all analytical methods due to the exploratory nature and limited sample size. Nonetheless, the findings of this study will provide valuable preliminary evidence in evaluating the app's potential utility and impact.

The insights gained from this study are expected to significantly contribute to refining the implementation strategies of the app, particularly regarding its effects on self-efficacy. Additionally, these findings will guide the design of future large-scale RCTs, with a larger sample size and pre-specified hypotheses to address the exploratory limitations identified in this study. By identifying key outcome variables and potential barriers, this research establishes a critical foundation for rigorously evaluating the efficacy and broader applicability of the CAMA+® app as a comprehensive, evidence-based, patient-centric digital solution aimed at transforming cancer care.

Abbreviations

ANOVA	Analysis of variance
CAMA	Cancer Manager
CAMA+	Cancer Manager Plus
CCM	Chronic Care Model
GAD-7	Generalized Anxiety Disorder-7
HBM	Health Belief Model
KOCAS	Korean Cancer Survivor Healthcare Research and Development Project of Korean National Cancer Center
MSAS-SF	Memorial Symptom Assessment Scale - Short Form
QOL	Quality of life
RCT	Randomized controlled trial

Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s12889-025-25710-9>.

Supplementary Material 1.

Supplementary Material 2.

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None.

Authors' contributions

H.C.H. contributed to validation, preparing Figs. 1 and 2, and writing the original draft. S.M.K. contributed to project administration, funding acquisition, and reviewing and editing the manuscript. N.Y.K. and D.S.K. contributed to methodology and writing the original draft. E.S.Y. contributed to methodology and validation. H.J.K. contributed to conceptualization, methodology, and reviewing and editing the manuscript. All authors reviewed the manuscript and approved the submitted version.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

The study protocol was approved by the Institutional Review Board of Chung-Ang University Hospital (approval number: 2311-005-577). Adverse events will be recorded and reported to relevant bodies according to the guidelines of the Chung-Ang University Hospital Institutional Review Board. Changes in the protocol will be confirmed by the Institutional Review Board before being applied to the trial. All participants will provide written informed consent prior to participation. Informed written consent will be obtained by the primary researcher and other researchers deemed fit by the Institutional Review Board. The clinical trial was registered with the Clinical Research Information Service, a part of the WHO International Clinical Trials Registry Platform, on March 5, 2024 (approval number: KCT0009219).

All procedures contributing to this work comply with the ethical standards of the Korean Association of Institutional Review Boards and the Helsinki Declaration of 1975, as revised in 2008. Patient information will be protected in accordance with the guidelines approved by the Chung-Ang University Hospital Institutional Review Board and relevant legislation. The results of this study will be published in a timely manner in an appropriate journal. Currently, no information regarding the results of this study has been published or submitted elsewhere.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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References

- Bray F, Ferlay J, Soerjomataram I, Siegel RL, Torre LA, Jemal A. Global cancer statistics 2018: GLOBOCAN estimates of incidence and mortality worldwide for 36 cancers in 185 countries. *CA Cancer J Clin*. 2018;68(6):394–424.
- Crosby D, Lyons N, Greenwood E, Harrison S, Hiom S, Moffat J, et al. Early detection of cancer. *Science*. 2022;375(6586):eaay9040.
- Siegel RL, Miller KD, Fuchs HE, Jemal A. Cancer statistics, 2023. *CA Cancer J Clin*. 2023;73(1):17–48.
- American Cancer Society. Cancer treatment & survivorship facts & Figs. 2022–2024. American Cancer Society Atlanta; 2022.
- Cai T, Huang D, Zhang X, Wang H, Liu Y, Zhang X. Mobile health applications for the care of patients with breast cancer: a scoping review. *Int J Nurs Sci*. 2021;8(4):470–6.
- Charbonneau DH, Hightower S, Katz A, Zhang K, Abrams J, Senft N. Smartphone apps for cancer: A content analysis of the digital health marketplace. *Digit Health*. 2020;6:2055207620905413.
- McCann L, Kearney N, Maguire R, Wengström Y, Aranda S, Donnan P, et al. Patients' and clinicians' experiences using a real-time remote monitoring system for chemotherapy symptom management (ASyMS): qualitative study. *J Med Internet Res*. 2024;26:e53834.
- Singleton AC, Raeside R, Broadbent S, Regan T, Jones L, Schüz B, et al. Electronic health interventions for patients with breast cancer: systematic review and meta-analyses. *J Clin Oncol*. 2022;40(20):2257–70.
- Rock CL, Thomson C, Gansler T, Gapstur SM, McCullough ML, Patel AV, et al. American cancer society nutrition and physical activity guideline for cancer survivors. *CA Cancer J Clin*. 2022;72(3):230–62.
- Wu W, Wang H, Li Y, Zhang J, Chen X, Liu S, et al. Acceptability, effectiveness, and roles of mHealth applications in supporting cancer pain self-management: integrative review. *JMIR mHealth uHealth*. 2024;12(1):e53652.
- Buneviciene I, Bunevicius A, Deltuva VP, Pranckeviciene A. Can mHealth interventions improve quality of life of cancer patients? A systematic review and meta-analysis. *Crit Rev Oncol Hematol*. 2021;157:103123.
- Kim H, Xie B, Zhou L. Mobile health application and e-health literacy: opportunities and concerns for cancer patients and caregivers. *J Cancer Educ*. 2019;34:3–8.
- Park HR, Kim YA, Kim JH, Lee EH, Kim SH. Effect of a smart pill bottle reminder intervention on medication adherence, self-efficacy, and depression in breast cancer survivors. *Cancer Nurs*. 2022;45(6):E874–82.
- Lozano-Lozano M, Galiano-Castillo N, Fernández-Lao C, Postigo-Martin P, Álvarez-Salvago F, Arroyo-Morales M. A mobile system to improve quality of life via energy balance in breast cancer survivors (BENECA mHealth): prospective test-retest quasiexperimental feasibility study. *JMIR Mhealth Uhealth*. 2019;7(6):e14136.
- Changrani K, Patel S, Ramakrishnan A, Lee S, Misra D. A systematic review of smartphone applications for cancer survivors. *J Cancer Surviv*. 2024;18(6):1951–73.
- Leach CR, Fisher JL, Beckjord E, Hall IJ, Watson L, Joseph DA. Cancer health self-efficacy improvement in a randomized controlled trial. *Cancer*. 2022;128(3):597–605.
- Kirsch EP, Lee CH, Dunn GP, Gagliardi AR. Digital health platforms for breast cancer care: a scoping review. *J Clin Med*. 2024;13(7):1937.
- Horn A, Schneider S, Kleinert J, Fuchs R. Systematic review on the effectiveness of mobile health applications on mental health of breast cancer survivors. *J Cancer Surviv*. 2023;19(1):1–17.
- Brouard B, Larcheveque L, Mura M, Grimfeld A. Mobile applications in oncology: is it possible for patients and healthcare professionals to easily identify relevant tools? *Ann Med*. 2016;48(7):509–15.
- Chan RJ, Aranda S, Chan A, Mihalopoulos C, Yong J, Kantaris M, et al. Advances and future directions in the use of mobile health in supportive cancer care: proceedings of the 2019 MASCC annual meeting symposium. *Support Care Cancer*. 2020;28:4059–67.
- Kurt S, Altan Sarikaya N. Correlation of self-efficacy and symptom control in cancer patients. *Support Care Cancer*. 2022;30(7):5849–57.
- Bandura A. Self-efficacy: toward a unifying theory of behavioral change. *Adv Behav Res Ther*. 1978;1(4):139–61.
- White LL, Cohen MZ, Berger AM, Kupzyk KA, Bierman PJ. Self-efficacy for management of symptoms and symptom distress in adults with cancer: an integrative review. *Oncol Nurs Forum*. 2019;46(1):113–28.
- Liang SY, Yates P, Tsay SL. Factors influencing opioid-taking self-efficacy and analgesic adherence in Taiwanese outpatients with cancer. *Psychooncology*. 2008;17(11):1100–7.
- Bunkarn O, Kusol K. The relationship between perceived self-efficacy and cervical cancer screening among village health volunteers in Suratthani province, Thailand. *Asian Pac J Cancer Prev*. 2021;22(1):179.
- Coroiu A, Moran C, Bergeron C, Dalfen A, Körner A. Short and long-term barriers and facilitators of skin self-examination among individuals diagnosed with melanoma. *BMC Cancer*. 2020;20(1):123.
- Manne SL, Badr H, Kashy DA, Zaider T, Lee M, Heckman C, et al. Self-efficacy in managing post-treatment care among oral and oropharyngeal cancer survivors. *Eur J Cancer Care (Engl)*. 2022;31(6):e13710.
- Zhang X, Ma L, Feng L. Web-based self-management intervention for patients with cancer: A meta-analysis and systematic review. *J Nurs Schol-arsh*. 2022;54(5):598–606.
- Martín-Núñez J, Medina-Milla J, Ruiz-Montero PJ, Mena-Delgado S, Rivas-Ruiz F, Gómez-Salgado J, et al. Efficacy in urinary symptom burden, psychological distress, and self-efficacy of education-enhanced interventions in prostate cancer patients: a systematic review and meta-analyses. *Support Care Cancer*. 2023;31(6):340.

30. Zhu C, Huang Y, He Y, Wang Y, Gao Z, Lu B, et al. Exercise in cancer prevention and anticancer therapy: efficacy, molecular mechanisms and clinical information. *Cancer Lett*. 2022;544:215814.
31. Salas S, Bernabeu-Wittel M, Walsdorff T, Oyonarte J, Abizanda P, Rodríguez-Manas L et al. Nutritional factors during and after cancer: impacts on survival and quality of life. *Nutrients*. 2022;14(1):2958.
32. Loeb S, Haywood T, Sarwar A, Siddiqui MW, Lieser J, Butaney M, et al. Quality of bladder cancer information on YouTube. *Eur Urol*. 2021;79(1):56–9.
33. Johnson SB, Parsons M, Doroshenko L, Holroyd TA, Waller J, Nutbeam D, et al. Cancer misinformation and harmful information on Facebook and other social media: a brief report. *JNCI J Natl Cancer Inst*. 2022;114(7):1036–9.
34. Kim SM. Development of digital health service for providing patient-specific information and coaching for a healthy life for cancer survivors: annual report, In: Chung-Ang University Industry-Academic Cooperation Foundation, editor. National Cancer Center; Seoul, Republic of Korea. 2024.
35. Wagner EH, Austin BT, Von Korff M. Organizing care for patients with chronic illness. *Milbank Q*. 1996;74(4):511–44.
36. Grover A, Joshi A. An overview of chronic disease models: a systematic literature review. *Glob J Health Sci*. 2014;7(2):210–27.
37. Rosenstock IM, Strecher VJ, Becker MH. Social learning theory and the health belief model. *Health Educ Q*. 1988;15(2):175–83.
38. Carpenter CJ. A meta-analysis of the effectiveness of health belief model variables in predicting behavior. *Health Commun*. 2010;25(8):661–9.
39. Kim SM, Park J, Lee Y, Choi H, Kim H, Kang E, et al. Efficacy of a mobile app for assisting in the self-management of patients with breast cancer on self-efficacy: A non-randomized intervention trial. *JMIR mHealth uHealth*. Forthcoming/in; 2025:63989.
40. Strecher VJ, DeVellis BM, Becker MH, Rosenstock IM. The role of self-efficacy in achieving health behavior change. *Health Educ Q*. 1986;13(1):73–92.
41. Barlow J, Wright C, Sheasby J, Turner A, Hainsworth J. Self-management approaches for people with chronic conditions: a review. *Patient Educ Couns*. 2002;48(2):177–87.
42. Cohen S, Conway BA, Tan YY, Pham V, McKeown MJ. Characterizing patient compliance over six months in remote digital trials of parkinson's and huntington disease. *BMC Med Inf Decis Mak*. 2018;18(1):138.
43. Gaston CM, Mitchell G. Information giving and decision-making in patients with advanced cancer: a systematic review. *Soc Sci Med*. 2005;61(10):2252–64.
44. Liu C, Wang Y, Zhang H, Li J, Zhou X, Zhang X, et al. Effect of multidisciplinary collaborative empowerment education on psychological distress and quality of life in patients with colorectal cancer undergoing chemotherapy. *Support Care Cancer*. 2023;31(2):116.
45. Paltzat K, O'Connor K, Mandarino C, Jeon C, Palepu A, Fainman-Adelman N, et al. Patient perspectives on a tailored self-management education and support intervention for low-income seniors with chronic health conditions. *CJC Open*. 2023;5(11):808–15.
46. Adegoke BO, Odugbese T, Adeyemi C. Harnessing big data for tailored health communication: A systematic review of impact and techniques. *Int J Biol Pharm Res Updates*. 2024;3(2):1–10.
47. Ye M, Du K, Zhou J, Zhou Q, Shou M, Hu B, et al. A meta-analysis of the efficacy of cognitive behavior therapy on quality of life and psychological health of breast cancer survivors and patients. *Psychooncology*. 2018;27(7):1695–703.
48. Heinen JM, Borker A, Heneghan C, Montgomery J, Mohan S, Leneghan A, et al. How do mindfulness-based interventions promote coping and self-efficacy in patients with cancer: a systematic review of qualitative and quantitative data. *Psychooncology*. 2024;33(5):e6350.
49. Ghavami H, Akyolcu N. The impact of lifestyle interventions in breast cancer women after completion of primary therapy: a randomized study. *J Breast Health*. 2017;13(2):94.
50. Krok-Schoen JL, Dancse SC, Rezaee ME, Krok JL. Prevalence of lifestyle behaviors and associations with health-related quality of life among older female cancer survivors. *Support Care Cancer*. 2021;29(6):3049–59.
51. Olson JL, Thompson L, Martinez A, Patel K, Carter D, Lee J, et al. Lifestyle behaviors and health-related quality of life in cancer survivors: a latent class analysis. *Health Educ Behav*. 2024;51(3):341–51.
52. Etz RS, Cohen DJ, Woolf SH, Holtrop JS, Donahue KE, Isaacson NF, et al. Bridging primary care practices and communities to promote healthy behaviors. *Am J Prev Med*. 2008;35(5 Suppl):S390–7.
53. Foster C, Haviland J, Winter J, Grimmett C, Chivers P, Batehup L, et al. Cancer survivors' self-efficacy to self-manage in the year following primary treatment. *J Cancer Surviv*. 2015;9(1):11–9.
54. Kim SH, Lee YJ, Kim JH, Shin SW, Park JH. Psychometric evaluation of a Korean version of the cancer survivors' self-efficacy scale. *Cancer Nurs*. 2019;42(6):509–14.
55. Kang JI, Lee ES, Jo MS, Min JH, Lee S, Son CG. Standardization of the Korean version of Mini-Mental adjustment to cancer (K-Mini-MAC) scale: factor structure, reliability and validity. *Psychooncology*. 2008;17(6):592–7.
56. Watson M, Law MG, Santos MD, Greer S, Baruch J, Bliss J. The Mini-MAC: further development of the mental adjustment to cancer scale. *J Psychosoc Oncol*. 1994;12(3):33–46.
57. Herdman M, Gudex C, Lloyd A, Janssen M, Kind P, Parkin D, et al. Development and preliminary testing of the new five-level version of EQ-5D (EQ-5D-5L). *Qual Life Res*. 2011;20(10):1727–36.
58. Kim SH, Ahn J, Lee Y, Park H, Kim H, Bae S, et al. The EQ-5D-5L valuation study in Korea. *Qual Life Res*. 2016;25(7):1845–52.
59. Vogl D, Rosenfeld B, Breitbart W, Thaler H, Passik S, McDonald M, et al. Symptom prevalence, characteristics, and distress in AIDS outpatients. *J Pain Symptom Manage*. 1999;18(4):253–62.
60. Kroenke K, Spitzer RL, Williams JB. The PHQ-9: validity of a brief depression severity measure. *J Gen Intern Med*. 2001;16(9):606–13.
61. Spitzer RL, Kroenke K, Williams JB, Löwe B. A brief measure for assessing generalized anxiety disorder: the GAD-7. *Arch Intern Med*. 2006;166(10):1092–7.
62. An JY, Park YJ, Kim JH, Kang HJ, Kim DS. Standardization of the Korean version of screening tool for depression (Patient health Questionnaire-9, PHQ-9). *J Korean Soc Biol Ther Psychiatry*. 2013;19(1):47–56.
63. Ahn JK, Kim Y, Choi KH. The psychometric properties and clinical utility of the Korean version of GAD-7 and GAD-2. *Front Psychiatry*. 2019;10:127.
64. Riba MB, Donovan KA, Andersen B, Braun I, Breitbart WS, Brewer BW, et al. Distress management, version 3.2019, NCCN clinical practice guidelines in oncology. *J Natl Compr Canc Netw*. 2019;17(10):1229–49.
65. Cancer Therapy Evaluation Program (CTEP). Common terminology criteria for adverse events (CTCAE) version 5.0. USA: Department of Health and Human Services; 2017.
66. Oken MM, Creech RH, Tormey DC, Horton J, Davis TE, McFadden ET, et al. Toxicity and response criteria of the Eastern cooperative oncology group. *Am J Clin Oncol*. 1982;5(6):649–55.
67. Armstrong T, Bull F. Development of the world health organization global physical activity questionnaire (GPAQ). *J Public Health*. 2006;14:66–70.
68. Borosund E, Varsi C, Clark MM, Ekstedt M, Ruland CM. Digital stress management in cancer: resting stressproffen in a 12-month randomized controlled trial. *Cancer*. 2022;128(7):1503–12.
69. Jacobs JM, McPhillips K, Williams EL, Klem ML, Kinne K, Ip EH, et al. A telehealth intervention for symptom management, distress, and adherence to adjuvant endocrine therapy: A randomized controlled trial. *Cancer*. 2022;128(19):3541–51.
70. Hong JS, Wasden C, Han DH. Introduction of digital therapeutics. *Comput Methods Programs Biomed*. 2021;209:106319.
71. Aapro M, Bossi P, Dasari A, Fallowfield L, Gascón P, Geller M, et al. Digital health for optimal supportive care in oncology: benefits, limits, and future perspectives. *Support Care Cancer*. 2020;28(10):4589–612.
72. van den Berg SW, Gielissen MF, Custers JA, van der Graaf WT, Ottevanger PB, Prins JB. BREATH: Web-based self-management for psychological adjustment after primary breast cancer—results of a multicenter randomized controlled trial. *J Clin Oncol*. 2015;33(25):2763–71.
73. Kim HJ, Lim H, Lee S, Kim JH, Paik S, Sohn TS, et al. A mobile game for patients with breast cancer for chemotherapy self-management and quality-of-life improvement: randomized controlled trial. *J Med Internet Res*. 2018;20(10):e273.
74. Peltola MK, Pöllänen PJ, Jousmäki V, Koskinen S, Pitkänen O, Mäkitie AA, et al. A novel digital patient-reported outcome platform for head and neck oncology patients—a pilot study. *Clin Med Insights Ear Nose Throat*. 2016;9:1–6.
75. Head BA, Keeney CE, Studts JL, Khayat M, Bumpous JM. Development of a telehealth intervention for head and neck cancer patients. *Telemed J E Health*. 2009;15(1):44–52.
76. Cleeland CS, Wang XS, Shi Q, Mendoza TR, Wright SL, Berry MD, et al. Automated symptom alerts reduce postoperative symptom severity after cancer surgery: a randomized controlled clinical trial. *J Clin Oncol*. 2011;29(8):994–1000.
77. Kearney N, McCann L, Norrie J, Taylor L, Gray P, MacGillivray S, et al. Evaluation of a mobile phone-based, advanced symptom management system (ASyMS) in the management of chemotherapy-related toxicity. *Support Care Cancer*. 2009;17(4):437–44.

78. Maguire R, Ream E, Richardson A, Connaghan J, Kotronoulas G, Pedersen VH, et al. Real time remote symptom monitoring during chemotherapy for cancer: European multicentre randomised controlled trial (eSMART). *BMJ*. 2021;374:n1647.
79. Giannopoulos P, Fountzilas E, Papaxoinis G, Karamouzis MV, Andreadis C, Pantazopoulos A, et al. Development, validation and evaluation of a patient information booklet for rectal cancer survivors with a stoma: a three-step approach. *Patient Educ Couns*. 2021;104(9):2275–85.
80. Panjwani A, Li M. Recent trends in the management of depression in persons with cancer. *Curr Opin Psychiatry*. 2021;34(5):448–59.
81. Eldridge SM, Chan CL, Campbell MJ, Bond CM, Hopewell S, Thabane L et al. CONSORT 2010 statement: extension to randomised pilot and feasibility trials. *BMJ*. 2016;355:i5239.
82. Bowen DJ, Kreuter M, Spring B, Cofta-Woerpel L, Linnan L, Weiner D, et al. How we design feasibility studies. *Am J Prev Med*. 2009;36(5):452–7.

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