Effects of “AI-TA” Mobile Application with Intelligent Design on Psychological and Related Symptoms of Young Breast Cancer Survivors: A Randomized Controlled Trial

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Table of Contents

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Abstract

Background: Psychological issues are highly prevalent among breast cancer survivors, especially in the first few years after diagnosis. Young breast cancer survivors reportedly have inadequate mental management and subsequently report lower quality of life compared to older survivors. And mobile health has been widely applied and played a crucial role in this population.

Objective: This study aimed to evaluate the effectiveness of a mobile application with intelligent design called "AI-TA" on cancer-related psychological health and ongoing symptoms in young breast cancer survivors.

Methods: Using the person-centered care framework, a three-month, randomized, controlled, and parallel-group trial was conducted from January 2022 to December 2022. Young breast cancer survivors were recruited from three university-affiliated hospitals. The intervention was composed of a mobile application “AI-TA” with seven modules and two-way online follow-up every two weeks. Participants were randomly assigned to two groups. The primary outcome measures were psychological symptoms measured by the Memorial Symptom Assessment Scale-Short Form (MSAS-SF), the Cancer Behavior Inventory-Brief Version (CBI-B), and the Social Support Rating Scale (SSRS). The secondary outcome is quality of life measured by the Functional Assessment of Cancer Therapy-Breast (FACT-B). Data from both the intention-to-treat and per-protocol groups were analyzed at three time points (baseline, 1-month, and 3-months).

Results: A total of 124 participants were randomly allocated to the control group (n=62) and the intervention group (n=62). The overall dropout rate was 7.3%, and 92.7% of the participants completed the intervention. There were significant improvements in all outcome variables over time for both groups. At the three-month intervention, greater decreases in psychological distress were observed in the intervention group compared to the control group (ITT vs. PP vs. control: 0.52 vs. 0.41 vs. 0.93; P<.001) and in psychological frequency (ITT vs. PP vs. control: 0.74 vs. 0.77 vs. 0.95; P<.001). Moreover, these differences between the intervention and the control groups in physical, social/family, and emotional well-being became significant at the three-month follow-up (P<.001).

Conclusions: The mobile application “AI-TA” incorporating intelligent design shows promise in reducing cancer-related psychological symptoms among young breast cancer survivors. Clinical Trial: Chinese Clinical Trial Registry ChiCTR2200058823; https://www.chictr.org.cn/listbycreater.aspx

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Effects of “AI-TA” Mobile Application with Intelligent Design on Psychological and Related Symptoms of Young Breast Cancer Survivors: A Randomized Controlled Trial

Abstract

Background: Young women often face significant psychological challenges in the initial years following diagnosis, leading to a comparatively lower quality of life than older survivors. While mobile applications have emerged as potential interventions, their effectiveness remains inconclusive due to the diversity in intervention types and variation in follow-up periods. Furthermore, there is a particular dearth of evidence regarding the efficacy of these applications' intelligent features in addressing psychological distress with these applications.
Objective: This study aimed to evaluate the effectiveness of a mobile application with intelligent design called "AI-TA" on cancer-related psychological health and ongoing symptoms with a randomized controlled design.
Methods: Women aged 18 to 45 years old diagnosed with breast cancer were randomly assigned to the intervention or control group. The intervention was “AI-TA” which included two-way online follow-up every two weeks. Both intention-to-treat (ITT) and per-protocol (PP) analyses were adopted repeated measures methods. The participants’ background features, primary outcomes (psychological distress and frequency, self-efficacy, social support) and secondary outcomes (quality of life) were measured using multiple instruments at three time points (preintervention, 1-month intervention, 3-month intervention).
Results: A total of 124 participants were randomly allocated to the control group (n=62) or intervention group (n=62). 92.7% of the participants completed the intervention. Significant improvements in psychological symptoms (Memorial Symptom Assessment Scale-Short Form [MSAS-SF]) were observed in the ITT group from preintervention to 1-month postintervention relative to the control group (ITT vs. control: 1.17 vs. 1.23; *P*<.001) which persisted at 3-month follow-up (ITT vs. control: 0.68 vs. 0.91; *P*<.001). Both the ITT and PP groups exhibited greater improvements in self-efficacy (Cancer Behavior Inventory-Brief Version [CBI-B]) than did the control group at 1-month (ITT vs. PP vs. control: 82.83 vs. 77.12 vs. 65.35; *P*<.001) and 3-month postintervention (ITT vs. PP vs. control: 92.83 vs. 89.30 vs. 85.65; *P*<.001). However, the change in social support (Social Support Rating Scale [SSRS]) did not increase significantly until 3-month postintervention (ITT vs. PP vs. control: 50.09 vs. 49.78 vs. 45.10; *P*<.05). All groups also experienced beneficial effects on quality of life (Functional Assessment of Cancer Therapy-Breast [FACT-B]), which persisted at 3-month follow-up (*P* < .05).
Conclusions: The intelligent mobile application “AI-TA” incorporating intelligent design shows promise for reducing psychological and cancer-related symptoms among young breast cancer survivors.
Trial Registration: Chinese Clinical Trial Registry ChiCTR2200058823; https://www.chictr.org.cn/listbycreater.aspx

Keywords: mobile application; artificial intelligence; interactivity; young breast cancer survivors; psychological symptoms; self-efficacy; social support; quality of life

Introduction

Breast cancer is a significant health concern for women globally, particularly in China, where the incidence

and mortality rates have been steadily rising, accounting for 12.2% and 9.6%, respectively, of the world's total [1,2]. In 2020 alone, approximately 416,371 women were newly diagnosed with breast cancer [3]. Moreover, there is a trend toward a younger age at diagnosis, with the peak prevalence of breast cancer among Chinese women occurring between 45 and 55 years old, which is younger than that of their Western counterparts [2-4].

Life after breast cancer, especially for younger survivors, often entails adverse psychological consequences [5]. Young breast cancer survivors (YBCSs) have greater psychologic morbidity than older women and age-matched women with no cancer history; this includes elevated levels of psychological distress and frequency of persistent disease for at least two years after diagnosis [6]. A substantial proportion of younger women experience long-term iatrogenic effects, including fatigue, persistent pain, lymphedema, and infertility, all of which may negatively affect psychological health [7,8]. Other cancer-related symptoms, such as psychosocial maladjustment, have also been reported during both cancer treatment and rehabilitation [9]. Lacking of confidence and preparedness to cope with can intensify survivors' distress, hinder their reintegration into society, reduce their self-efficacy, and cause significant impairment in quality of life [10,11]. Understanding the dynamic demands of YBCSs is crucial for providing targeted and culturally sensitive support. Our previous research on YBCSs indicated that psychological support is desired early in diagnosis and there is more focus on information provided during treatment [12]. Thus, recognizing the unique characteristics of YBCSs is vital for delivering tailored and comprehensive psychosocial care.

Research indicates that YBCSs have more complex and dynamic needs and face challenges related to cultural norms, psychological disturbances, and a decreased quality of survivorship [13]. Online programs that leverage the accessibility, availability, and cost-effectiveness of the internet have been widely used in breast cancer interventions [14,15]. However, most programs aimed at improving well-being in cancer survivors are not tailored to the specific functions, components, or characteristics of the target population. Information is often generalized and looped and does not accurately align resources with individual needs, rendering them ineffective for many patients. This means that there is no coordinated, personalized, or supportive care; rather, there is only a one-way relationship between programs and patients.

Incorporating artificial intelligence (AI) into interventions offers a promising avenue to address these challenges. AI, as a major component of the internet, can enhance technical interventions and interactions, through the use of a sophisticated blend of human-computer and human-human techniques [16]. Specifically, AI algorithms can analyze user input and provide tailored advice or support based on the user's history and preferences. This personalized interaction increases user engagement and satisfaction, effectively bridging psychological gaps and facilitating a deeper understanding of user needs. At the humanistic level, AI can significantly enhance communication and collaboration. For example, AI-driven platforms can facilitate social support networks or groups, connecting individuals with similar interests or experiences. This approach is particularly useful in therapeutic contexts or online intervention. In healthcare, AI can analyze patient data in real-time to provide up-to-date, personalized health recommendations or alerts, empowering users to access relevant information and engage in dynamic dialogues [17].

Building on previous studies and feedback from interventionists, YBCSs, and health care

professionals, we developed an intelligent interactive mobile application called “AI-TA” (a WeChat Mini Program) guided by a Person-Centered Care (PCC) framework [12,18,19]. The PCC emphasizes collaborative partnerships between patients and healthcare providers [20]. It has been shown to enhance patients’ convictions to engage in desired activities and take responsibility for disease management and clinical outcomes [21-23]. Informed by our pilot study results, we have made necessary adjustments to the intervention strategy and module design [24]. In this study, we expand the sample size to further enhance the effectiveness and generalizability of the findings, hypothesizing that users of “AI-TA” will experience significant improvements in psychological symptoms.

Methods

Study Design

This study was designed as a multicenter, three-month, parallel group, single-blind, two-arm randomized controlled trial (RCT) conducted in three university-affiliated hospitals from January 2022 to December 2022. The present study investigated the effectiveness of “AI-TA” on psychological and related symptoms of YBCSs from baseline (T0) to two follow-up points (1 month (T1) and 3 months (T2)). The trial was approved by the Chinese Clinical Trial Registry (ChiCTR2200058823).

Recruitment

Participants were recruited through convenience sampling, aligning with findings from prior studies [25-27], and considering the menopausal age of women. The inclusion criteria for the participants were as follows: (1) Chinese females; (2) aged 18 to 45 years old; (3) diagnosed with stage I-III breast cancer; and (4) able to access the internet using computer or mobile devices; (5) able to read and write in Chinese (traditional or simplified); and (6) provided informed consent. The exclusion criteria were as follows: (1) chronic or acute physical conditions that significantly impairs daily functioning or requires intensive medical care and supervision that could detract from intervention participation or measurement of outcomes; (2) serious cognitive or communication barriers (including but not limited to medical diagnoses of advanced dementia, severe aphasia, or other neurological conditions significantly impairing understanding or expression); (3) recurrent or metastatic breast cancer; and (4) concurrent involvement in other studies.

Randomization

To ensure the quality of the entire study and prevent selection and information bias, our researchers received unified training and were divided into different group role: (1) recruiter: two breast clinical nurses will strictly recruit YBCSs according to the inclusion and exclusion criteria, and record recruitment information; (2) an independent master candidate randomly assigned YBCSs to two-armed parallel groups at a 1:1 ratio via a computer-generated digital sequence; (3) intervener: an experienced researcher conducted the interventions, with another researcher serving as the intervention companion, responsible for supervision and evaluation; and (4) data collectors: collect and analyze all participants' data and the results of the intervention by double-checking. During the process, blinding was applied to the recruiters and data collectors.

Procedure

The participants in the control and intervention groups received oral and written instructions

on how to use the "AI-TA", which combines a mobile application with fortnightly online follow-up. Each participant used her own WeChat ID to register and log in with a unique or random number for access to "AI-TA" and was told not to discuss the research with other YBCSs so that no identifying information would be linked to them and to reduce contamination. At first enrollment, they were required to complete and return electronic questionnaires, which included sociodemographic, cancer-related characteristics, and psychological and accompanying symptoms in "AI-TA" after informed consent was obtained. The initial baseline evaluation of symptoms was classified at T0. Data collection and assessments of outcomes took place over two time points in the follow-up period. T1 assessment took place at 1 month after allocation (intermediate period of intervention), T2 assessment took place at 3 months after allocation (endpoint of the intervention). Follow-up assessments were collected via "AI-TA"-assisted self-reported surveys. Each result was saved and available for participants to view their own at any time. In addition, all participants were awarded 100 yuan (US $13.80) upon completing all the assessments. And there was a questionnaire to assess participants' interaction of and satisfaction with the "AI-TA" mobile application program for further improvements in the following research (see Multimedia Appendix 1).

Intervention

"AI-TA" consisted of several modules designed to support YBCSs in various aspects of their survivorship. The mobile application that stores reliable resources uploaded by health care professionals occasionally from time to time and covers psychological counseling, coping effectiveness, symptom management, social security, etc., in text, image, and animation formats. It also allowed YBCSs to synchronously save their log-in, comments, likes, history, duration and traces. In addition, the health care professionals invited breast clinical experts to hold salon lectures, focusing on common problems in treatments involving diet guidance, functional exercise, tube maintenance and other guidance. Q&A sessions were incorporated, and recorded videos were made available for review. Visual representations of "AI-TA" are shown in Figure 1. Additional details relating to the intervention construction can be found in Figure 2.

AI-driven System

An AI-driven system is central to our intervention, utilizing text extraction techniques and behavioral data analysis to provide personalized recommendations. This innovative approach significantly enhances user engagement and retention by tailoring content to individual preferences and interests. The following functions were taken: (1) Personalized content delivery: The AI system analyzes responses from questionnaires to prioritize issues and deliver tailored content. For instance, if YBCSs reported low physical activity and poor sleep quality, keywords like "physical", "exercise", "activity", and "sleep" were used to recommend relevant articles. (2) Symptom tracking and management: The system regularly tracks YBCSs' symptoms and allows healthcare professionals to update and tailor content based on YBCSs' browsing preferences, enhancing the relevance and effectiveness of the information provided. (3) Data monitoring and evaluation: AI algorithms can calculate and monitor assessment progress, and synchronous storage in the server backend. (4) Social support network: AI can enable the formation of connections in forums with independent YBCSs. It fosters a supportive online environment through interactive Q&A sessions, experience sharing, and emotional support. (5) Privacy and security: Adhering to healthcare data regulations, the AI system employs encryption measures to ensure the utmost privacy and security of user data. AI-driven system is a vital link, that enables the exchange and feedback of information in peer-to-peer interactions, between YBCSs and healthcare professionals, and enhances the interactive experience. This dynamic approach ensures that the intervention remains relevant, engaging,

and supportive of the unique needs of YBCSs.

Two-way Online Follow-up

Furthermore, the intervention program included fortnightly online follow-up, employing two-way communication through private messages or calls. This approach encouraged narration from YBCSs and aimed to establish a partnership using PCC communication skills such as open-ended questions, reflections, and summaries. In the initial conversation, health care professionals focused on listening to YBCSs' narratives about daily life events and customs (diet, motion, pressure, hobbies, relationships, and sharing) to build trust relationships. The subsequent step entailed the anticipation and cocreation of a health plan jointly based on YBCSs' feedback through discussion and agreement, including goals, resources, and needs. The contents about what YBCSs had talked about, how they felt, what goals they had, and what they wanted to accomplish will be the points for the forthcoming conversations to consider. During the three-month intervention, YBCSs were also free to get in touch with the health care professionals during office hours. Each follow-up was recorded and uploaded to the platform.

General Information Support

The control group was granted access to general information on the mobile application, with all modules available in "AI-TA" except for forums and intelligent recommendations. That meant that they could not participate in the forum and obtain recommendations made by the system based on questionnaire results. In addition, YBCSs in the control group also had no follow-up conversations.

Measures and Instruments

A comprehensive set of questions was used to assess YBCSs' sociodemographic and health characteristics, including age, height, weight, habitation, educational attainment, marital status, employment, income, offspring, parent, cancer stage (stage I-III), cancer type, diagnosis time, and treatment.

Primary Outcome Measures

Psychological distress and frequency

The Memorial Symptom Assessment Scale-Short Form (MSAS-SF) was used to assess the frequency and severity of psychological symptoms during the past 7 days [28]. The distress level of each symptom was rated on a 5-point Likert scale (0 = "not at all," 1 = "a little bit," 2 = "somewhat," 3 = "quite a bit," 4 = "very much"). If the symptom was not present, a value of zero was assigned. The frequency of psychological symptoms is rated from 1 to 4 (1 = "rarely," to 4 = "almost constantly").

Self-efficacy

The Cancer Behavior Inventory-Brief Version (CBI-B) developed by Heitzmann was adopted to rate self-efficacy for coping with cancer [29]. It is used to assess four factors: (1) maintaining independence and positive attitude, (2) participating in medical care, (3) coping and stress management, and (4) managing affect. There are 12 items in total (on a 9-point Likert scale; from 1 = "not at all confident" to 9 = "totally confident"); a score ≤ 36 is considered low, a score between 37 and 72 is considered moderate, and a score between 73 and 108 is considered high.

Social Support

The Social Support Rating Scale (SSRS) is a 10-item questionnaire developed by Shuiyuan Xiao for measuring social support, including objective social support, subjective social support, and

utilization of social support [30]. A higher score indicated more social support. The SSRS has been widely used and has shown acceptable reliability and validity in the cancer population. A SSRS score ≤ 22 is considered poor social support, a score between 23 and 44 is considered moderate social support, and a score between 45 and 66 indicates adequate social support.

Secondary Outcome Measures

Quality of Life

The Functional Assessment of Cancer Therapy-Breast (FACT-B) translated and adapted by Chonghua Wan was used to evaluate the quality of life of breast cancer patients [31]. The five dimensions included: physical well-being, social/family well-being, emotional well-being, functional well-being, and additional concerns (cancer type-specific questions). A total of 36 items were scored on a 5-point Likert scale (0 = “not at all,” 1 = “a little bit,” 2 = “somewhat,” 3 = “quite a bit,” 4 = “very much”). Among them, 19 items were scored in a reverse manner. Higher scores represent better quality of life.

Sample Size

This study used G*Power 3.1 software to calculate the necessary sample size. Based on a similarly designed study, mobile application support reduced the psychological symptoms among breast cancer survivors with an effect size of 0.77 [32]. Considering the conservative estimate and the variability of previous pilot research [24] as well as the statistical power [33], we estimated that 66 participants were needed to compare between-group differences and present a large effect size (d=0.8) in the primary outcome after intervention with an alpha level of .05 (2-sided test), 80% statistical power, 1:1 allocation rate, 20% attrition rate. Thus, a final sample of 124 with 62 individuals in each group the was adequate.

Ethics Approval

The trial was approved by the Ethics Committee of Public Health and Nursing Research, School of Medicine, Shanghai Jiao Tong University (SJTUPN-201803). All participants provided electronic informed consent before enrollment in the study. All data and information were anonymized according to the established guidelines, and a password-protected document containing participants’ personal information was stored on secure servers.

Statistical Analysis

Data analysis was performed using SPSS version 26.0. Descriptive and comparative statistics were used to characterize the study groups (e.g., percentage or mean and standard deviation). Two-sample t tests and chi-square or Fisher exact tests were used where appropriate, and these tests assessed demographic variable differences between the intervention and control groups. Before performing the t test, the continuous variables were checked for normality using the Shapiro–Wilk test, and all the data were revealed to be normal (P>.05). To confirm the improvements in psychological symptoms, the baseline and postintervention results of the dependent variables were analyzed using the paired t tests, whereas the two-sample t tests were used to detect differences between the intervention and control groups at each time point. To estimate the effects of the intervention on the outcomes over time, a linear mixed-effect model for repeated measurements was performed. The main effects of group, time as well as group × time interaction effects were examined. The significance level was set at P<.05 (2-sided).

For this study, both intention-to-treat (ITT) and per-protocol (PP) analyses were conducted. The primary analysis used an ITT approach which can reflect the results of all participants randomly assigned to receive intervention; and missing fields were imputed with the Expectation Maximization (EM) Algorithm. Post hoc sensitivity analyses for missing data were performed to ensure the integrity and reliability of the trial outcomes (see Multimedia Appendix 2). The PP group analysis included participants who fully followed the intervention protocol. The primary endpoints for evaluating the efficacy of "AI-TA" were MSAS-SF, CBI-B and SSRS to assess psychological symptoms (distress and frequency), self-efficacy and social support, respectively, at T2. Secondary end point was FACT-B, measures of quality of life.

Results

Participants

Data were collected through questionnaires at T0, T1 and T2. Approximately 7.3% (9/124) of participants (2/62, 3.2% in the intervention group and 7/62, 11.3% in the control group) did not complete all baseline assessment at T0. At T1 and T2, 1.7% (2/115) of participants did not return their questionnaires despite being reminded. A flowchart of the study participants is given in Figure 3.

Overview

Table 1 provides an overview of the sociodemographic and health characteristics of YBSCs at T0. In this study, the participants had an average age of 40.21 (SD 4.24) years, a mean height of 161.16 (SD 4.24) cm, and a mean weight of 55.9 (SD 8.56) kg. The average time since diagnosis was 1.42 (SD 0.3) years. Approximately 90% of YBCSs were living in urban areas and were married. Approximately 94% had children, and 82% of the YBCSs' parents were in good health. Over 50% were employed, and their monthly income was more than 10,000 RMB. Additionally, YBCSs tended to be highly educated; approximately 50% were college graduates and some had graduate degrees. Almost 95% of YBCSs had invasive breast cancer, and approximately 65% were diagnosed with stage II or stage III breast cancer. A total of 11% only underwent surgical treatment, 43% only received adjuvant treatment, and 46% had both. No significant differences were observed in the demographic characteristics between the intervention and control groups, except that the time since diagnosis of YBCSs in the control group was significantly longer than that in the intervention group (P=.03). However, this difference did not remain when comparing the control and PP groups (P=.18).

The Effects on Primary outcomes

Table 2 presents the overall test results of the intervention effect on psychological symptoms through repeated measures analysis. There were statistically significant group effects, time effects and group × time interaction effects on the changes in the MSAS-SF and CBI-B scores. And significant time effects (F=236.123 P<.001) and group × time interaction effects (F=36.639 P<.001) were found in the ITT analysis for the SSRS score, yet, only a significant time effect (F=231.187 P<.001) in the PP analysis.

As demonstrated in Table 3, there were no significant differences in any of variables between groups at T0, which supported successful randomization. Over time, the impact of the intervention grows increasingly significant across all primary outcomes except for psychological frequency, there is no significant difference within the ITT group (P>.05). At T2, psychological distress (ITT vs. PP vs. control: 0.40 vs. 0.41 vs. 0.93; P<.001) were significantly different among the groups. In addition, each group exhibited significant differences (ITT vs. PP

vs. control: 92.83 vs. 89.30 vs. 85.65; *P*<.001) in self-efficacy; however, compared with those in the control group, the ITT group and PP groups did not show significant increases in social support scores until T2 (*P*<.05).

The Effects on Secondary Outcomes

First, the analysis highlighted a statistically significant group effect, time effect and group × time interaction effect for quality of life (all *P*<.05) in both the ITT group and PP group (Table 2).

The results at T1(ITT vs. PP vs. control: 106.68 vs. 105.73 vs. 100.33; *P*<.05) and T2 (ITT vs. PP vs. control: 124.47 vs. 126.04 vs. 113.50; *P*<.001) indicated that there was significant improvement in overall quality of life. Notably, significant differences between and within all groups were found in functional well-being and additional concerns both in T1 and T2. And compared with those in the control group, the ITT group and PP groups did not show significant increases in physical, social/family, and emotional well-being until T2 (*P*<.05).

Table 1. Participant characteristics at baseline (N=115)

Characteristics	Control group (n=55)	[a]ITT group (n=60)		[b]PP group (n=52)	
	Value	Value	*P* value	Value	*P* value
Age (years), mean (SD)	40.02 (4.32)	40.40 (4.16)	.68	40.66 (4.34)	.27
Height (cm), mean(SD)	160.55 (4.36)	161.76 (4.12)	.19	161.71 (4.43)	.32
Weight (kg), mean (SD)	55.37 (7.51)	56.43 (9.61)	.57	56.60 (9.56)	.86
Diagnosis (years), mean (SD)	1.53 (0.34)	1.31 (0.26)	.03	1.50 (0.29)	.18
Residence, n (%)			.62		.69
Urban	48 (87.3)	55 (91.7)		50 (96.2)	
Rural	7 (12.7)	5 (8.3)		2 (3.8)	
Marital status, n (%)			.74		.09
Married	51 (92.7)	53 (88.3)		48 (92.4)	
Single	3 (5.5)	5 (8.3)		2 (3.8)	
Other	1 (1.8)	2 (3.4)		2 (3.8)	
Child, n (%)			.62		.63
Have	52 (94.5)	56 (93.3)		49 (94.2)	
Do not have	3 (5.5)	4 (6.7)		3 (5.8)	
Parent, n (%)			.99		.44
Both	46 (83.6)	48 (80.0)		44 (84.5)	
Either	7 (12.7)	11(18.3)		8 (15.5)	
Neither	2 (3.7)	1 (1.7)		0 (0.0)	
Work status, n (%)			.95		.55
Unemployed	19 (34.5)	18 (30.0)		14 (26.9)	
Employed	36 (63.5)	42 (70.0)		38 (73.1)	
Education level, n (%)			.60		.36
≤Junior college	24 (43.6)	33 (55.0)		26 (50.0)	
College	26 (47.3)	23 (38.3)		23 (44.2)	
Postgraduate	5 (9.1)	4 (6.7)		3 (5.8)	
Monthly income (CNY ¥), n (%)			.57		.90
<5000	11 (20.0)	11 (18.3)		8 (15.5)	
5000-10000	15 (27.3)	17 (28.3)		15 (28.8)	

>10000	29 (52.7)	32 (53.4)		29 (55.7)	
Type of breast cancer, n (%)			.45		.89
Invasive	51 (92.7)	58 (96.7)		50 (96.2)	
Noninvasive	4 (7.3)	2 (3.3)		2 (3.8)	
Stage of breast cancer, n (%)			.13		.07
Stage I	19 (34.5)	21 (35)		14 (26.9)	
Stage II	30 (54.5)	28 (46.7)		28 (53.8)	
Stage III	6 (11.0)	11 (8.3)		10 (19.3)	
Therapy for breast cancer, n (%)			.34		.66
Operation	5 (9.1)	8 (13.3)		3 (5.8)	
[c]Adjuvant therapy	26 (47.3)	23 (38.4)		20 (38.5)	
Both	24 (43.6)	29 (48.3)		29 (55.7)	

[a]ITT: intention-to-treat.
[b]PP: per-protocol.
[c]Adjuvant therapy includes radiotherapy, chemotherapy, endocrine therapy, etc.

Table 2. Repeated measures analysis of variance results for scores of psychological symptoms

Variable	[a]ITT			[b]PP		
	Group effect (*P* value)	Time effect (*P* value)	Group × time effect (*P* value)	Group effect (*P* value)	Time effect (*P* value)	Group × time effect (*P* value)
[c]MSAS-SF	14.118 (<.001)	75.718 (<.001)	2.219 (<.001)	13.916 (<.001)	75.007 (<.001)	2.222 (<.001)
[d]CBI-B	7.956 (.007)	526.864 (<.001)	23.850 (<.001)	7.838 (.007)	529.502 (<.001)	23.558 (<.001)
[e]SSRS	0.099 (.754)	236.123 (<.001)	36.639 (<.001)	0.123 (.192)	231.187 (<.001)	37.928 (.162)
[f]FACT-B	6.081 (.018)	275.261 (<.001)	36.978 (<.001)	2.571 (.017)	325.216 (<.001)	45.457 (<.001)

[a]ITT: intention-to-treat; n=60 in the intervention group, n=55 in the control group.
[b]PP: per-protocol; n=52 in the intervention group, n=55 in the control group.
[c]MSAS-SF: The Memorial Symptom Assessment Scale-Short Form.
[d]CBI-B: The Cancer Behavior Inventory-Brief Version.
[e]SSRS: Social Support Rating Scale.
[f]FACT-B: The Functional Assessment of Cancer Therapy-Breast.

Table 3. Changes in psychological symptoms at baseline and postintervention

Variable		Control group (n=55)	[a]ITT group (n=60)		[b]PP group (n=52)	
		Mean (SD)	Mean (SD)	[c]*P* value	Mean (SD)	[c]*P* value
[d]MSAS-SF						
	T0	1.51 (0.50)	1.56 (0.47)	.250	1.59 (0.43)	.209
	T1	1.23 (0.37)[e]	1.17 (0.46)[e]	<.001	1.07 (0.50)[e]	.375

T2	0.91 (0.22)[e]	0.68 (0.21)[ef]	<.001	0.88 (0.20)[e]	.050
Psychological frequency					
T0	1.52 (0.29)	1.43 (0.36)	.670	1.50 (0.25)	.490
T1	1.45 (0.14)	1.41 (0.19)	.006	1.36 (0.17)	<.001
T2	0.95 (0.21)[ef]	0.83 (0.13)	<.001	0.77 (0.20)[ef]	<.001
Psychological distress					
T0	1.59 (0.14)	1.48 (0.11)	.380	1.37 (0.18)	.750
T1	1.22 (0.12)[e]	0.79 (0.25)[e]	<.001	0.80 (0.13)[e]	<.001
T2	0.93 (0.17)[ef]	0.40 (0.16)[ef]	<.001	0.41 (0.19)[ef]	<.001
Global distress					
T0	1.46 (0.26)	1.30 (0.17)	.070	1.31 (0.22)	.920
T1	1.23 (0.11)[e]	0. 94(0.23)[e]	<.001	0.95 (0.14)[e]	<.001
T2	1.03 (0.13)[ef]	0.41 (0.20)[ef]	<.001	0.54 (0.11)[ef]	<.001
Physical distress					
T0	1.08 (0.15)	1.16 (0.10)	.300	1.13 (0.17)	.410
T1	0.75 (0.14)[e]	0.56 (0.25)[e]	.002	0.61 (0.15)[e]	.030
T2	0.49 (0.15)[ef]	0.32 (0.12)[ef]	<.001	0.39 (0.11)[ef]	.010
[g]CBI-B					
T0	37.07 (3.50)	36.13 (6.72)	.075	36.62 (3.81)	.439
T1	65.35 (3.06)[e]	82.83 (5.70)[e]	<.001	77.12 (4.27)[e]	<.001
T2	85.65 (2.79)[ef]	92.83 (3.04)[ef]	<.001	89.30 (5.18)[ef]	<.001
Maintaining independence and a positive attitude					
T0	5.27 (1.56)	5.39 (1.88)	.791	5.28 (1.63)	.225
T1	6.00 (1.41)[e]	6.98 (1.88)[e]	.045	6.97 (1.88)[e]	.021
T2	6.48 (1.35)[ef]	7.84 (1.48)[ef]	.001	7.85 (1.47)[ef]	.001
Participating in medical care					
T0	6.32 (1.55)	6.27 (2.06)	.577	6.07 (1.74)	.55
T1	6.89 (1.31)[e]	7.28 (1.56)[e]	.013	7.27 (1.56)[e]	.039
T2	7.77 (1.19)[ef]	7.78 (1.63)[e]	.031	7.80 (1.35)[ef]	.050
Coping and stress management					
T0	4.91 (1.67)	5.07 (1.69)	.911	5.14 (1.16)	.891
T1	5.76 (1.24)[e]	6.91 (1.55)[e]	.001	6.88 (1.56)[e]	.049
T2	6.79 (1.18)[ef]	7.74 (1.27)[ef]	<.001	7.70 (1.26)[ef]	<.001

Managing affect						
	T0	5.55 (0.95)	5.40 (1.81)	.147	5.39 (1.85)	.131
	T1	5.60 (1.67)[e]	6.62 (1.57)[e]	<.001	6.62 (1.58)[e]	<.001
	T2	6.76 (0.59)[ef]	7.62 (1.47)[ef]	<.001	7.63 (1.45)[ef]	<.001
[h]SSRS						
	T0	39.33 (7.39)	38.04 (8.19)	.073	39.47 (7.24)	.50
	T1	42.31 (6.68)[e]	42.67 (7.94)[e]	.735	42.45 (7.80)[e]	.743
	T2	45.10 (6.44)[ef]	50.09 (4.95)[ef]	.002	49.78 (5.09)[ef]	<.001
Objective social support						
	T0	10.24 (3.58)	9.53 (3.08)	.267	9.70 (3.12)	.531
	T1	11.62 (3.24)[e]	11.76 (3.51)[e]	.620	11.82 (3.32)[e]	.787
	T2	12.69 (3.19)[ef]	14.66 (2.63)[ef]	.027	14.88 (2.57)[ef]	.010
Subjective social support						
	T0	21.62 (4.19)	21.72 (4.99)	.360	21.33 (4.66)	.425
	T1	22.48 (3.87)[e]	22.62 (4.88)[e]	.804	23.52 (4.42)[e]	.617
	T2	23.4 (3.71)[ef]	25.28 (2.74)[ef]	.019	25.61 (2.62)[ef]	.030
Utilization of social support						
	T0	7.48 (2.03)	7.57 (2.03)	.311	7.36 (2.04)	.135
	T1	8.21 (1.8)[e]	8.29 (2.22)[e]	.403	8.39 (2.21)[e]	.241
	T2	9 (1.75)[ef]	10.16 (1.33)[ef]	.007	10.09 (1.38)[ef]	.047

[a]ITT: intention-to-treat.
[b]PP: per-protocol.
[c]*P* value of between-group differences.
[d]MSAS-SF: The Memorial Symptom Assessment Scale-Short Form.
[e]Compared with T0, P<.05.
[f]Compared with T1, P<.05.
[g]CBI-B: The Cancer Behavior Inventory-Brief Version.
[h]SSRS: Social Support Rating Scale.

Table 4. Changes in quality of life at baseline and postintervention

Variable		Control group (n=55)	[a]ITT group (n=60)		[b]PP group (n=52)	
		Mean (SD)	Mean (SD)	[c]*P* value	Mean (SD)	[c]*P* value
[d]FACT-B						
	T0	92.48 (15.15)	90.02 (12.44)	.525	91.64 (12.85)	.301
	T1	100.33 (12.32)[e]	106.68 (12.49)[e]	.014	105.73 (12.54)[e]	.022

T2	113.50 (11.20)[ef]	124.47 (9.14)[ef]	<.001	126.04 (10.69)[ef]	<.001
Physical well-being					
T0	20.5 (4.27)	20.04 (5.05)	.652	19.73 (4.99)	.755
T1	21.17 (3.66)[e]	21.61 (4.44)[e]	.450	22.8 (4.41)[e]	.449
T2	22 (3.57)[ef]	24.91 (3.00)[ef]	<.001	24.48 (3.73)[ef]	<.001
Social/family well-being					
T0	19.86 (5.07)	20.11 (7.93)	.092	19.48 (5.35)	.075
T1	20.52 (3.76)[e]	21.31 (4.37)[e]	.395	21.10 (4.51)[e]	.396
T2	21.45 (3.47)[ef]	24.89 (2.88)[ef]	<.001	24.73 (2.24)[ef]	<.001
Emotional well-being					
T0	12.88 (4.27)	12.87 (4.28)	.988	12.48 (4.51)	.844
T1	15.45 (3.01)[e]	15.98 (2.57)[e]	.399	18.36 (4.78)[e]	.401
T2	17.24 (2.99)[ef]	18.50 (2.57)[ef]	<.001	22.48 (3.51)[ef]	.024
Functional well-being					
T0	12.57 (5.11)	12.89 (6.75)	.818	12.14 (5.06)	.482
T1	15.55 (3.92)[e]	17.86 (4.72)[e]	.008	17.91 (4.21)[e]	.008
T2	18.29 (3.63)[ef]	23.85 (3.84)[ef]	<.001	22.14 (3.08)[ef]	<.001
Additional concerns (cancer type-specific questions)					
T0	26.67 (3.69)	26.91 (5.85)	.573	26.48 (4.11)	.481
T1	27.64 (3.35)[e]	29.92 (4.78)[e]	.025	28.00 (3.66)[e]	.021
T2	28.52 (3.38)[ef]	32.31 (3.29)[ef]	<.001	31.17 (3.52)[ef]	<.001

[a]ITT: intention-to-treat.
[b]PP: per-protocol.
[c]*P* value of between-group differences.
[d]FACT-B: The Functional Assessment of Cancer Therapy-Breast.
[e]Compared with T0, P<.05.
[f]Compared with T1, P<.05.

Discussion

Principal Results

This RCT examined the effectiveness of an internet-enabled, mobile, intelligent interactive intervention for YBCSs over a three-month period. The findings demonstrated the benefits of utilizing a mobile application and engaging in two-way online follow-up. Significant improvements were observed in psychological symptoms, including distress and frequency, indicating the positive impact of the intervention. Additionally, there was a noticeable trend toward improvement in quality of life outcomes, with both the ITT and PP analyses showing consistent overall outcomes.

We observed that the MSAS-SF score decreased from moderate to mild in all groups, and

psychological distress also significantly decreased by 1.08 in the ITT group and 0.96 in the PP group from baseline; these findings were more pronounced than those of American breast cancer survivors [32] and lung cancer survivors [34]. In addition, a significant reduction between groups in the frequency of psychological problems was found (e.g., sadness, worry, irritability, nervousness), with 0.83 in the ITT group and 0.77 in the PP group at T2. Clinical evidence has confirmed that cancer survivors who approach isolated/marginalized people with stigmatized conditions and underserved populations to confide negative emotions and relieve themselves, may become stuck in a psychological trap [35]. “AI-TA” adopted multiple approaches to alleviate psychological distress and reduce the frequency of psychological symptoms. For example, individuals could connect and offer spiritual support to each other in a private forum, allowing YBCSs to openly share experience and advice and thereby overcoming the hesitation often caused by traditional cultural norms. Online follow-up enables continuous care between health care professionals and YBCSs, providing targeted educational contents such as information about stress relief, emotional management, and other relevant information [36]. By integrating the assessments from AI-driven system with qualitative insights from interviews, the follow-up can be more accurate to address the nuanced needs of YBCSs, ensuring that the care provided is both relevant and effective. In this study, YBCSs had a lower frequency of psychological symptoms at baseline and therefore had little margin for improvement at T1 and T2 in the ITT group, conversely, the PP group demonstrated notable enhancements. This disparity may relate the duration or intensity of the intervention [37]. In addition, the greater increase in physical and global distress in the intervention group identified the necessity of intelligent interactive support for YBCSs.

The findings reported in this paper align with the literature, indicating that the intervention program "AI-TA" had a positive effect on increasing self-efficacy levels, as reported previously [32]. In particular, the ITT and PP groups had already reached a high level of self-efficacy at T1, which was faster than the control group. Among them, coping and stress management showed a borderline significant trend between groups at T1, and it became better at T2. This is likely because YBCSs lacked motivation and familiarity with “AI-TA” at first, resulting in insufficient in-depth effects on YBCSs [38]. Although the intervention group exhibited more favorable changes in several self-efficacy variables, all the groups experienced positive changes, which indicated that the general information support also played a certain role in promoting YBCSs.

In this study, the changes in symptoms among YBCSs were similar to changes in their levels of self-efficacy. Several explanations have been proposed to account for the relationship between syndrome and self-efficacy: cancer patients with high self-efficacy have a high level of health beliefs, which may promote the recovery from symptoms; in contrast, those with low self-efficacy are prone to negative emotions such as anxiety and depression, which are not conducive to recovery from psychological and physical symptoms [39,40]. AI-driven system and fortnightly online follow-up encouraged YBCSs to actively engage with the provided content, enhancing their participation and initiative. This interactive process improved their confidence and self-efficacy in managing their symptoms, as the AI continually adapts to their evolving needs and responses.

Furthermore, while all groups’ total social support scores were sustained and reached adequacy by T2; no significant effect was observed across any dimension at T1. This initial absence can be attributed to the challenges faced by YBCSs. Frequently undergoing treatments and grappling with severe side effects, YBCSs likely found themselves with limited energy to engage with the AI-driven tool (AI-TA) or to communicate effectively with healthcare

professionals [41]. Besides, research has identified several factors that affect cancer survivors' perception of social support. Specifically, young patients with a collectivist orientation who value in-group solidarity and interdependence, may feel alienated from or resist joining groups perceived as outside their usual social circles in a short term [42]. Initially, "AI-TA" may not show a significant impact. The novelty of such applications and their integration into survivors' lives requires time to manifest tangible benefits. However, as these AI-driven systems evolve to more accurately assess and respond to daily symptoms, their potential to significantly enhance health management and symptom control for YBCSs grows. Over time, continued engagement with "AI-TA", is likely to foster social support, deeper understanding of the disease, and overall better well-being for YBCSs. The gradual accumulation of these positive effects underscores the promise of long-term interventions to bolster survivors' outcomes.

This work revealed that "AI-TA" mobile application has been shown to work effectively in improving quality of life. The findings in physical, social/family, and emotional well-being of YBCSs did not increase until T2. Previous literature has also been published in the field of internet- or computer-based interventions for breast cancer survivors, and the results indicate that internet support has no significant impact on quality of life in recently diagnosed breast cancer survivors [43]. Particularly in the early postoperative period and before and after chemotherapy, the recovery of physical well-being and role function was slower [44]. In addition to confronting the challenges of disease itself, YBCSs often experience negative emotions associated with work, childbirth, support, and other pressures, as well as feelings about being abandoned by the medical system [45]. The integration of online follow-up through AI-driven system fosters continuous interaction and support, which is crucial for YBCSs managing sensitive and often underdiscussed topics such as sexual health. These not only allow real-time monitoring and assistance but also facilitates a space for YBCSs to seek guidance and share experiences securely and comfortably.

Limitations

There are several limitations to this research that weaken the generalizability of these findings and warrant further investigation. First, because of the relatively small population size and heterogeneity of treatment, a small study that may not detect significant effects on whole psychological symptom outcomes. Second, it is possible that YBCSs with different types of cancer would react differently to the content of this intervention. Furthermore, the duration of this study was short; thus, in the future, long-term interventions could be carried out to detect differences between groups.

Conclusions

The mobile application "AI-TA" demonstrated significant benefits in addressing the psychological health needs of YBCSs during their survivorship journey. The consistent duration, intelligent support, and ease of interaction and online follow-up facilitated through digital platforms contributed to the success of the intervention. Specifically, AI-driven features such as personalized content delivery based on user feedback, symptom tracking and management, and interactive support networks have proven crucial for enhancing self-efficacy and social support among YBCSs. Emphasis should be placed on optimizing the frequency of interaction and content delivery during an intervention to sustain user engagement without inducing fatigue. The observed effect size on psychological and related symptoms warrants further exploration, prompting future research to expand and investigate the efficacy of such AI-driven interventions in larger trials and across diverse populations over extended periods.

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Conflicts of Interest

None declared.

Abbreviations

AI: artificial intelligence
CBI-B: Cancer Behavior Inventory-Brief Version
FACT-B: Functional Assessment of Cancer Therapy-Breast
ITT: intention-to-treat
MSAS-SF: Memorial Symptom Assessment Scale-Short Form
PCC: Person-Centred Care
PP: per-protocol
RCT: randomized controlled trial
SSRS: Social Support Rating Scale
T0: baseline
T1: 1-month postintervention
T2: 3-month postintervention
YBCSs: young breast cancer survivors

Multimedia Appendix 1

Questionnaire to assess participants' interaction of and satisfaction with the "AI-TA" mobile application program.

Multimedia Appendix 2

Post hoc sensitivity analyses for missing data.

Multimedia Appendix 3

CONSORT EHEALTH form V1.6.

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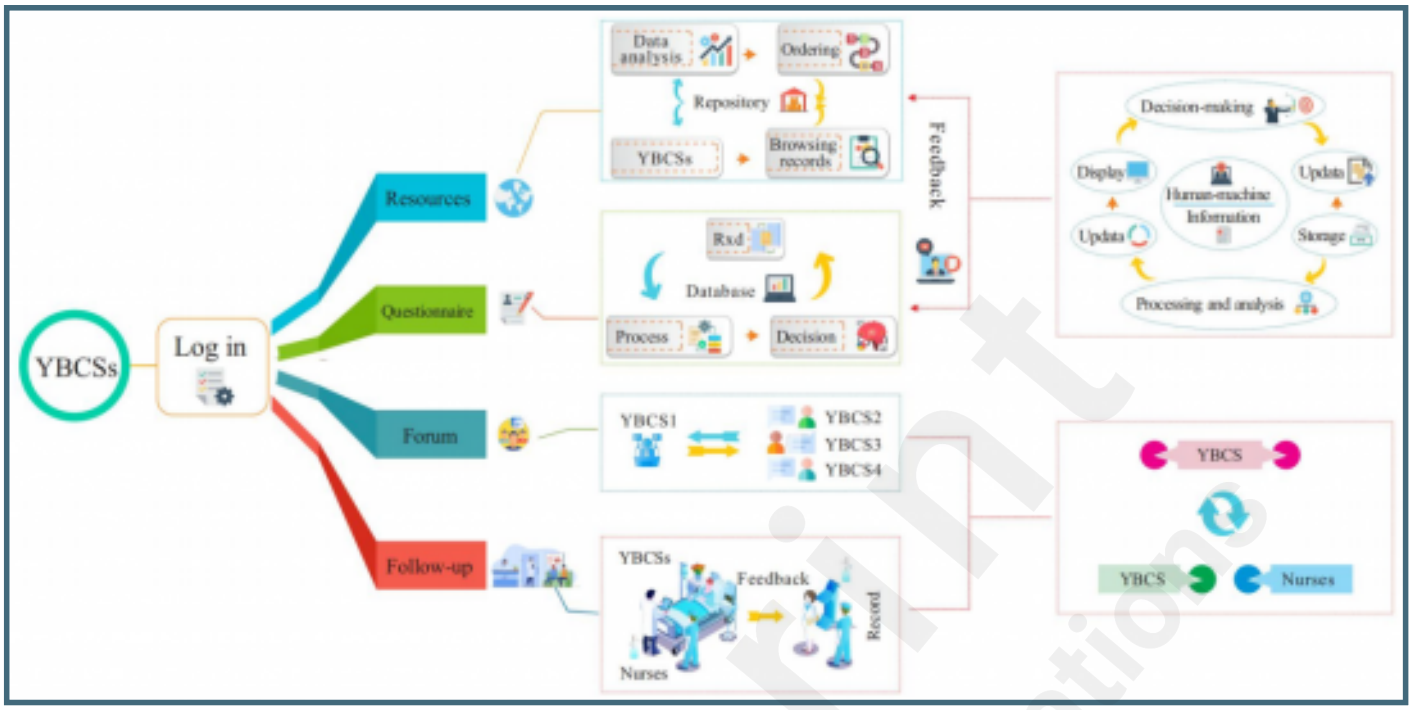
Supplementary Files

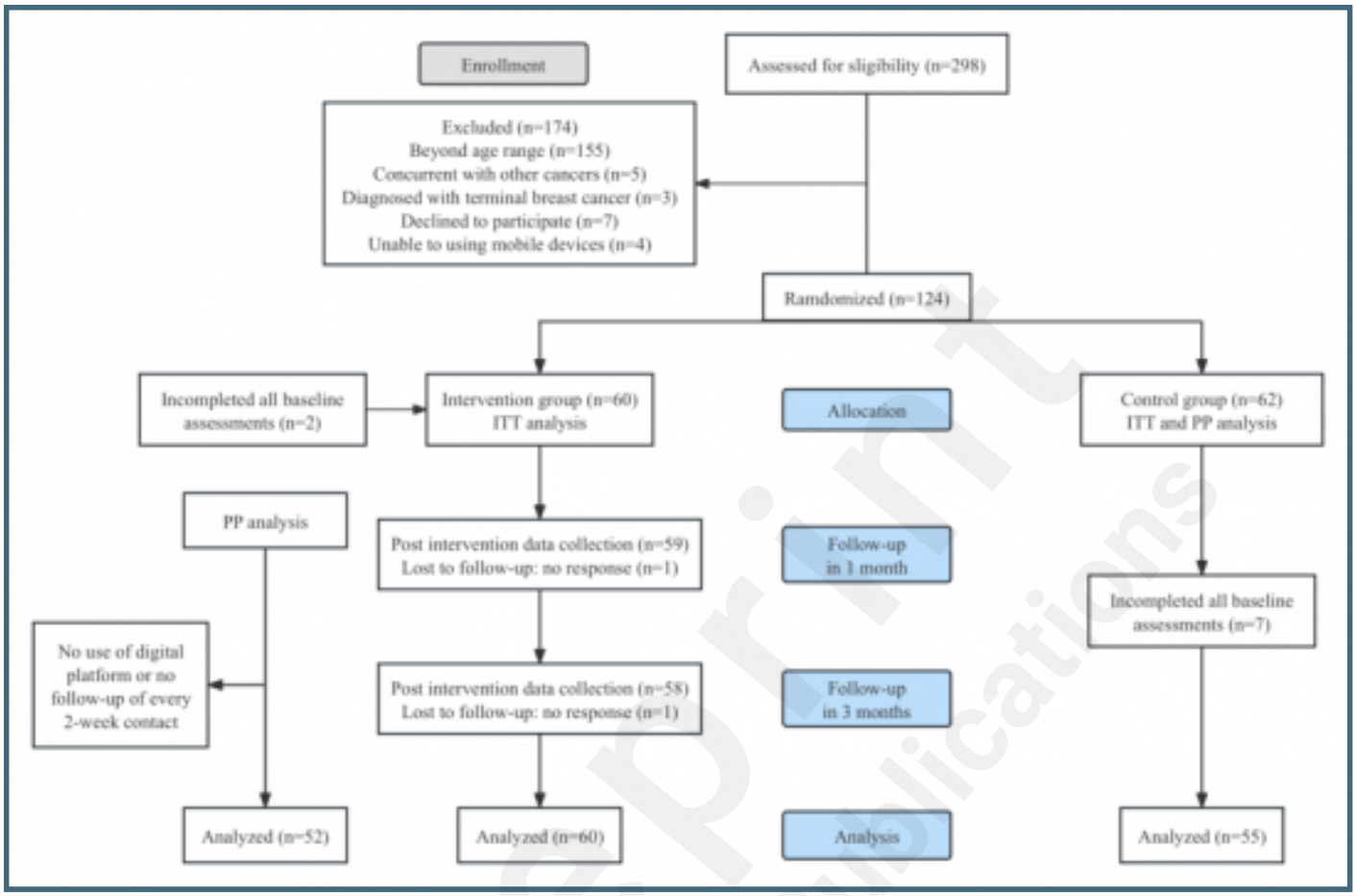
Figures

Visual representations of “AI-TA”.

Frame diagram for intervention design.



A flowchart of the study participants.



Multimedia Appendixes

Questionnaire to assess participants' interaction of and satisfaction with the "AI-TA" mobile application program.
URL: http://asset.jmir.pub/assets/292a2bfa40db8040a9a722cec6c88453.docx

Post hoc sensitivity analyses for missing data.
URL: http://asset.jmir.pub/assets/5fa3ae302d888eb8c9ad2de4461dba94.docx

CONSORT EHEALTH form V1.6.
URL: http://asset.jmir.pub/assets/a8cd028a247fc503863c2101920bef56.pdf