Review

Mobile health applications for the care of patients with breast cancer: A scoping review

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ABSTRACT

Objectives: In recent years, the use of mobile health applications (mHealth apps) to deliver care for patients with breast cancer has increased exponentially. This study aimed to summarize the available evidence on developing mHealth apps to care for patients with breast cancer and identify the need for systematic efforts.
Methods: A scoping review was performed according to Arksey and O'Malley's framework, aiming to identify eligible research studies in PubMed, CINAHL, and Web of Science between January 2010 and December 2020. All identified studies were screened, extracted, and analyzed independently by two reviewers.
Results: A total of 676 studies were retrieved, and eight eligible studies were finally included. Four themes emerged: the involvement of patients and health professionals in the phases of design and development, patients' preferences, the characteristics of patients, and the motivators to use mHealth apps. The results indicated promising prospects for using mHealth apps to care for patients with breast cancer and identified the need for systematic efforts to develop and validate relevant apps.
Conclusions: The attributes of patient characteristics, needs, and patient-reported outcomes data are vital components for developing mHealth apps for patients with breast cancer. Additionally, collaborative efforts, including patients, nurses, and other significant health professionals, should develop mHealth apps for breast cancer care. Additional research focusing on the design and development of mHealth apps for patients with breast cancer is warranted.
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What is known?

- Current interventions for breast cancer do not optimally satisfy patients' individual care needs, and there is a growing demand for long-term care services throughout the cancer continuum.
- In recent years, the wide use of mobile technologies has provided innovative possibilities for advancing the delivery of health care.

What is new?

- Current evidence supports promising prospects for using mobile health applications (mHealth apps) in caring for patients with breast cancer.
- The attributes of patient characteristics, needs, and patient-reported outcomes data are vital components for developing mHealth apps for patients with breast cancer. Additionally, collaborative efforts, including patients, nurses, and other significant health professionals, should develop mHealth apps for breast cancer care.

1. Introduction

Breast cancer is the most commonly diagnosed cancer among

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women [1]. Improved screening and advances in early detection have led to a decline in mortality and increased survival rates for patients with breast cancer [2,3]. In addition, improved medical treatment continues to transform breast cancer into a chronic disease [4]. During survivorship, patients greatly need care but have fewer opportunities to obtain assistance from health professionals [4]. Current interventions for breast cancer do not optimally satisfy patients' individual care needs, and there is a growing demand for long-term care services throughout the cancer continuum [5]. Addressing the care needs of patients with breast cancer has been increasingly emphasized.

One promising way to provide long-term care to this population is by using mobile health applications (mHealth apps). In recent years, the wide use of mobile technologies has provided innovative possibilities for advancing the delivery of health care [6–8]. As mobile devices become widely accessible, their potential as personalized care platforms attracts more researchers' attention. Currently, mHealth apps are designed for various purposes, such as raising public health awareness, transmitting health information, receiving instant therapeutic feedback, and maintaining timely interactions for patient-provider communication [9]. In conjunction with the rising number of cancer patients and the increasing use of mobile devices, some studies have developed mHealth apps to cater to patients' various care needs [10,11]. Compared with traditional intervention, apps show advantages in collecting self-report data, offering user-friendly interfaces, and reducing researchers' bias [11]. With the help of mHealth apps, patients can report the side effects of treatments promptly. Furthermore, mHealth apps provide accessible health care information at a minimal cost and motivate patients to achieve the goals recommended by health professionals because patients can obtain instantaneous feedback [12,13].

Currently, several apps have been specifically developed for patients with breast cancer [7,12]. However, there is a lack of synthesized evidence focusing specifically on the design and development of mHealth apps targeting the care of patients with breast cancer. This gap will prevent an understanding of care via mHealth apps and hinder digital health intervention strategies that support these patients. Given the increasing needs of patients with breast cancer, the magnitude of the care burden, and the wide use of mHealth apps, it is necessary to review the available evidence to improve care in this population. Therefore, this study systematically maps recent literature on mHealth apps specifically developed to care for patients with breast cancer and identifies the need for systematic efforts to develop and validate the apps.

2. Methods

2.1. Review design

A scoping review was performed using the framework recommended by Arksey and O'Malley [14,15]. The framework consists of five steps: identifying the research question; identifying the relevant studies; developing eligibility criteria for study selection; charting the extracted data; and collating, summarizing, and reporting the results.

2.1.1. Identification of the research question
The review question of this scoping review was as follows: How were mHealth apps designed and developed for the care of patients with breast cancer?

2.1.2. Identification of relevant studies
Based on the review question, the mnemonic "PICo" (population, interest, context) was utilized to identify relevant keywords

and search terms [16]. The search strategy is presented in Table 1.

The data searched in the databases PubMed, CINAHL, and Web of Science were from January 2010 to December 2020. Two reviewers performed the procedures in December 2020. Search terms included "breast neoplasm," "neoplasm of the breast," "breast cancer," "breast tumor," "mobile health application," "smartphone app," "mobile phone app," "mobile app," "app," "care," and "intervention." All the terms were used during the search in different combinations (Table 1).

Studies that met the following criteria were included: 1) published in English from peer-reviewed journals between 2010 and 2020; 2) exclusively focused on the target group of patients with breast cancer, and 3) original studies that focused on the design and development of mHealth apps for the care of patients with breast cancer. The exclusion criteria were studies about telecommunication technologies (such as websites and telephone notifications), unlike mobile apps; studies targeting mixed cancer types; posters, abstracts, or reviews; and studies for which the full text was inaccessible.

2.1.3. Study selection
Two independent reviewers screened the titles and abstracts of studies according to the inclusion and exclusion criteria. A total of 676 records were identified and subsequently screened; from these, we excluded 231 duplicates. The remaining 445 articles were further scrutinized based on titles and abstracts, and 290 articles were later excluded. Further screening excluded 147 studies that did not exclusively target patients with breast cancer or where the full text was inaccessible. A final selection of eight articles was identified as the literature related to the topic of interest in this scoping review (Fig. 1).

2.1.4. Charting the data
Relevant data were charted; these included author, year, country, study design, name of the app, target group, framework, features, components of the app, and findings (Table 2).

3. Collating, summarizing, and reporting findings

3.1. An overview of the findings

A comprehensive search resulted in 676 records, and eight eligible studies were finally identified after several rounds of screening. Seven of these studies were published in the past five years (2015–2020). The included studies were from different countries: three were from the USA, two were from Spain, and one was from Britain, Korea, and China. The objectives of the mHealth apps were sorted into four categories: functional exercise [17], lifestyle promotion [18,21,23,24], symptom management [19], and informational and emotional support [20,22]. Regarding the technological characteristics, all the studies introduced the name of their apps. Two of the studies introduced an app targeted at general patients with breast cancer [18,24], and two introduced an app targeted at patients undergoing chemotherapy for breast cancer [19,22]. Additionally, one introduced an app focused on patients with upper-limb dysfunction after treatment for breast cancer [17], two introduced an app for patients with breast cancer in a Hispanic population and rural patients with breast cancer [21,23], and one was an app for patients after active treatment for breast cancer [20]. Regarding the framework of the mHealth apps, three studies utilized relevant guidelines [17,18,24]. Theories used to develop mHealth apps included eHealth intervention models of stress and coping [21], the theory of learning, goal-setting theory, social cognitive theory [24], Bandura's self-efficacy theory, and social exchange theory [22]. Two mHealth apps utilized the findings from

Table 1
Search strategy.

|	Inclusion criteria	Exclusion criteria	Derived search terms
P "Population"	Patients with breast cancer	Did not exclusively target patients with breast cancer	"breast neoplasm", OR "neoplasm of the breast", OR "breast cancer", OR "breast tumor" AND
I "Interest"	Design and development of mobile health applications for breast cancer care	Website and telephone notifications	"mobile health application", OR "smartphone app", OR "mobile phone app", OR "mobile app", "app" AND "care", OR "intervention"
Co "Context"	All healthcare settings	Nonhealthcare settings	–
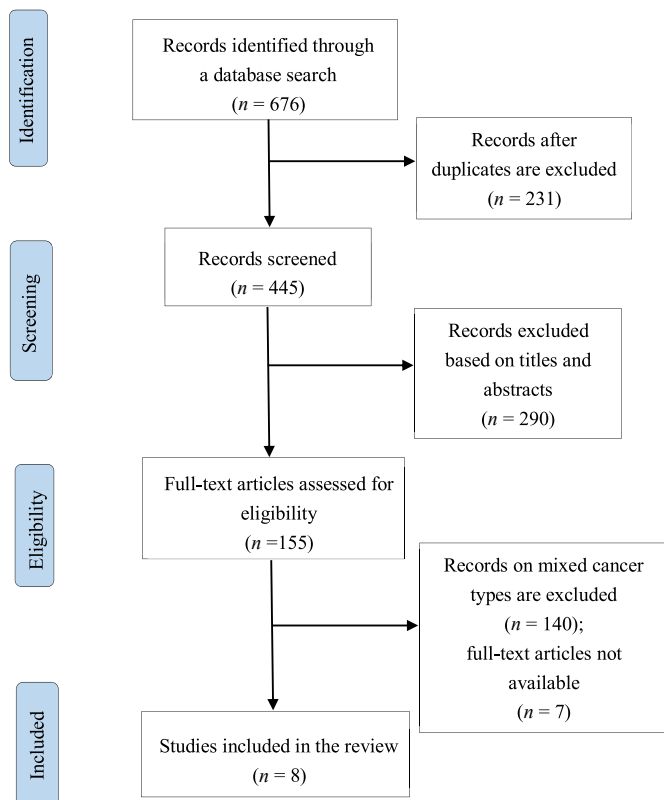
Fig. 1. Flow diagram of the study selection.

a survivorship care plan [20,23], and two used patient-reported outcome measures [19,20]. Two of the eight studies utilized a combination of guidelines, theories, or literature [21,24]. The articles differed concerning research design: three were feasibility studies [18—20], two were randomized controlled trials [21,22], one was a prospective quasi-experimental prep-post study [24], one was a pilot study [23], and one used a qualitative analysis [17]. Table 2 provides a summary of important information extracted from the included studies.

3.2. Thematic analysis of the findings

Thematic analysis helps identify topics that appear frequently and can be modified for use in literature reviews [14,15]. For clarification purposes, thematic analysis was utilized to determine the effort component that could be conductive in designing and developing mHealth apps in this paper. Four major themes were identified, and some encompassed multiple subthemes: 1) involvement of patients and health professionals in the phases of design and development; 2) preferences of patients; 3) characteristics of patients; and 4) motivators to use mHealth apps.

3.2.1. Theme 1: involvement of patients and health professionals in the phases of design and development

The consensus of the included studies was that the active involvement of patients with breast cancer and health professionals was necessary for the phases of design and development for mHealth apps [17—23]. All the included apps were tested in patients with breast cancer [17—24]. Additionally, health professionals, such as oncologists [17,18,23] and care providers [18,20], were included in different app processes.

For example, *bWell* was developed based on the combined efforts of patients with breast cancer, health professionals, and related academics [17]. The participants reported that patients and health professionals would be empowered by better tracking, communication, and app portability. In addition, the app should be integrated with other information sources and have a better reminder function tailored for rural survivors [17]. The *trackC* app was pretested by patients with breast cancer, psycho-oncologists, and bilingual-bicultural researchers [18]. Similarly, *My Health* was tested and refined in the targeted population before intervening for patients with breast cancer [21]. *SmartSurvivor* was tested with patients with breast cancer, oncologists, and primary care providers [23]. In developing the *CSPro-BC* app, patients who had completed active treatment were invited to participate in quantitative and qualitative studies to elaborate on their perceptions of the app at both clinical appointments and during follow-up by using online questionnaires and follow-up phone interviews [20]. The feedback from patients provided important information for developers to optimize the structure of the app. Additionally, three nurses with 10—17 years of experience caring for patients with breast cancer were invited to participate in the design and testing of the app regarding the app's clinical capabilities [20]. The nurses reported that the app could provide clinically graphic outputs and brief instructions for problem-solving regarding the nurses' identified problems; these app features contributed to timely and individual care for patients [20].

3.2.2. Theme 2: preferences of patients

The preferences of patients with breast cancer are another important factor that should be considered in developing mHealth apps [17,19,20,24]. Both quantitative and qualitative methods are optimal for understanding patients' preferences regarding mHealth apps. Patients reported having varied needs concerning personalized care [17,20], informational support [17,20], symptom management [19], and professional guidance [17,20]. For example, a qualitative research study that included a focus group was

Table 2
A summary of research studies included in the review.

Author, Year, Country	Study design	Name of the app, target group	Framework of the app	Features of the app	Components of the app	Findings
Harder et al., 2017 [17] Britain	Qualitative research design	*bWell*; patients with upper-limb dysfunction after treatment for breast cancer	Previous practice of guidelines for a cancer prevention smartphone application	The app optimized self-management of upper-limb dysfunction in patients with breast cancer.	The app included ten modules: information provision, video demonstrations, graded tasks, record of exercises performed, motivational statements, push notifications, opt-in/opt-out option, behavior and progress tracking, diary function, section FAQs, and web links.	The top desired features of the app were the remind function and detailed video demonstrations of the exercises. bWell was identified as a promising management app for posttreatment exercise routines in patients with breast cancer.
Nápoles et al., 2019 [18] Spain	Feasibility study	*trackC*; patients with breast cancer	American Clinical Society of Oncology treatment guidelines	The app introduced the history of breast cancer treatment and provided information on survivorship, potential side effects and healthy lifestyles.	The app included three modules: daily walks, treatment follow-up care, and managing symptoms.	Most of the participants reported the app as feasible for patients with breast cancer.
Min et al., 2014 [19] Korea	Feasibility study	*Pit-a-Pat*; patients undergoing chemotherapy for breast cancer	Patient-reported outcomes	The app aimed to collect sleep disturbance-related data from patients undergoing chemotherapy for breast cancer.	The app included three modules: sleep-disturbance symptoms related to mild depression, acute symptoms related to cytotoxic chemotherapeutic agents, and a medication diary for antihormonal treatment.	Participants reported that the collection of daily sleep-disturbance data via the app was feasible.
Gehrke et al., 2018 [20] USA	Feasibility study	*CSPro-BC* app; patients after active treatment for breast cancer	Research results regarding the unmet needs of patients with breast cancer after treatment; patient-reported outcomes.	The app aimed to identify unmet needs and facilitate self-management in patients after active treatment for breast cancer.	The app included four modules: survey delivery, calculate raw scores, standardize scores, and generate profile.	The app was optimized according to the feedback of patients with breast cancer and nurses.
Yanez et al., 2018 [21] USA	Randomized controlled trial	*My Health*; patients with breast cancer	eHealth intervention models of stress and coping; literature on psychosocial adaptation of breast cancer	The app included health education on nutrition and general advice on complication prevention and lifestyle change.	The app included six modules: food and nutrition, eating well, preventing diabetes and heart disease, exercise, lifestyle, and doctor's recommendations.	Smartphone-based interventions helped increase access to hard-to-reach populations and could be used by patients anytime and anywhere.
Zhu et al., 2017 [22] China	Randomized controlled trial	*Breast Cancer e-Support Program*; patients undergoing chemotherapy for breast cancer	Bandura's self-efficacy theory and the social exchange theory	The app offered information and emotional support for patients undergoing chemotherapy for breast cancer to promote their self-efficacy and social support.	The app included four modules: learning forum, discussion forum, ask-the-expert forum, and personal stories forum.	The app was reported to be valuable to promote self-efficacy, symptom interference, and the quality of life of patients.
Baseman et al., 2017 [23] USA	Pilot study	*SmartSurvivor*; rural patients with breast cancer	Recommended components of a survivorship care plan	The app was based on an existing survivorship care plan.	The app included five modules: medical profile, journal and reports component, calendaring link-in for reminders, appointments and	Both patients and health professionals reported that the app was a valuable tool to support long-term care.

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Table 2 (*continued*)

Author, Year, Country	Study design	Name of the app, target group	Framework of the app	Features of the app	Components of the app	Findings
					notifications, tips and tools that could deliver tailored tips to survivors, and mobile phone audiotaping links.	
Lozano-Lozano et al., 2019 [24] Spain	Prospective quasi-experimental pre-post study	*BENECA* mHealth app; patients with breast cancer	The theory of learning, goal-setting theory and social cognitive theory together with some international guidelines related to the topic	The app aimed to help patients with breast cancer overcome energy balance challenges and motivate them to adhere to fully personalized medical plans.	The app used a dietary recording questionnaire structured according to six consumption times per day.	An association was found between biological changes and an mHealth energy balance monitoring strategy in patients with breast cancer.

conducted to collect information on patients' needs and preferences for *bWell* [17]. The app was structured to have modules on assistance with information provision, video demonstrations, graded tasks, exercise recording, and other forms of support according to patients' desired features [17]. A dietary record questionnaire was incorporated into *BENECA* to record their diet for each meal; this app aimed to assist the patients with adherence to personalized diet plans [24]. The *CSPro-BC* app included a module for patients with breast cancer to acquire online professional information for problem-specific links, including websites, social media, podcasts, and videos corresponding to potential problem areas from official websites to meet patients' varied preferences [20]. All resources were reviewed before delivery and were consistent with recent guidelines, literature, or clinical practices for patients following acute treatment for breast cancer and could thus motivate patients to adhere to self-management behaviors [20]. The app could generate a personalized user profile of potential problem areas for every patient; this capability is conducive to providing medical and self-care options [20].

3.2.3. Theme 3: characteristics of patients

Most of the apps identified in this review had the characteristics of the targeted group considered in their development, such as patients' health status [17], culture and religion [21], economic conditions [23], and treatment [20,22].

3.2.3.1. Health status.
The arm and shoulder exercise programs in *bWell* were based on evidence-based exercise guidelines and practices for patients after treatment for breast cancer; these programs provided tailored guidance to facilitate lymphatic transport and rehabilitation of the affected arm and shoulder [17]. In addition, the *bWell* exercises did not include patients with immediate breast reconstruction. The video exercises in the app were performed by a patient who had surgery for breast cancer nine months before filming, thus indicating that the app accorded with the patients' ability [17]. Considering that most of the patients did not have adequate exercise equipment, all the exercises in the app were performed without special equipment according to the patients' ability.

3.2.3.2. Culture and socioeconomic characteristics.
My Health was specially designed to promote healthy lifestyle education for Hispanic patients with breast cancer [21]. These patients compose the largest and fastest-growing ethnic minority group in the USA. They are reported to have culture-driven beliefs and language barriers that prevent them from acquiring cancer-related information [25].

Additionally, patients in this population have low adherence to tailored cancer-related information during the follow-up period [25]. Therefore, *My Health* was designed to be a culturally tailored app by Hispanic values and beliefs [21]. The app consisted of a series of relevant modules on treatment, diet, exercise, disease knowledge, and medical recommendations targeted toward Hispanic women with breast cancer [21]. The app provided patients with easier access to lifestyle change-related health education and enhanced their interaction with health professionals. Similarly, *SmartSurvivor* was explicitly developed for rural survivors of breast cancer [23]. The app considered the characteristics of rural users and included modules on medical profiles, medical reports, reminders, appointments, and delivering tailored tips; these modules promoted and reminded patients to comply with their follow-up care.

3.2.4. Theme 4: motivators to use mHealth apps

It is vital to set motivators to encourage patients with breast cancer to use the apps [17—20,22,24]. Motivators, specifically visible progress [18,20], targeted suggestions [20,24], professional guidance [24], vivid interfaces [19], and informational and emotional support from peers or other significant people [22,24], were applied in the identified apps.

3.2.4.1. Visual or auditory interface.
bWell had a tracking and progress function, which motivated patients to adhere to the exercises and observe their progress [17]. Patients could keep their history of daily steps in the visual maps of the achieved goal for personal daily actions and receive instant visual and auditory feedback in the *trackC* app, thereby motivating them to achieve their goals [18]. Similarly, *Pit-a-Pat* used a 10-point rating scale for sleep quality and anxiety severity in the form of a thermometer to attract patients to use the app [19].

3.2.4.2. Timely feedback.
Patients could acquire their personal treatment history and information on cancer survivorship through the *trackC* app, contributing to a better understanding of their disease and treatment [18]. Similarly, *BENECA* automatically provided helpful suggestions for improving the energy imbalance regarding patients' energy status and nutritional information [24]. Patients could contact health professionals to communicate doubts [24]. Online video tutorials were also available whenever they were needed [24]. A range of expressions was displayed to indicate a change in mood in *Pit-a-Pat* [19]. Participants received a push notification if they failed to report their data in the time required [19].

On the other hand, tailored information and reminders are also valued apps for patients with breast cancer. Patients with breast cancer often have unmet care needs of acquiring cancer-related knowledge and interacting with health professionals. The *Breast Cancer e-Support Program* aimed to offer information and emotional support for patients with breast cancer receiving chemotherapy [22]. The app included several learning and forum modules, including an ask-the-expert forum and a personal stories forum. The learning forum was updated every two weeks based on the doubts and concerns expressed by patients [22]. Patients could receive feedback from the ask-the-expert forum module within one day through the app. In addition, helpful questions and answers were added to the discussion forum when permitted by corresponding patients [22]. The *CSPro-BC* app offered patients the opportunity to compare their scores with those of a group of patients with breast cancer who lived a median of two years post active treatment. Therefore, the app allowed app users to understand their health conditions and better self-management behaviors [20].

4. Discussion

To optimize care delivery for patients with breast cancer via mHealth apps, collaboration among patients and health professionals is imperative. The involvement of patients and health professionals is helpful to researchers for modifying the format, content, and delivery of mHealth apps [19,23]. Practical mHealth efforts require providers to monitor and satisfy patients' unmet needs, promote self-management behaviors [17—19,21,22], and identify high-risk patients [19,20]. Therefore, health care professionals are required to assume a coaching role. Although nurses are influential health professionals in follow-up care, the design, and development of mHealth apps for patients with breast cancer lack the active involvement of nurses. Only one study in this review reported a mHealth app that involved nurses [20]. Nurse-led follow-up has been an effective alternative to routine clinical follow-up with the advancement of mHealth apps [26,27]. Evidence suggests that patients with breast cancer appear to be more satisfied with nurse-led follow-up than physician-led follow-up [4]. Nurses often act as liaisons among multidisciplinary teams and are health professionals who work closely with patients, provide continuity of supportive care, and evaluate patients' individual support needs [3]. As one of the most critical health professionals to conduct interventions via mHealth apps, nurses should be actively involved in developing the apps to maintain close contact with patients and ensure continuity of care [28]. Therefore, collaborative efforts, including nurses, are highly recommended for using mHealth apps for breast cancer care [20].

The preferences and characteristics of patients with breast cancer may influence the usability and implementation of mHealth apps [17,19,20,24]. Tailored apps might effectively promote the care delivery of patients from certain cultures or with specific characteristics, such as patients who have obstacles to accessing generic mHealth apps. For example, culturally tailored mHealth apps are a viable way to serve the unique needs of patients belonging to an ethnic minority [29,30]. Language, cultural beliefs, values, and obstacles should be considered to develop apps tailored to individual circumstances and characteristics [21,23,31]. However, patients were more likely to respond to apps to sensitive topics (e.g., sexual function) they were unwilling to discuss during clinical visits [20]. Therefore, patient-reported outcome measures are highly recommended to be incorporated into mHealth apps; these measures are optimal and comparable for understanding patients' symptoms, functions, and preferences [32—34].

Motivators are essential factors promoting the continuity of care via mHealth apps. Instant visual feedback [18,20] is a crucial component that attracts patients and thus plays an active role in inspiring patients to use apps and achieve their goals [18]. In addition, expressions or other vivid graphics, which motivate patients to use the apps, are recommended to be incorporated into the interface. Patients with breast cancer reported having limited access to resources that provide them with information and support during their survivorships [35]. However, these patients are sometimes challenged by attendance barriers to face-to-face clinic visits. They often seek medical and lifestyle-related help during or after their diagnosis [35]. mHealth apps can provide access to satisfy patient needs for support-seeking preferences from peers, health professionals, or others [36,37]. When design modules are present to facilitate communication for patients, the views and stories of patients can be considered for sharing in the apps when permission from the patient is received [22]. In addition, regular updates of the content are required to motivate patients to use the apps continuously. Therefore, when developing mHealth apps, there is a need to consider the motivators to maintain patients' interests in operating the apps.

5. Conclusion

This review highlights the need for further investigation with rigorous research designs to develop mHealth apps to care for patients with breast cancer. The attributes of patient characteristics and needs and patient-reported outcomes data should be considered in developing mHealth apps for patients with breast cancer. Additionally, collaborative efforts, including patients, nurses, and other significant health professionals, should develop mHealth apps for breast cancer care.

CRediT authorship contribution statement

Tingting Cai: Conceptualization, Methodology, Writing original draft, Writing-review & editing. **Yueshi Huang:** Data curation, review & editing. **Yuxia Zhang:** Review & editing. **Zhenqi Lu:** Review & editing. **Qingmei Huang:** Review & editing. **Changrong Yuan:** Conceptualization, Methodology, Writing original draft, Writing-review & editing.

Ethics approval

This study does not need ethical approval as it is a scoping review of literature.

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Declaration of competing interest

The authors declare that there are no conflicts of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijnss.2021.07.003.

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