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Effectiveness of a mobile application for tracking symptoms and enhancing symptom management among breast cancer patients receiving chemotherapy in Bangkok, Thailand: a non-randomized controlled trial

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Purpose: This study evaluated the effectiveness of a mobile application in tracking symptoms and improving symptom management and quality of life (QoL) among breast cancer patients undergoing chemotherapy in Thailand.

Methods: A non-randomized controlled trial was used, with 25 participants in the intervention group and 25 in the control group. Research instruments included a demographic data form, the NCI-PRO-CTCAE Items-Thai-Thailand version 1.0, and the European Organization for Research and Treatment of Cancer Quality of Life Core Questionnaire and Breast Cancer-Specific Module.

Results: The intervention group had significantly less severe side effects than the control group, with mean differences of −23.33 (95% confidence interval [CI], −27.82 to −18.83) on day 1, −28.18 (95% CI, −33.22 to −23.14) on day 3, −34.63 (95% CI, −40.18 to −29.08) on day 7, −42.56 (95% CI, −48.72 to −36.40) on day 14, and −51.31 (95% CI, −58.13 to −44.48) on day 21 (p<.001 for all). On day 21, participants in the intervention group reported significantly higher scores in the Global Health QoL and Functional Scales compared to the control group (p<.001). Additionally, intervention group participants reported lower scores on the Symptom Scales and higher scores on the Functional Scales than those in the control group (p<.001).

Conclusion: The ChemoPro application helped manage chemotherapy-related symptoms and was associated with improved symptom monitoring and QoL. Nonetheless, the study was limited by a small sample size and restriction to Android users. Future research with larger and more diverse populations is recommended before broader implementation in clinical practice.

Keywords: Breast neoplasms; Chemotherapy; Management; Mobile application; Side effects; Symptom burden

Introduction

The incidence of breast cancer increased by approximately 1.0 % per year from 2012 to 2021. This trend is particularly noticeable in localized and hormone receptor-positive cases, with a more pronounced rise among women under 50 years old and white women. Additionally, Asian American and Pacific Islander women showed the fastest increase in incidence across all age groups, surpassing Black women by 2021 [1]. In Thailand, breast cancer remains the most

commonly diagnosed cancer, accounting for 23.2% of all reported cancer cases nationwide. In 2022, a total of 21,628 cases were documented [2].

Breast cancer treatments include chemotherapy, surgery, hormone therapy, radiation, and immunotherapy. Chemotherapy regimens, such as cyclophosphamide, methotrexate, fluorouracil (5-FU), doxorubicin, and paclitaxel, have been shown to increase the chance of cure and reduce the risk of recurrence [3]. However, chemotherapy is associated with various side effects, including gastrointestinal symptoms (e.g., nausea, vomiting, diarrhea, loss of appetite) [4-7], cardiotoxicity (e.g., heart damage) [4,5,8], neurotoxicity (e.g., neuropathy, confusion) [7,9], dermatological changes (e.g., hair loss, nail and skin changes) [4,5,7], and systemic symptoms such as fatigue, headache, and dyspnea [6,9].

Lack of knowledge regarding chemotherapy side effects and symptom management after discharge increases the risk of developing severe illnesses [10]. Unfortunately, delays in detecting severe side effects by healthcare providers can result in patients not receiving timely care, leading to deterioration in their condition and reduced quality of life (QoL) [11]. Cancer treatment decreases the capacity of patients' functional and emotional status; consequently, it may influence the QoL [12]. Moreover, these side effects include persistent symptoms such as chronic pain, severe sensory disturbances, early menopause, weight loss, fatigue, stress, insomnia, and cognitive impairment, which can continue post-treatment and significantly disrupt daily life [13,14]. Therefore, improving the detection and management of chemotherapy-related side effects in breast cancer patients is crucial.

In Thailand, patients undergoing chemotherapy typically receive information regarding symptom management through printed self-care manuals. However, many patients report difficulties in effectively managing symptoms after chemotherapy. This is because traditional educational materials lack accessibility and convenience; patients may misplace or fail to utilize them when needed. Advances in mobile technology, particularly smartphone-based applications, offer an innovative solution by providing immediate access to healthcare resources. These applications empower patients to manage symptoms and achieve their health goals more effectively by promoting real-time guidance, self-monitoring, and interactive education [15].

Several studies have demonstrated that mobile applications can enhance the QoL of breast cancer patients undergoing chemotherapy by supporting symptom monitoring and real-time self-management [16-18]. While many cancer-related apps exist, the majority focus on awareness-raising (32.2%) and educational support (26.4%), with only a small proportion (3.7%) designed for symptom monitoring and management [19]. Furthermore, research evaluating the effectiveness and safety of these applications remains scarce [19].

This study specifically evaluates a mobile application for symptom tracking and management, aiming to enhance patient self-care and facilitate timely intervention. Previous research has shown that motivating self-management and promoting health behaviors can help breast cancer patients feel more confident and in control of their condition [20]. Mobile applications provide accessible and structured symptom management tools, allowing patients to monitor chemotherapy-related side effects and actively participate in their care [21].

Furthermore, evidence suggests that mobile applications can help patients detect and manage side effects in the early stages more effectively than those who do not use them [17]. Using a mobile application is associated with good health status [22]. The ability to monitor and track symptoms enables patients to cope better with side effects, prevent serious complications, and ultimately enhance their QoL and that of their caregivers also [23].

Even though chemotherapy has become more targeted and effective for breast cancer patients, side effects remain a significant concern. Substantial evidence supports the role of mobile health tracking technologies in empowering patients and engaging them in health promotion. However, the use of such technologies for symptom management in breast cancer patients receiving chemotherapy is still underutilized in Thailand.

This study aimed to evaluate the effectiveness of ChemoPro, a mobile application for real-time symptom tracking and management, on the QoL of breast cancer patients undergoing chemotherapy. The primary outcome was assessed using the Thai versions of the EORTC QLQ-C30 and QLQ-BR23, and the secondary outcome involved tracking chemotherapy-related side effects using the NCI-PRO-Common Terminology Criteria for Adverse Events (CTCAE) Items version 1.0 (National Cancer Institute).

Methods

1. Study design

This non-randomized controlled trial was conducted with breast cancer patients receiving the first cycle of chemotherapy at the chemotherapy unit of Vajira Hospital, Faculty of Medicine Vajira Hospital, Navamindradhiraj University, Bangkok, Thailand.

2. Setting and participants

This non-randomized controlled trial was conducted at the chemotherapy unit of Vajira Hospital, a tertiary care hospital in Bangkok, Thailand. The study population consisted of breast cancer patients undergoing chemotherapy who met specific eligibility criteria. Purposive sampling was employed to minimize potential contamination between the control and intervention groups.

Inclusion criteria were as follows: participants were eligible if they: (1) had a diagnosis of breast cancer at stages I–IV; (2) were between 18 and 59 years of age; (3) were receiving chemotherapy with a single regimen such as CMF (cyclophosphamide, methotrexate, and fluorouracil), AC (doxorubicin and cyclophosphamide), FAC (fluorouracil, doxorubicin, and cyclophosphamide), ACT (doxorubicin, cyclophosphamide, and paclitaxel), TC (docetaxel and cyclophosphamide), or targeted therapy; (4) owned a smartphone with an Android operating system; and (5) had a caregiver.

Exclusion criteria included: diagnosis of brain metastasis or inability to access the internet.

The sample size was calculated using G*Power ver. 3.1.9.4 (Heinrich-Heine-Universität Düsseldorf), with a significance level of .05, power of .80, and an effect size of .46 based on a previous study [22]. The required sample was 40 participants (20 per group); however, it was increased to 50 (25 per group) to accommodate a potential 20.0% loss to follow-up.

Eligible participants were recruited through purposive sampling by oncologists and oncology nurses during routine outpatient visits at the chemotherapy unit between June 2022 and May 2023. Of the 110 patients initially approached, 45 did not meet the inclusion criteria and 15 met the exclusion criteria. Fifty eligible participants were enrolled and non-randomly assigned to either the control or intervention group. Data were collected from the control group first, followed by the intervention group. The recruitment process and participant flow are illustrated in Figure 1.

3. Measurements/instruments

The data were collected using a demographic data form, the NCI-PRO-CTCAE Items-Thai-Thailand version 1.0 [24], the Eu-

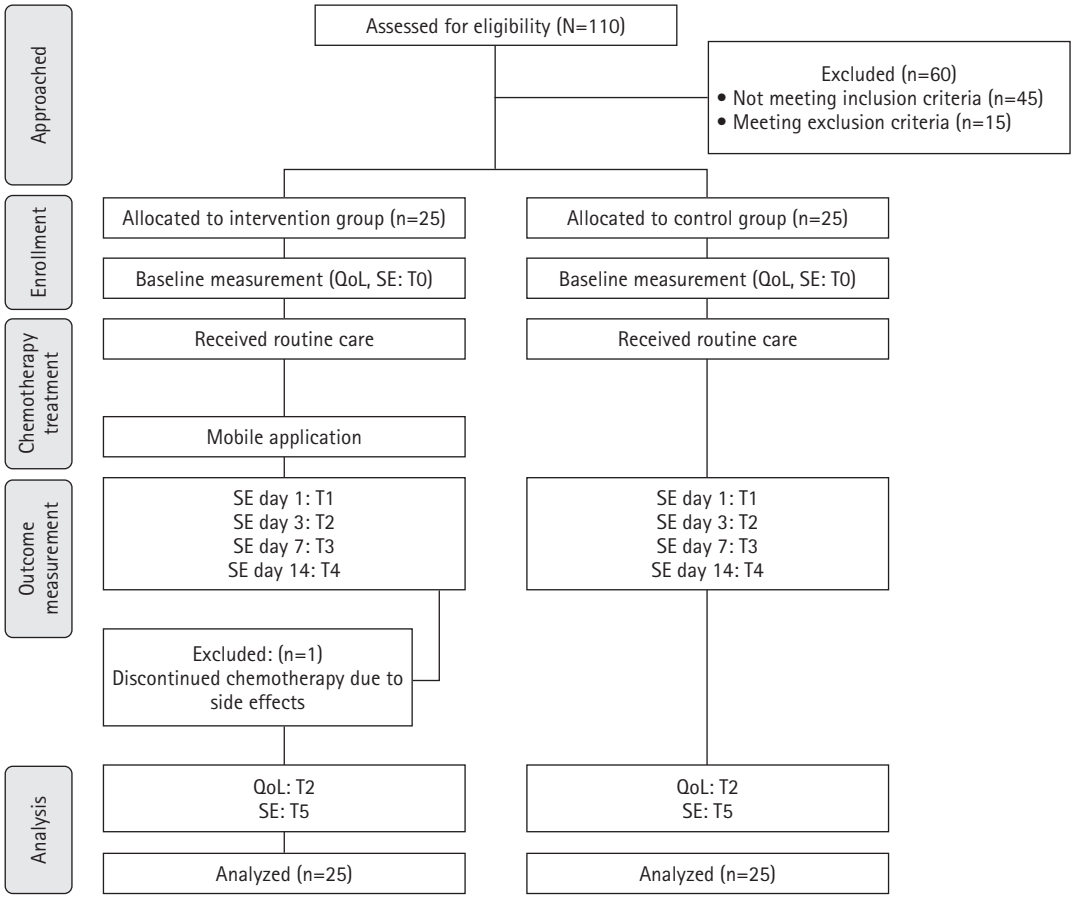

Figure 1. Flowchart of participant enrollment and allocation. QoL, quality of life; SE, side effect.

ropean Organization for Research and Treatment of Cancer Quality of Life Core Questionnaire (The EORTC QLQ C-30 version 3) [25] and the European Organization for Research and Treatment of Cancer Quality of Life Core Questionnaire with breast cancer (EORTC QLQ-BR23) [26].

1) Demographic data form

The demographic data form was developed by the researchers, consisted of nine questions on sociodemographic characteristics (age, gender, educational status, marital status, and occupational status) and clinical data (health care welfare, time since diagnosis [years], treatments received, chemotherapy history—including regimen and number of cycles—and cancer stage).

2) The NCI-PRO-CTCAE Items-Thai-Thailand version 1.0

The NCI-PRO-CTCAE Items-Thai-Thailand version 1.0 assesses side effects experienced by cancer patients and was developed by the National Cancer Institute in 2020 [24]. The Thai version of the PRO-CTCAE was translated and validated under the US National Cancer Institute using ISPOR methodology. The process included forward and back translation, expert reconciliation, and oncology-trained review, with linguistic validation in Thai patients to ensure clarity and cultural relevance. This tool consists of 24 questions assessing the presence/absence, frequency, severity, interference, and extent of side effects, including dry mouth, mouth/throat sores, taste changes, decreased appetite, nausea, vomiting, constipation, diarrhea, shortness of breath, rash, hair loss, nail discoloration, sensitivity to sunlight, skin darkening, dizziness, general pain, headache, pain and swelling at the injection site, insomnia, fatigue, anxiety, discouragement, sadness, missed expected menstrual periods, vaginal dryness, hot flashes, and fever. The severity scores of side effects after receiving chemotherapy are categorized into five levels: none, mild, moderate, severe, and very severe. In this study, the Cronbach's α coefficient of this measure was .86.

3) The European Organization for Research and Treatment of Cancer Quality of Life Core Questionnaire

The EORTC QLQ-C30 version 3 was developed to assess the QoL in cancer patients [25]. This tool consists of 30 items measuring physical, role, emotional, cognitive, and social functioning, as well as global health status and various symptoms. It uses a Likert scale with four levels (1=not at all, 2=a little, 3=quite a bit, 4=very much), where higher functional scores indicate better QoL, while higher symptom scores indicate greater severity. The Thai version of the EORTC QLQ-C30 underwent official translation and psychometric validation following the EORTC Study Group on Quality of Life guidelines. It was tested among Thai cancer patients and demonstrated good reliability, with Cronbach's α coefficients above .70 in most scales [25]. In this study, the internal reliability of the EORTC QLQ-C30 was assessed, and the Cronbach's α coefficient for this tool was .80.

4) The European Organization for Research and Treatment of Cancer Quality of Life Core Questionnaire breast cancer specific module

The EORTC QLQ-BR23 is a breast cancer-specific QoL assessment tool [26]. The Thai version underwent official translation and psychometric validation following the EORTC Study Group on Quality of Life guidelines. A validation study in Thai breast cancer patients receiving adjuvant treatment confirmed good reliability (Cronbach's α=.71–.75), supporting its use in this population [26]. This 23-item measure assesses body image, sexual functioning, future perspective, systemic therapy side effects, breast and arm symptoms, and distress from hair loss. Higher functional and QOL scores indicate better well-being, while higher symptom scores reflect greater severity. The tool is rated on a four-level Likert scale: 1=not at all, 2=a little, 3=quite a bit, 4=very much. In this study, the Cronbach's α coefficient was .81.

4. Study procedure

1) Pre-test (baseline data collection)

On day 1, all participants—both in the intervention and control groups—were instructed to complete demographic and clinical information forms, along with baseline assessments using the NCI-PRO-CTCAE Items-Thai-Thailand version 1.0 [24], the EORTC QLQ-C30 [25], and the EORTC QLQ-BR23 [26] via Google Forms (Google LLC). These assessments were administered after participants received chemotherapy at the outpatient unit.

2) Intervention description (ChemoPro Application)

Participants in the intervention group received standard care supplemented with the ChemoPro Application. This mobile application was developed based on the Symptom Management Model by Dodd et al. [27] and informed by evidence-based guidelines, including the NCI-PRO-CTCAE Items-Thai-Thailand version 1.0 [24], the CTCAE version 5 [28], and symptom management guidelines from the British Columbia Cancer Agency [29] and the American Cancer Society [30].

The ChemoPro Application incorporated key features such as a symptom checklist, real-time tracking, infographic-based self-care

guidance, and an alert system for moderate-to-severe symptoms. Participants were instructed to log their symptoms on days 1, 3, 7, and 14 post-chemotherapy. The app generated personalized, guideline-based recommendations tailored to the severity and type of symptoms reported.

For mild to moderate symptoms, participants were encouraged to follow in-app self-care strategies derived from standardized clinical protocols. In cases where symptoms escalated to a moderate or severe level, the application automatically alerted oncology nurses in the research team. These nurses subsequently provided individualized support via telephone or video calls. Their guidance was based on the model by Dodd et al. [27] and aligned with internationally recognized nursing practices [29,30].

For symptoms that could not be adequately managed at home, the research team coordinated with nearby healthcare facilities. Additionally, patients' caregivers were advised to seek immediate medical attention and notify Vajira Hospital to facilitate emergency admission.

In this study, 40% (10/25) of participants in the intervention group required direct nursing intervention. This finding highlights the importance of continuous symptom surveillance and timely, nurse-led support for managing treatment-related side effects.

3) Control group management

Participants in the control group received routine care from oncology nurses and physicians, including printed educational materials on chemotherapy-related symptom management. No app-based symptom monitoring or follow-up interventions were provided beyond usual clinical care. Participants completed symptom and QoL assessments on days 1, 3, 7, and 14 after chemotherapy.

4) Post-test (follow-up evaluation)

On day 21, all participants returned for a follow-up session at the outpatient chemotherapy unit. Post-intervention assessments were conducted using the same instruments as at baseline: the NCI-PRO-CTCAE Items-Thai-Thailand version 1.0 [24], the EORTC QLQ-C30 [25], and the EORTC QLQ-BR23 [26]. In the intervention group, symptom data logged in the ChemoPro Application were reviewed by the research team, and participants received additional personalized feedback. Each follow-up session lasted approximately 30–45 minutes.

5. Data analysis

The collected data were analyzed using the program Stata ver. 13.0 (Stata Corp.), and statistical significance for all analyses was set at $p<.05$. Descriptive statistics were used for baseline characteristics of participants. Variables were presented as means and standard deviation for continuous data and as the frequency and percentages for categorical data. Differences between groups were assessed by independent sample t-test or Mann-Whitney U test (as appropriate) for continuous variables and chi-square test or Fisher's exact test (as appropriate) for categorical variables. Linear mixed-effects models with an autoregressive correlation matrix were used for analysis of QoL and experiences of side effects. A participant was included in the model as a random effect. Estimates of difference in change from the model were presented as mean difference with 95% confidence interval (CI).

6. Ethical considerations

This study received ethical approval from the Institutional Review Board (IRB) of the Faculty of Medicine Vajira Hospital, Navamindradhiraj University (IRB approval no., COA 208/2564; study code: 172/64 FB, dated 25 February 2022). All participants provided written informed consent after receiving detailed information about the study, including its objectives, potential risks and benefits, and their right to withdraw at any time without consequences. Data were kept confidential and used exclusively for research purposes. Participants received monetary compensation upon completing the post-screening outcome questionnaires. The clinical trial registration was completed (TCTR20250427009).

Results

1. Baseline data

The demographic and clinical baseline characteristics were similar between the control group and the intervention groups (Table 1).

2. Baseline equivalence

At baseline, in terms of side effects after receiving chemotherapy, patients in the intervention group had lower scores for side effects than those the control group (mean±standard deviation: 9.08±7.22 and 16.48±12.13, respectively).

The EORTC QLQ-C30, patients in the intervention group had

Table 1. Homogeneity of demographic and clinical characteristics between intervention and control groups (N=50)

Demographics and clinical data	Intervention group (n=25)	Control group (n=25)	*p*
Age (yr)	54.6±8.44	54.1±9.53	.839[a]
Educational level			
Primary	2 (8.0)	9 (36.0)	.060[b]
Secondary	6 (24.0)	2 (8.0)	
Diploma	7 (28.0)	7 (28.0)	
Undergraduate	10 (40.0)	6 (24.0)	
Missing	0	1 (4.0)	
Marital status			
Married/living together	15 (60.0)	18 (72.0)	.478[b]
Single	5 (20.0)	2 (8.0)	
Widowed	2 (8.0)	3 (12.0)	
Divorced	3 (12.0)	1 (4.0)	
Separated	0	1 (4.0)	
Occupational status			
Government official/government-owned company	4 (16.0)	0	.052[b]
Employee company	2 (8.0)	5 (20.0)	
Self-employed/freelance	9 (36.0)	6 (24.0)	
Work for money	3 (12.0)	1 (4.0)	
Housekeeper	2 (8.0)	8 (32.0)	
Retired	2 (8.0)	0	
Others	1 (4.0)	1 (4.0)	
Unemployed	2 (8.0)	4 (16.0)	
Health care welfare			
Universal coverage	10 (40.0)	12 (48.0)	.231[b]
Social security scheme	8 (32.0)	11 (44.0)	
Government enterprise officer	6 (24.0)	1 (4.0)	
Cash rights	1 (4.0)	1 (4.0)	
Time since diagnosis (yr)	2 (1–5)	1 (0.5–4)	.050[c]
Treatments received			
Chemotherapy	25 (100.0)	25 (100.0)	>.999
Surgery	0	12 (48.0)	<.001[d]
Radiation	0	4 (16.0)	.110[b]
Chemotherapy received			
AC	15 (60.0)	16 (64.0)	.771[d]
Paclitaxel	10 (40.0)	9 (36.0)	
Cancer stage			
1	6 (24.0)	7 (28.0)	.845[d]
2	6 (24.0)	5 (20.0)	
3	7 (28.0)	9 (36.0)	
4	6 (24.0)	4 (16.0)	

Values are presented as mean±standard deviation, number (%), or median (interquartile range).
AC, doxorubicin and cyclophosphamide.
[a]By independent-samples t-test. [b]By Fisher's exact test. [c]By Mann-Whitney U test. [d]By chi-square test.

lower scores in the Global Quality of Life and functioning scales, including physical functioning, role functioning, emotional functioning, and cognitive functioning, compared to those in the control group (p<.001). Regarding symptom scales, the intervention group had higher scores than the control group. Still, the differences were not statistically significant (p>.050), except for insomnia, which had a statistically significant difference (p=.031).

From the BR-23 Scales, patients in the intervention group had higher scores in symptom scales, including systemic therapy side effects, upset by hair loss, and breast symptoms than the control

group (p<.001), except for arm symptoms, which did not show a statistically significant difference (p=.136). In terms of functional scales, including body image, and future perspective, the intervention group had lower scores than the control group with statistically significant differences (p<.001). For sexual functioning and sexual enjoyment, the intervention group had lower scores than the control group. Still, the differences were not statistically significant (p=.942 and p=.200, respectively).

3. Engagement and compliance with the application

During the 21-day intervention period, participants in the intervention group exhibited different levels of engagement with the ChemoPro Application. The median frequency of app usage was 10 times (range, 6–15 times) per participant, indicating moderate but varied engagement across individuals.

In terms of symptom reporting, 85.0% (21/25) of participants recorded their symptoms at least once every 3 days, demonstrating a high level of adherence to symptom tracking. Additionally, 65.0% (16/25) of participants actively followed the self-management strategies recommended by the application, indicating a positive response to the intervention. However, 40.0% (10/25) of participants required direct intervention from the research team due to moderate to severe symptoms, highlighting the necessity of continuous monitoring and personalized support for effective symptom management.

4. Outcomes and estimation

1) QoL (EORTC QLQ-C30)

At day 21, the QoL scores based on the EORTC QLQ-C30 showed no statistically significant differences from baseline in most dimensions. The Global Health Status/QoL increased by 12.50 points (95% CI, 4.31 to 20.69), while the functional scales showed the following changes: physical functioning increased by 2.50 points (95% CI, −3.97 to 8.97), role functioning decreased by 1.39 points (95% CI, −8.48 to 5.70), emotional functioning increased by 6.94 points (95% CI, −0.10 to 13.99), cognitive functioning increased by 6.94 points (95% CI, −6.96 to 5.57), and social functioning decreased by 2.08 points (95% CI, −11.45 to 7.28).

For the symptom scales, most changes were not statistically significant: nausea and vomiting decreased by 0.69 points (95% CI, −6.31 to 4.92), pain decreased by 6.25 points (95% CI, −14.28 to 1.78), dyspnea decreased by 1.39 points (95% CI, −6.31 to 4.92), insomnia decreased by 1.39 points (95% CI, −22.01 to 2.57), appetite loss decreased by 2.78 points (95% CI, −12.91 to 7.35), constipation decreased by 1.39 points (95% CI, −12.55 to 9.77), and diarrhea decreased by 1.39 points (95% CI, −9.36 to 6.58). Financial difficulty increased by 4.17 points (95% CI, −4.73 to 13.06). However, fatigue showed a statistically significant improvement, decreasing by 8.33 points (95% CI, 1.53 to 15.14; p=.010).

Compared to the control group, participants in the intervention group demonstrated significantly higher scores in Global Health QoL and all functional scales (p<.001), along with significantly lower scores on the symptom scales (p<.001) (Table 2).

2) QoL (EORTC QLQ-BR23)

According to the EORTC QLQ-BR23 scale, symptom scale scores at day 21 showed significant improvements compared to baseline. Specifically, the mean change scores were as follows: systemic therapy side effects decreased by 9.33 points (95% CI, −15.12 to −3.53), arm symptoms decreased by 12.50 points (95% CI, −20.26 to −4.74), and breast symptoms decreased by 7.99 points (95% CI, −13.78 to −2.19). In contrast, the score for upset by hair loss increased by 4.17 points (95% CI, −7.88 to 16.22), but this change was not statistically significant (p=.498).

For the functional scales, there were no statistically significant changes from baseline. The mean differences were as follows: body image increased by 1.04 points (95% CI, −6.30 to 8.38), future perspective decreased by 1.39 points (95% CI, −12.99 to 10.22), sexual functioning decreased by 8.89 points (95% CI, −18.00 to 0.23), and sexual enjoyment decreased by 6.94 points (95% CI, −17.40 to 3.51).

When comparing between groups, participants in the intervention group had lower scores on the symptom scales and higher scores on the functional scales than those in the control group (p<.001), except for sexual enjoyment, which did not differ significantly (p=.301) (Table 3).

5. Side effects

The analysis demonstrated a significant reduction in side effect scores in the intervention group compared to the control group at all assessed time points. The mean differences between groups were as follows: −23.33 points (95% CI, −27.82 to −18.83) on day 1, −28.18 points (95% CI, −33.22 to −23.14) on day 3, −34.63 points (95% CI, −40.18 to −29.08) on day 7, −42.56 points (95% CI, −48.72 to −36.40) on day 14, and −51.31 points (95% CI, −58.13 to −44.48) on day 21. All differences were statistically significant (p<.001 across all time points) (Table 4, Figure 2).

Table 2. Effects of a mobile application for tracking symptoms and enhancing symptom management on QoL assessed by EORTC-QLQ-C30 among breast cancer patients receiving chemotherapy (N=50)

QoL	Intervention group		Control group		Mean difference (95% CI)	*p*
	Mean change from baseline (95% CI)	*p*	Mean change from baseline (95% CI)	*p*		
Global health status/QoL	12.50 (4.31 to 20.69)	.003	−35.00 (−43.03 to −26.97)	<.001	47.50 (36.03 to 58.97)	<.001
Functional scales						
Physical functioning	2.50 (−3.97 to 8.97)	.449	−36.53 (−42.87 to −30.2)	<.001	39.03 (29.98 to 48.09)	<.001
Role functioning	−1.39 (−8.48 to 5.70)	.701	−40.67 (−47.61 to −33.72)	<.001	39.28 (29.36 to 49.20)	<.001
Emotional functioning	6.94 (−0.10 to 13.99)	.053	−39.00 (−45.90 to −32.10)	<.001	45.94 (36.08 to 55.81)	<.001
Cognitive functioning	−0.69 (−6.96 to 5.57)	.828	−41.33 (−47.47 to −35.2)	<.001	40.64 (31.87 to 49.40)	<.001
Social functioning	−2.08 (−11.45 to 7.28)	.663	−43.33 (−52.51 to −34.16)	<.001	41.25 (28.14 to 54.36)	<.001
Symptom scales						
Fatigue	8.33 (1.53 to 15.14)	.016	32.00 (25.33 to 38.67)	<.001	−23.67 (−33.19 to −14.14)	<.001
Nausea and vomiting	−0.69 (−6.31 to 4.92)	.808	39.33 (33.83 to 44.83)	<.001	−40.03 (−47.89 to −32.17)	<.001
Pain	−6.25 (−14.28 to 1.78)	.127	35.33 (27.46 to 43.20)	<.001	−41.58 (−52.83 to −30.34)	<.001
Dyspnea	−1.39 (−12.39 to 9.61)	.805	34.67 (23.89 to 45.45)	<.001	−36.06 (−51.46 to −20.65)	<.001
Insomnia	−9.72 (−22.01 to 2.57)	.121	29.33 (17.29 to 41.37)	<.001	−39.06 (−56.26 to −21.85)	<.001
Appetite loss	−2.78 (−12.91 to 7.35)	.591	30.67 (20.74 to 40.59)	<.001	−33.44 (−47.62 to −19.27)	<.001
Constipation	−1.39 (−12.55 to 9.77)	.807	28.00 (17.06 to 38.94)	<.001	−29.39 (−45.01 to −13.76)	<.001
Diarrhea	−1.39 (−9.36 to 6.58)	.733	25.33 (17.52 to 33.15)	<.001	−26.72 (−37.89 to −15.55)	<.001
Financial difficulties	4.17 (−4.73 to 13.06)	.358	45.33 (36.62 to 54.05)	<.001	−41.17 (−53.62 to −28.72)	<.001

Analyses used a linear mixed-effects model with an autoregressive correlation matrix adjusted for baseline values.
CI, confidence interval; EORTC-QLQ-C30, European Organization for Research and Treatment of cancer–Quality of Life Questionnaire Core 30; QoL, quality of life.

Table 3. Effects of a mobile application for tracking symptoms and enhancing symptom management on QoL assessed by EORTC QLQ-BR23 among breast cancer patients receiving chemotherapy (N=50)

Dimension/dimension of QoL	Intervention group		Control group		Mean difference (95% CI)	*p*
	Mean change from baseline (95% CI)	*p*	Mean change from baseline (95% CI)	*p*		
Symptom scales						
Systemic therapy side effects	−9.33 (−15.12 to −3.53)	.002	28.00 (22.32 to 33.68)	<.001	−37.33 (−45.43 to −29.22)	<.001
Upset by hair loss	4.17 (−7.88 to 16.22)	.498	37.33 (25.53 to 49.14)	<.001	−33.17 (−50.04 to −16.30)	<.001
Arm symptoms	−12.50 (−20.26 to −4.74)	.002	28.44 (20.84 to 36.05)	<.001	−40.94 (−51.81 to −30.08)	<.001
Breast symptoms	−7.99 (−13.78 to −2.19)	.007	29.67 (23.99 to 35.34)	<.001	−37.65 (−45.77 to −29.54)	<.001
Functional scales						
Body image	1.04 (−6.30 to 8.38)	.781	−33.33 (−40.53 to −26.14)	<.001	34.38 (24.10 to 44.65)	<.001
Future perspective	−1.39 (−12.99 to 10.22)	.815	−29.33 (−40.70 to −17.96)	<.001	27.94 (11.70 to 44.19)	.001
Sexual functioning	−8.89 (−18.00 to 0.23)	.056	−22.00 (−30.85 to −13.15)	<.001	13.11 (0.41 to 25.82)	.043
Sexual enjoyment	−6.94 (−17.4 to 3.51)	.193	−14.67 (−24.91 to −4.42)	.005	7.72 (−6.92 to 22.36)	.301

Analyses used a linear mixed-effects model with an autoregressive correlation matrix adjusted for baseline values.
CI, confidence interval; EORTC-QLQ-C30, European Organization for Research and Treatment of cancer–Quality of Life Questionnaire Core 30; QoL, quality of life.

Discussion

This study evaluated the effectiveness of the ChemoPro mobile application in enhancing symptom management and improving QoL among breast cancer patients undergoing chemotherapy at the chemotherapy unit of Vajira Hospital, Bangkok, Thailand. The primary objective was to assess the impact of the intervention on patients' QoL, while the secondary objective focused on changes in chemotherapy-related side effects over time.

By day 21, participants in the intervention group showed better Global Health QoL and functional scores, with fewer symptoms compared to the control group. These findings align with previous studies demonstrating the effectiveness of mHealth in oncology care. For instance, mobile app–based interventions have been

Table 4. Effects of a mobile application for tracking symptoms and enhancing symptom management on side effects scores assessed by NCI-PRO-CTCAE Items-Thai-Thailand version 1.0 among breast cancer patients receiving chemotherapy (N=50)

Overall score of side effects	Intervention group		Control group		Mean difference (95% CI)	*p*
	Mean change from baseline (95% CI)	*p*	Mean change from baseline (95% CI)	*p*		
Day 1 after chemotherapy	−3.44 (−6.62 to −0.26)	.034	19.89 (16.87 to 22.91)	<.001	−23.33 (−27.82 to −18.83)	<.001
Day 3 after chemotherapy	−3.48 (−7.04 to 0.08)	.056	24.70 (21.37 to 28.04)	<.001	−28.18 (−33.22 to −23.14)	<.001
Day 7 after chemotherapy	−3.83 (−7.77 to 0.11)	.057	30.80 (27.22 to 34.37)	<.001	−34.63 (−40.18 to −29.08)	<.001
Day 14 after chemotherapy	−5.07 (−9.45 to −0.68)	.024	37.49 (33.63 to 41.36)	<.001	−42.56 (−48.72 to −36.40)	<.001
Day 21 after chemotherapy	−6.12 (−10.96 to −1.28)	.013	45.19 (40.98 to 49.40)	<.001	−51.31 (−58.13 to −44.48)	<.001

Analyses used a linear mixed-effects model with an autoregressive correlation matrix adjusted for baseline values.
CI, confidence interval; NCI-PRO-CTCAE, National Cancer Institute–Patient-Reported Outcomes version of the Common Terminology Criteria for Adverse Events.

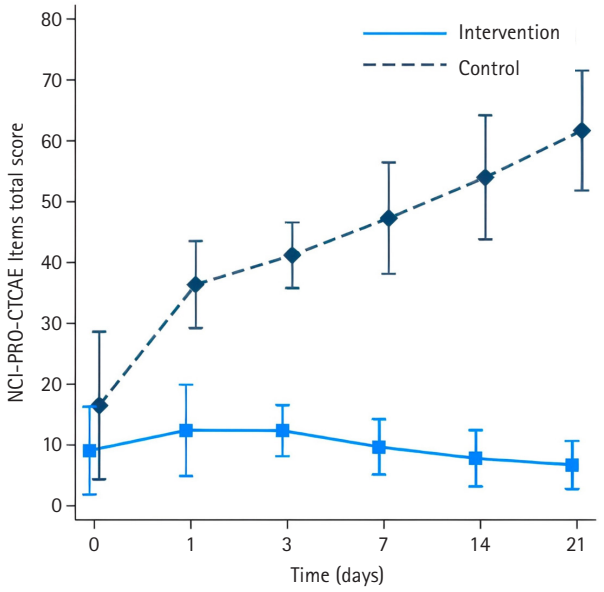

Figure 2. Comparison of mean side effect scores between intervention and control groups across all time points. NCI-PRO-CTCAE, National Cancer Institute–Patient-Reported Outcomes version of the Common Terminology Criteria for Adverse Events.

shown to enhance QoL and reduce distress in women receiving adjuvant endocrine hormonal therapy [21] and chemotherapy [22]. Other studies have similarly reported that mHealth tools—ranging from interactive apps [31,32], pharmacist-led telephone follow-ups [33], and self-management platforms [34]—improve treatment adherence, reduce side effects, and enhance emotional functioning. A systematic review further confirmed mHealth's role in improving symptom control and QoL across cancer populations [35-37]. These findings highlight the growing value of mobile health solutions in supporting cancer patients.

The improvement in QoL observed in this study may be attributed to the multidimensional features of the ChemoPro Application. Real-time symptom tracking enabled early detection and intervention, reducing symptom escalation. Timely support from the research team provided reassurance and continuity of care [38,39]. These features not only reduced treatment-related distress but also enhanced daily functioning and emotional comfort key components of health-related QoL.

Importantly, oncology nurses in the research team played a key role in supporting symptom self-management, particularly when symptoms reached a moderate or severe level. In such cases, the application immediately notified the nurses, who then provided personalized coaching via phone or video calls. During these interactions, they assessed the patient's condition and offered tailored advice based on the Symptom Management Model by Dodd et al. [27]. Their guidance was aligned with side effect management guidelines from the British Columbia Cancer Agency [29] and the American Cancer Society [30], ensuring clinical decisions remained consistent with international best practices. Nurses also recommended both pharmacological and non-pharmacological interventions based on the severity of symptoms and patient records. This nurse-led intervention likely contributed to patients' increased confidence in self-care and overall psychological security during chemotherapy.

Furthermore, the structured symptom guidance and the perception of being closely monitored may have fostered greater confidence, emotional support, and reduced anxiety among patients [38-40]. These findings are supported by a recent systematic review demonstrating that mHealth interventions effectively reduce anxiety and depressive symptoms in cancer patients by offering accessible mental health support [41]. As previously reported, telephone-based follow-up programs can enhance patients' treatment tolerability and promote trust and rapport with healthcare providers during chemotherapy [33]. The emotional security and empowerment facilitated by the ChemoPro Application likely contributed to improved psychological well-being and perceived support both critical domains within the QoL framework. These

observations are consistent with prior studies demonstrating the positive effects of nurse-led mHealth interventions on self-management and patient-reported outcomes during chemotherapy [38].

In terms of the secondary outcome, the intervention group experienced significantly fewer and less severe chemotherapy-related side effects across all time points compared to the control group. These consistent reductions suggest that the ChemoPro Application effectively supported symptom control throughout the entire chemotherapy cycle.

Patients with mild symptoms were able to manage independently using app-based guidance, while those experiencing moderate to severe symptoms received personalized telephone-based support from the research team. This proactive and nurse-guided approach likely prevented symptom exacerbation, improved treatment experiences, and supported adherence to care protocols, as similarly reported in earlier mHealth studies [31,32,36,37].

Moreover, the educational infographics embedded within the ChemoPro Application enhanced patients' understanding of symptom patterns and management strategies. This likely promoted active engagement and self-regulation, further contributing to both the reduction of symptom burden and the enhancement of QoL. Prior research has emphasized the role of health literacy and patient empowerment in improving outcomes for individuals undergoing cancer treatment [31].

Nonetheless, it is important to acknowledge that not all studies report consistent findings. Some research has suggested that mobile health interventions may have limited effects on symptom improvement or complication prevention, particularly in populations with low digital literacy or poor app adherence [42,43]. Despite these discrepancies, the current study adds valuable evidence supporting the integration of mobile health tools particularly those combining self-monitoring, education, and professional support as an effective strategy for optimizing supportive care and improving QoL in patients receiving chemotherapy.

This study has several limitations that should be considered. First, the quasi-experimental design without randomization may introduce selection bias, which limits the generalizability of the findings. Second, the relatively small sample size from a single institution may not represent the broader population of breast cancer patients undergoing chemotherapy. Additionally, self-reported symptom data may be subject to reporting bias.

Despite these limitations, the study provides practical implications for clinical practice. The integration of a mobile application, combined with nurse-led support, shows promise in enhancing symptom self-management and improving QoL among breast cancer patients. The findings support the potential of digital health tools in oncology care and underscore the importance of continuous monitoring and personalized guidance. Future studies with larger and more diverse populations are recommended to confirm these results.

Conclusion

Mobile applications designed to support breast cancer patients in tracking symptoms and enhancing symptom management remain limited in Thailand. This study confirms the effectiveness of a mobile application, such as the ChemoPro Application, in supporting symptom monitoring and promoting patients' self-management through educational content and tailored guidance. This app helped raise awareness of chemotherapy-related side effects and empowered patients to manage their symptoms more effectively. In cases of severe symptoms, the app also facilitated timely intervention by nurses through additional support and guidance. Future research should focus on expanding the sample size, extending the follow-up period, and increasing the number of ChemoPro users. Additionally, the application should be made freely available on both Android and iOS platforms to enhance accessibility and usability.

Article Information

Conflicts of Interest

No potential conflict of interest relevant to this article was reported.

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Data Sharing Statement

Please contact the corresponding author for data availability.

Author Contributions

Conceptualization and/or Methodology: DK, SJ, BS. Data curation and/or Analysis: DK, SJ, BS. Funding acquisition: DK, SJ. Investigation: DK, SJ, BS, CS, PS. Project administration and/or Supervision: DK, SJ. Resources and/or Software: DK, SJ. Validation:

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