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Expert evaluation of mobile health apps for breast cancer management: a feature-based analysis using the Mobile Application Rating Scale (MARS)

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Abstract

Background Breast cancer remains a major global health issue, with millions of cases diagnosed annually and limited diagnostic and treatment options, particularly in developing countries. This study aimed to evaluate the quality of breast cancer mobile health (m-health) applications using the Mobile Application Rating Scale (MARS) to guide healthcare stakeholders and patients identify high-quality mobile health applications that meet their needs.

Methods A cross-sectional study was conducted in Mashhad, Iran, from February to July 2023, targeting breast cancer apps. Relevant apps were identified through comprehensive searches in databases and app stores based on predefined inclusion criteria. Four health information technology experts independently assessed the apps using MARS and the Feature-based Application Rating Method (FARM), with discrepancies resolved through discussion to ensure reliability. Data analysis included calculating mean scores, testing for data normality, and examining correlations between MARS and FARM dimensions using Spearman's correlation.

Results Of the 453 identified apps, 44 met the inclusion criteria. The average MARS and FARM score was 3.3 out of 5, indicating moderate quality. The functionality dimension scored highest at 4.1, reflecting strong technical performance; however, deficiencies in informational quality negatively impacted user trust and satisfaction. A strong correlation ($r = 0.806$) was observed between engagement and other quality dimensions, indicating variability in user engagement across apps.

Conclusions While many breast cancer apps demonstrated high technical functionality, significant informational gaps reduced user trust and satisfaction. This study underscores the need for regulatory standards to ensure reliable content in breast cancer apps. Future app development should prioritize user engagement and informational quality to better meet patient needs.

Keywords Breast neoplasms, Health information technology, Mobile applications, Patient satisfaction, Telemedicine, Usability testing

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Introduction

Breast cancer is a condition characterized by the uncontrolled proliferation of cells in the breast [1]. In 2020, the World Health Organization (WHO) reported 2.3 million women diagnosed with breast cancer and 685,000 fatalities worldwide [2]. Moreover, in 95% of the global nations, Breast cancer ranks as the primary or secondary cause of cancer-related mortality among women [3]. It is also the most common cancer among women in both developing and developed countries [4]. In 2023, the National Center for Health Statistics projects 1,958,310 new cancer cases and 609,820 cancer fatalities in the United States. In 2023, it is projected that there will be 43,700 fatalities from breast cancer in the United States, comprising 43,170 women and 530 males [5]. An estimated 60% of deaths worldwide attributed to breast cancer occur in economically developing countries such as Brazil despite low incidence rates [6]. Although breast cancer is predominantly diagnosed in women, it also affects men, albeit at a much lower incidence. In 2023, an estimated 530 men in the United States were projected to die from breast cancer, highlighting the need for awareness and resources tailored to male patients. Despite its rarity, male breast cancer presents unique challenges, including delayed diagnosis and limited access to targeted educational materials and support systems [5].

Familiarity with the prevalent symptoms of breast cancer may facilitate early diagnosis. A new lump in the breast or underarm, thickening or swelling of a portion of the breast, irritation or dimpling of breast skin, redness or flaking in the nipple area or breast, retraction of the nipple, or pain in the nipple region are some symptoms of breast cancer [7]. Although hormone usage, alcohol intake, and obesity are recognized risk factors for breast cancer, their contribution to the overall risk of developing the disease is moderate compared to major determinants such as genetic predisposition and age [8]. Breast cancer is treated using many methods, contingent upon the specific type of breast cancer and its extent of metastasis. Despite the multitude of treatment modalities, the insufficient understanding among patients regarding innovative technology for identifying suitable treatment options results in adverse outcomes, including mortality [9]. Currently, the smartphone is the most prevalent educational technology globally. Its widespread use and diverse functionalities have led to its adoption in the healthcare sector under the M-health designation [10]. This scoping review on mobile health apps for breast cancer care can be cited when discussing the role of mobile technology in breast cancer self-care and the increasing availability of such apps [11]. M-health is a branch of health care that uses Internet, digital, and mobile technologies to improve health or treat specific medical conditions [12]. A 2021 IQVIA analysis indicates an increasing quantity of digital healthcare applications, with over 350,000 apps about health, fitness, or medical categories accessible on the App Store and Google Play [9]. The studies showed that mobile health in breast cancer care management effectively managed weight, improved quality of life, improved patient well-being, better coping with symptoms, and reduced stress levels [13]. Moreover, several studies have shown that using mobile apps to help patients with breast cancer has numerous benefits, including improved information needs, increased physical activity, decreased nervousness and anxiety, decreased fearlessness, and improved personal satisfaction [14]. Moreover, disease-specific applications may enhance patients' self-efficacy and self-care through information technology services, including educational resources, peer support, and electronic patient-reported outcomes [15]. Morbidity and mortality can be diminished by advocating for exercise, a nutritious diet, and sufficient access to screening services, treatment, and care management. Nevertheless, insufficient awareness and support have hindered numerous women with breast cancer from adopting healthier practices during their treatment [9]. New eHealth and m-Health initiatives have been promising in managing cancer patients, especially in supportive care and follow-up [15]. Selecting an appropriate application for breast cancer patients is crucial since a failure to meet the patient's requirements may result in discontinuation of its use. Comprehending the informational requirements of women with breast cancer might facilitate the identification of opportunities for mobile applications to enhance the experience of this patient demographic [9]. The user interface is essential to meet user expectations and support the practical functionality of your app. A well-executed user interface facilitates effective interaction between the user and the app [16]. Due to the swift expansion of smartphone applications, users, health professionals, and academics find it more challenging to identify and evaluate high-quality apps [17]. Other than the star ratings displayed on retailers' websites, limited information regarding app quality exists, and app reviews are inherently subjective and may originate from dubious sources. Choosing applications based on popularity provides minimal or no substantive insight into their quality [18]. Numerous technologies exist for app assessment, and applications are analyzed and appraised from multiple perspectives. One of the instruments included in our research is the Mobile Application Rating Scale (MARS). The MARS offers researchers, developers, and healthcare practitioners a dependable and adaptable app-quality assessment scale. The MARS tool is a thorough and dependable resource commonly utilized to evaluate the quality of mobile health applications, including those for epilepsy, COVID-19, self-management, spine disorders, and Alzheimer's disease [19–21]. One criterion

for assessing an application is its quality measurement, conducted by MARS; another is its features, which can be evaluated using tools like the feature-based application rating method (FARM). A feature in an application is generally a fundamental function or service offered to consumers. Features may be advantageous or disadvantageous to users. The FARM assesses and ranks mobile applications according to the accessibility and caliber of each feature. The FARM tool rates the quality of mobile health apps like HIV/AIDS. These two tools complement each other to evaluate apps [14]. This study aimed to evaluate breast cancer-related mobile applications across various domains, including self-examination, risk assessment, patient education, community support, and treatment assistance, using MARS and FARM tools.

Methods

This study was a cross-sectional descriptive-analytical study conducted in Mashhad, the second-largest city in Iran. The exact search date was April 22, 2023.

Evaluation process

First, we conducted a systematic literature search in prominent databases such as PubMed, Scopus, and Web of Science to identify relevant studies on breast cancer-related mobile health applications. The search strategy was developed based on Medical Subject Headings (MeSH) terms and free-text keywords. A comprehensive search query was used: (breast AND (cancer OR neoplasms OR tumors OR carcinomas)).

In PubMed and Scopus, the search was performed in Title/Abstract/Keywords fields, whereas in Web of Science, a Topic search was conducted to maximize coverage. The searches were performed by three independent researchers who screened and cross-verified the results to ensure accuracy and reliability.

Subsequently, we searched for the term "breast cancer" and its equivalent synonyms (obtained from Step 1) in the Google Play Store and Apple App Store to ensure that no relevant applications were overlooked [13]. Three researchers conducted the searches independently and screened and cross-verified the results to enhance reliability and minimize selection bias. The PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines were followed to ensure a systematic and transparent approach to identifying and screening applications.

The Apple App Store has 1.96 million apps for download, and 2,597,819 apps are available on the Google Play Store [22]. From this number, approximately 54,546 healthcare and medical apps are available on the Google Play Store [23], and 41,517 healthcare and medical apps are available on the App Store [24]. The included mobile applications had to meet the following criteria: (1) be compatible with both Android and iOS operating systems, (2) be written only in English, (3) be available in Iran, and (4) focus specifically on breast cancer. The selected apps were installed on two test devices (Galaxy A51, Android 13.0, CPU 8, and iPhone X, iOS 16). After installation, several applications were excluded from the study, including (1) congress-related applications, (2) gaming applications, (3) social networking applications, (4) apps with content download issues, (5) apps that do not focus on breast cancer, (6) apps with login issues preventing access to content, and (7) journal-related applications. Finally, this study systematically reviewed and evaluated all eligible breast cancer applications. All evaluators assessed the apps in a pre-determined randomized order to minimize bias, ensuring no specific app benefited from order effects.

Evaluation tools

We employed MARS and FARM techniques to assess the quality and characteristics of the breast cancer applications, respectively. The MARS instrument comprises 23 inquiries across four distinct objective dimensions. The app quality criteria were organized into five categories: engagement, functionality, aesthetics, information quality, and subjective quality, resulting in the creation of 23 subcategories from which the 23 individual MARS items were derived. Each MARS item employed a 5-point scale (1-Inadequate, 2-Poor, 3-Acceptable, 4-Good, 5-Excellent), with descriptors written for each rating anchor. When an item may not pertain to all applications, a "not applicable" option has been incorporated. The expert group examined the MARS items and rating descriptor terms to guarantee the use of acceptable and consistent language throughout the scale.

A feature in an application is generally a fundamental function or service offered to consumers. Features may be advantageous or disadvantageous to users. The FARM assesses and ranks mobile applications according to the accessibility and caliber of each feature. The FARM tool rates the quality of mobile health apps like HIV/AIDS. These two tools complement each other when evaluating apps. The MARS and FARM tools are available in Additional files 1 and 2.

Evaluation participants

This study used three primary evaluators and one supervisor to assess breast cancer apps based on the MARS and FARM tools. One of the key selection criteria for evaluators was that they (1) were not breast cancer patients, (2) had no prior experience using mobile health applications for breast cancer, and (3) were thoroughly familiar with the evaluation methodology. All four evaluators had a background in health information technology. The evaluators used a shared mobile phone for the

assessment process to maintain consistency. Before initiating the evaluation, the evaluators underwent a coordination session to standardize the evaluation approach and ensure a uniform understanding of the methodology. All evaluations were conducted in a designated location to maintain consistency across assessments.

Before starting the evaluations, all assessors watched the official MARS training video [25] and received instructions on applying the FARM tool. The evaluation process was structured so that each evaluator first assessed the apps using the MARS tool and assigned ratings, followed by an evaluation using the FARM tool. To prevent any potential carryover effects, at the end of each evaluator's session, all application data entered by the first evaluator was deleted from the shared mobile phone before the second and third evaluators began their assessments. This ensured that previous assessments influenced no evaluator's scores. To minimize bias, all evaluators assessed the apps in a pre-determined randomized order to minimize order bias, ensuring that no particular app benefited from position effects.

Differences in scoring among the three primary evaluators were first discussed to reach a consensus. If a discrepancy remained unresolved, the fourth evaluator, acting as a supervisor, provided the final decision.

Structured break intervals were implemented to mitigate the risk of evaluator fatigue, which has been shown to impact study quality [26]. After each hour of evaluation, the assessors took a mandatory 15–20 min break, during which they could rest and have refreshments such as tea. To ensure that fatigue did not compromise the evaluation quality, assessments resumed only if all assessors confirmed they were ready to continue. Otherwise, the evaluation session was postponed to the following day.

Data analysis

We employed this study's mean and standard deviation to evaluate the applications. The calculation of mean scores excluded the zero scores from the FARM tool and the N/A score from the MARS instrument. The average results for the MARS and FARM instruments were categorized as 1: inappropriate, 2: poor, 3: acceptable, 4: good, and 5: excellent. We employed the Kolmogorov-Smirnov test to assess the normality of the variables associated with MARS and FARM tools, which did not validate the normality of these variables. Consequently, Spearman's correlation test was employed to examine the relationship between the characteristics of the MARS and FARM tools. Descriptive statistics were used to calculate the applications' MARS rankings and the FARM scale, including mean and standard deviation. The internal validity and consistency of the assessors were assessed using the two-way mixed intraclass correlation coefficient (ICC) [27]. Data analysis was conducted using the SPSS version. A significance level of $\alpha = 0.01$ was used to interpret the statistical results, ensuring rigorous control over Type I error rates.

Results

From our search of keywords in the Google Play Store and the App Store, 453 apps were retrieved, of which 375 irrelevant and duplicate apps were removed, leaving 78 apps. After reviewing the apps, 34 apps were excluded for the following reasons (apps were related to Congress ($n = 1$), social networks ($n = 5$), apps do not focus on disease ($n = 7$), other languages ($n = 12$), magazines apps ($n = 6$), and problem to login to apps ($n = 3$)) and finally 44 apps were included in the study based on the inclusion and exclusion criteria (Fig. 1). Figure 1 provides a structured overview of the app selection process, illustrating the number of applications retrieved, screened, excluded, and ultimately included in the study. A total of 453 apps were initially identified from the Google Play Store ($n = 300$) and the Apple App Store ($n = 153$). In the first screening phase, 375 apps were excluded due to duplication or irrelevance, leaving 78 apps for further evaluation. An additional 34 apps were excluded based on predefined eligibility criteria, including congress-related apps ($n = 1$), apps in languages other than English ($n = 12$), social networking apps ($n = 5$), apps with login issues ($n = 3$), magazine apps ($n = 6$), and apps not explicitly focused on breast cancer ($n = 7$). Following this screening process, 44 apps were deemed eligible for inclusion, with 32 apps from the Google Play Store and 12 from the Apple App Store. Figure 1 visually represents this multi-stage selection process, ensuring transparency and reproducibility of the app inclusion methodology.

Mobile application evaluation results

The results of evaluating apps related to breast cancer using MARS and FARM tools are shown in Table 1. The average score of all apps using both tools in both stores was 3.3 out of 5 (SD = 0.19). The average overall score of both tools for the apps of Google Play Store was 3.2 (SD = 0.18), and for the app store, it was 3.5 (SD = 0.22). Based on the evaluation results of the two tools, the absence of undesirable features had the highest mean, 4.7 (SD = 0.2), and the lowest subjective dimension, with an average score of 2.12 (SD = 0.3).

Moreover, four out of 32 Google Play Store apps (12.5%) scored higher than 4: ACS Reach, Breast Cancer Club, Owise, and The Breasties Cancer Community.

To further highlight the best-performing applications for specific breast cancer-related functions, Table 2. Presents the highest-rated apps in different categories based on their MARS evaluation scores. These applications were selected based on their superior performance

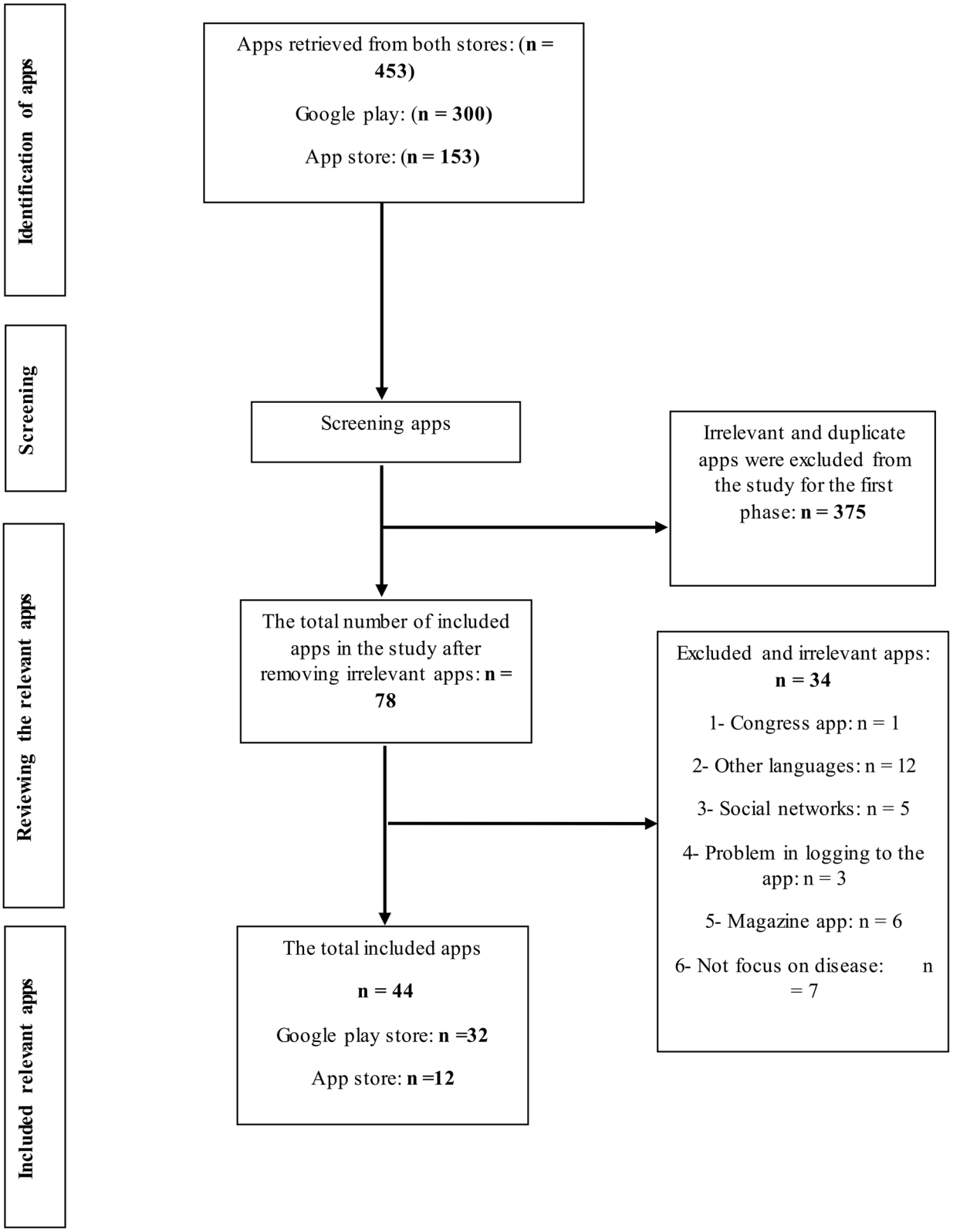

Fig. 1 Flow chart of the selection process for inclusion of the apps

Table 1 The results of the evaluation of breast cancer apps based on MARS and FARM tools

	MARS dimensions					MARS total score	FARM dimensions		FARM total score	Total score
	Engagement	Functionality	Aesthetics	Information quality	Subjective dimension		Desirable features	Absence of undesirable features		
Google Play Store apps										
Mean (SD)	2.7(1.004)	3.9(0.87)	2.8(1.05)	3.01(0.62)	2.11(0.81)	2.9(1.06)	3.2(1.22)	4.7(0.44)	3.98(1.18)	3.2(1.19)
Min, Max	1, 4.8	2.25, 5	1, 5	1.57, 4.57	1, 4.5	1, 5	0, 4.85	3.22, 5	0, 5	0, 5
Median (IQR)	2.6(1.7)	4.25(1.5)	3(1.67)	3(0.86)	2(1)	2.86(1.55)	3.7(1.73)	5(0.44)	4.4(1.37)	3.25(1.92)
App Store apps										
Mean (SD)	2.6(0.71)	4.5(0.39)	3.3(0.82)	3.06(0.38)	2.16(0.54)	3.14(1.01)	4.4(1.3)	4.9(0.18)	4.67(0.97)	3.5(1.21)
Min, Max	1.4, 4.4	3.5, 5	2, 4.67	2.29, 3.86	1.25, 3.25	1.25, 5	0, 5	4.22, 5	0, 5	0, 5
Median (IQR)	2.4(1)	4.75(0.5)	3.33(1.33)	3(0.57)	2(0.75)	3(1.6)	5(0.5)	5(0)	5(0.22)	3.6(2.26)
Mean of all apps										
Mean (SD)	2.7(0.9)	4.1(0.78)	3.0(0.96)	3.02(0.53)	2.12(0.7)	3.0(1.02)	3.5(1.33)	4.7(0.36)	4.18(1.14)	3.3(1.18)
Min, Max	1.27, 4.47	2.42, 5	1.22, 4.67	1.57, 4.38	1, 3.67	1, 5	0, 5	3.67, 5	0, 5	0, 5
Median (IQR)	2.5(1.58)	4.5(1.29)	3.1(1.42)	2.95(0.65)	2(0.88)	2.9(1.54)	3.9(1.86)	5(0.41)	4.5(1.2)	3.3(2.02)

in self-examination, risk assessment, patient education, community support, and treatment assistance. The selection criteria focused on app functionality, user engagement, and overall usability. By identifying the top-rated apps, this study provides valuable insights for patients, healthcare providers, and developers to enhance future mobile health interventions for breast cancer management.

Each of these applications excelled in their respective categories. Breast Self-Check demonstrated the best performance in the self-examination category with a MARS score of 3.7, attributed to its interactive self-exam tutorials, reminder alerts, and user-friendly interface. This app helps users establish a routine for self-examinations and increases awareness about early detection. iCheck was identified as the top-rated risk assessment app, scoring 3.9, providing evidence-based screening tools that allow users to evaluate their risk levels based on key factors. The app's intuitive user experience and simple yet effective design make it accessible to a broad audience.

ACS Reach received the highest score (4.2) in the Google Play Store for patient education. Developed by a reputable medical organization, this app offers comprehensive educational content covering early detection, diagnosis, treatment options, and post-treatment care. The Breasties Cancer Community app was rated the best in community support, achieving a MARS score of 4.3. This application is designed to connect breast cancer patients and survivors through emotional support groups and interactive forums, fostering a strong sense of community.

BWell stood out as the highest-rated application for treatment assistance, with an overall MARS score of 4.4. This app provides structured exercise plans tailored for breast cancer recovery, customizable physical therapy schedules, and guided rehabilitation programs supporting patients post-treatment recovery.

These findings suggest that while most apps demonstrate strong functionality, there remains room for improving user engagement and accessibility in future developments. Developers should focus on enhancing interactivity, integrating AI-based personalization, and ensuring stronger clinical validation to make these tools even more effective for patients. The results also emphasize the importance of balancing technical efficiency with user-centered design to ensure breast cancer mobile applications effectively meet patient needs and enhance long-term adherence to self-care and treatment protocols.

Also, four out of 12 App Store apps (33.3%) had scores higher than 4: BWell, Icheck, Breast Self-Check, and Pink Bra. Symptoms of Breast Cancer app in the Google Play Store and MBC Connect app in the App Store had the lowest scores among other apps. In Google Play Store,

Table 2 Top-rated mobile applications for different breast cancer-related functions based on MARS evaluation

Function	Recommended App	Platform	Overall MARS Score	Key Strengths
Self-examination	Breast Self-Check	Apple App Store	3.7	Interactive self-exam tutorials, reminder alerts, and a user-friendly interface.
Risk assessment	iCheck	Apple App Store	3.9	Simple risk assessment tool, evidence-based algorithms, intuitive UX.
Patient Education	ACS Reach	Google Play Store	4.2	Comprehensive educational resources trusted by medical institutions.
Community support	The Breasties Cancer Community	Google Play Store	4.3	Peer-to-peer networking, emotional support groups, and interactive discussions.
Treatment Assistance	BWell	Apple App Store	4.4	Exercise programs for recovery, customizable physical therapy plans.

Table 3 Characteristics and evaluation scores of breast cancer mobile applications

Application Name	Developer	Last Update	App Features	Description	Validation Status
ACS Reach	Chronus LLC, American Cancer Society Inc.	Android: September 2, 2024, iOS: October 26, 2023	User-friendly interface, personal profiles, online chat, treatment reminders	Connects cancer patients with survivors, providing guidance on treatment management and coping strategies.	Effectiveness was not evaluated; future evaluation is planned via clinical trials.
Breast Cancer Club	Gazal Kamal	August 29, 2024	Intuitive interface, messaging, information sharing	An online support network for women with breast cancer allows users to share experiences and support each other.	Not evaluated; plans for user feedback-based evaluation.
Owise	Px HealthCare Group Ltd.	March 12, 2025	Personalized information, guidance, and support	It helps users manage their lives post-diagnosis with secure, trustworthy information.	Not evaluated; planned future evaluations with patient surveys.
The Breasties Cancer Community	The Breasties Inc.	iOS: February 14, 2024	Interest-based groups, events section, educational resources	A platform designed to connect and support individuals affected by breast cancer.	Not evaluated; ongoing community-based evaluation.
iCheck	Three Swiss Physicians	March 27, 2015	A visual guide for breast examination, monthly reminders	Provides instructional content for breast self-examination.	It has not been evaluated; there are no current plans for clinical evaluation.
BWell	University of Sussex	September 27, 2017	Exercise program, educational videos, calendar reminders	A rehabilitation tool focused on arm and shoulder recovery after breast cancer treatment.	Not evaluated; future evaluation to assess effectiveness.
Pink Bra	George Ferzli, MD	December 5, 2017	Animated instructions, self-exam reminders	Provides animated guides and educational material for breast health awareness.	It has not been evaluated; no current plans for effectiveness testing exist.
NIH Breast Cancer	National Institutes of Health	August 15, 2023	Research-based information, treatment options	Offers comprehensive information on breast cancer research and treatment options.	Evaluated in clinical settings; ongoing updates based on new research findings.
Breast Advocate	Unknown	January 10, 2024	Support resources, treatment tracking	It aims to empower users with information and support throughout their breast cancer journey.	Not evaluated; user feedback will guide future improvements.
Young Breast Cancer Community	Unknown	March 5, 2024	Community support, educational resources	Focuses on providing a supportive environment for young women facing breast cancer.	Not evaluated; plans for community feedback collection.
Breast Cancer Awareness App	Unknown	January 15, 2024	Educational resources, reminders for screenings	Provides information on breast cancer awareness and screening reminders.	Not evaluated; user feedback planned.
MyBreastCancer App	Unknown	February 20, 2024	Symptom tracking, treatment management	It helps users track symptoms and manage treatment plans effectively.	Not evaluated; future evaluations planned.

12.5% of the apps had a score higher than 4, 65% of the apps had a score between 3 and 4, 18.5% of the apps had a score between 2 and 3, and 4% of the apps had a score lower than 2. In the App Store, 33.3% of the apps had a score higher than 4, 50% of the apps had a score between 3 and 4, 8.3% of the apps had a score between 2 and 3, and 8.4% of the apps had a score lower than 2. Table 3 presents detailed characteristics of this study's

breast cancer-related mobile applications. Each app's primary goals, latest update date, developer, targeted users, and validation status are outlined. Additionally, the overall MARS and FARM scores and the scores for individual dimensions of both tools are provided to comprehensively understand each application's quality and functionality.

Visual comparison of MARS and FARM scores

To better understand the differences in app quality, Fig. 2 presents a radar chart illustrating the scores of each dimension of the MARS and FARM tools for all included apps. The chart compares:

- All evaluated apps,
- Apps available in the Google Play Store, and.
- Apps available in the App Store.

This visualization provides an overview of how the apps performed across key evaluation criteria, including engagement, functionality, aesthetics, information quality, subjective perception, desirable features, and absence of undesirable features. Notably, apps from the App Store generally scored higher in functionality and desirable features, whereas Google Play Store apps showed slightly lower scores in engagement and aesthetics. These differences may be attributed to variations in app design, platform-specific development standards, and regulatory requirements.

Evaluation results of MARS tool

This study assesses the content and quality of breast cancer mobile health apps, which can be cited when reporting evaluation outcomes using the MARS and FARM tools [28]. The total MARS mean score for all apps was 3 ± 0.38. The highest rating was related to the Functionality dimension (4.1 ± 0.13), and the lowest was related to the Subjective dimension (2.12 ± 0.3) (Table 1). Also, 6.8% of the apps had scored higher than 4. The three apps that scored the highest in this tool are Surviving Breast

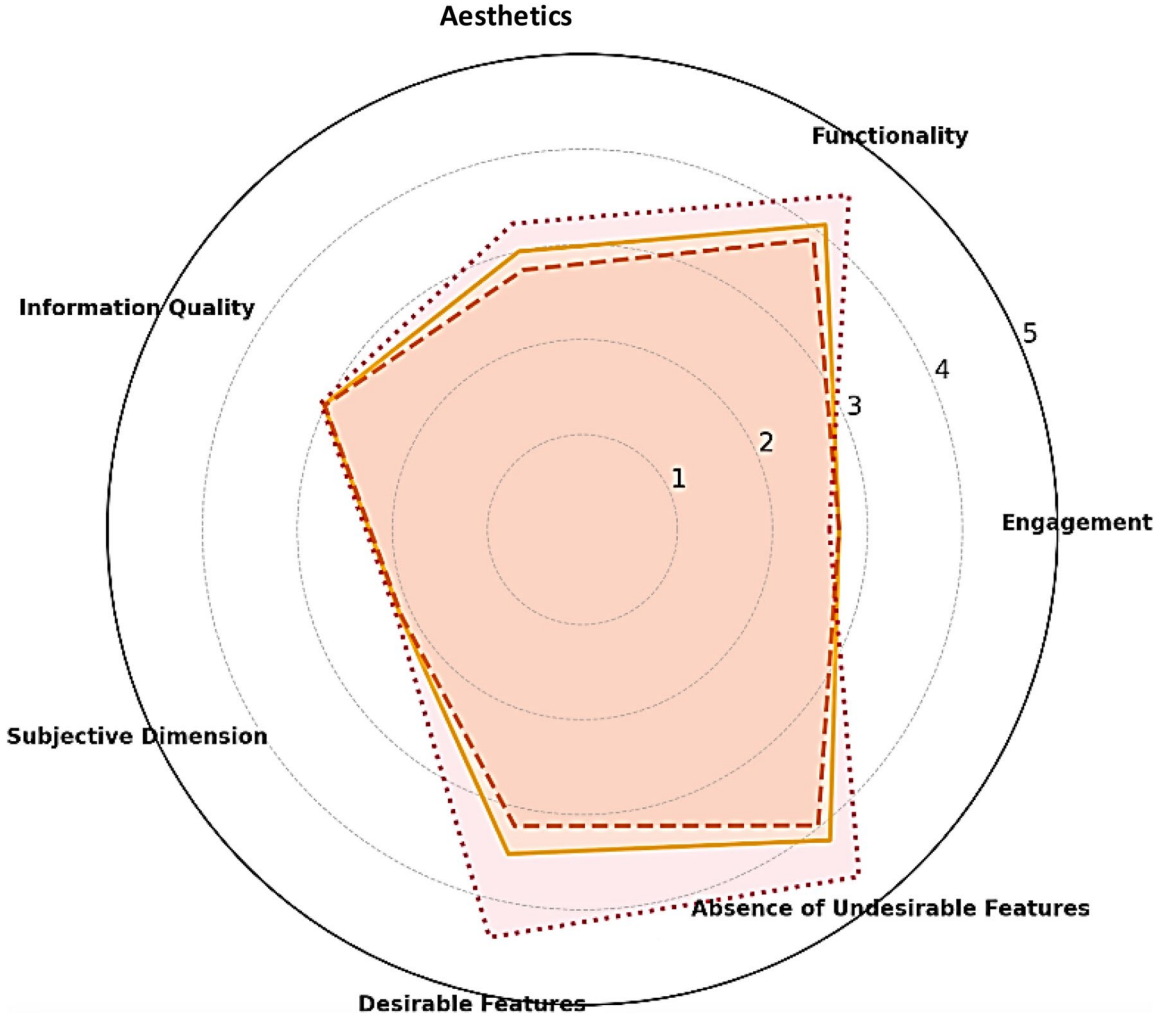

Fig. 2 Comparison of app quality scores across platforms

Cancer, The Breasties Cancer Community, and Owise. The Breast Health Care app had the lowest score in this tool. The normality of the dataset was assessed using the One-Sample Kolmogorov-Smirnov test. The results indicated that the functionality dimension ($D = 0.199$, $p < 0.001$), subjective dimension ($D = 0.162$, $p = 0.005$), desirable features ($D = 0.161$, $p = 0.006$), and absence of undesirable features ($D = 0.314$, $p < 0.001$) deviated significantly from a normal distribution. In contrast, engagement ($D = 0.122$, $p = 0.102$), aesthetics ($D = 0.088$, $p = 0.200$), and information quality ($D = 0.090$, $p = 0.200$) did not show significant deviations from normality.

FARM tool evaluation results

The results of assessing the features of mobile health applications for breast cancer management using the FARM tool are shown in Table 1. The mean score of FARM for all apps was 4.18 ± 0.24. The highest mean scores in the App Store were for GPS Functionality, Settings, Communication Ways, Data Import and Export Feature, and Note Feature. Breast Cancer App Store apps in the FARM tool for Undesirable Features, Corrupted and misleading links (4.7 ± 0.9), Inactive and misleading buttons (4.8 ± 0.6), and It was a free app, but required payment for basic features (4.8 ± 0.4) had the lowest value. Breast Cancer App Store apps in the FARM tool for Advertisement, the existence of unrelated information, difficulties in logging into the app, and the fact that it takes a long time to load the app's content, a total score (5) has been obtained.

The features with the highest scores in the Google Play Store were Medication Management (4.5 ± 0.5), Search Feature (4.4 ± 0.8), Password (4.4 ± 0.6), and Collect Patient Data (4.3 ± 1). Breast Cancer Google Play Store apps in the FARM tool had the lowest value for Advertisement (4.4 ± 1.3), and It takes a long time to load the app's content after execution (4.4 ± 1.3). Google Play Store apps of Breast Cancer in the FARM tool for Undesirable Feature, the existence of unrelated information (4.9 ± 0.1), Inactive and misleading buttons (4.8 ± 0.7), and Corrupted and misleading links (4.8 ± 0.5) had the highest score.

The degree of agreement between the three evaluators regarding the rating based on the FARM and MARS tools is shown in Table 4. The agreement rate between the three evaluators for the overall MARS score, calculated using the ICC, was 0.952 (CI 95%=0.929–0.971). The agreement rate between the three evaluators for the overall FARM score was 0.8 (CI 95%=0.692–0.879). The association between the dimensions of the MARS tool and the FARM tools' dimensions was assessed using the Spearman correlation test (Table 5). Table 5 indicates that the weakest association was found between the functionality dimension score and the information quality dimension score of the MARS tool ($\rho = 0.397$, $p = 0.016$). The strongest association was noted between the subjective dimension score and the engagement dimension score of the MARS instrument ($\rho = 0.806$, $p < 0.001$). Similarly, the strongest association within the FARM tool was observed between the absence and desired scores ($\rho = 0.254$, $p = 0.102$). The most significant correlation between the dimensions of the MARS and FARM tools was noted between the functionality dimension score and the absence dimension score ($\rho = 0.381$, $p = 0.022$). In contrast, the least significant correlation was found between the information quality dimension score and the absence dimension score ($\rho = 0.005$, $p = 0.964$). Apps with the highest scores based on the FARM and MARS tools in the Google Play Store and App Store are shown in Table 6.

Table 4 The agreement rate between the three evaluators regarding the rating based on FARM and MARS tools

Tools	Dimensions	ICC	Confidence interval of 95% for ICC
MARS	Engagement	0.965	0.942–0.980
	Functionality	0.944	0.908–0.967
	Aesthetics	0.941	0.903–0.966
	Information quality	0.946	0.910–0.968
	Subjective dimension	0.940	0.901–0.965
FARM	Desirable features	0.972	0.954–0.984
	Absence of undesirable features	0.917	0.863–0.952

Discussion

Self-care in breast cancer is recognized as a crucial strategy for preventing the worsening of the prognosis and managing the disease [29].

This systematic review on mobile health effectiveness in breast cancer care can be used to contextualize the findings related to the impact of mobile apps on patient care [30]. With the rise of mobile technology, smartphones have increasingly become valuable tools for supporting various aspects of self-care [31]. Accordingly, the present study was conducted to evaluate mobile health applications designed for breast cancer management, guiding healthcare stakeholders and patients in identifying high-quality mobile health applications that meet their needs.

In summary, the results revealed that out of 453 retrieved apps, 44 related to breast cancer were chosen after evaluation. The average app rating using the MARS and FARM tools across both app stores was 3.3 out of 5. In the Google Play Store, 12.5% of the apps, and in the Apple Store, 33.3% of the apps scored higher than 4. The highest MARS score was in the functionality category (4.1), while the lowest was in the subjective dimension

Table 5 The correlation between the FARM dimensions and the MARS dimensions

Tools and dimensions	MARS dimensions					FARM dimensions	
	Engagement	Functionality	Aesthetics	Information quality	Subjective dimension	Desirable features	Absence of undesirable features
MARS dimensions							
Engagement	1.0	0.469	0.718	0.648	0.806	0.217	- 0.244
	.	.001	<.001	<.001	<.001	.157	.110
Functionality	0.469	1.0	0.488	0.397	0.516	0.316	0.381
	.001	.	.001	.008	<.001	.036	.011
Aesthetics	0.718	0.488	1.0	0.577	0.719	0.337	- 0.102
	<.001	.001	.	<.001	<.001	.025	.511
Information quality	0.648	0.397	0.577	1.0	0.676	0.163	- 0.005
	<.001	.008	<.001	.	<.001	.289	.977
Subjective dimension	0.806	0.516	0.719	0.676	1.0	0.224	- 0.04
	<.001	<.001	<.001	<.001	.	.143	.797
FARM dimensions							
Desirable features	0.217	0.316	0.337	0.163	0.224	1.0	0.254
	.157	.036	.025	.289	.143	.	.096
Absence of undesirable features	- 0.244	0.381	- 0.102	- 0.005	- 0.04	0.254	1.0
	.110	.011	.511	.977	.797	.096	.

(2.12). The inter-rater reliability for MARS and FARM was 0.952 and 0.8, respectively.

In the current study, although apps from the App Store and Google Play received comparable and acceptable scores on the MARS and FARM evaluations, the highest average rating was attributed to the absence of undesirable features. In contrast, the subjective dimension received the lowest average score. Consistent with our findings, Raeesi et al. [31] utilized the MARS tool to evaluate HIV/AIDS mobile apps and reported similar results [32]. It is noteworthy, however, that their study differed from ours regarding the specific disease under consideration.

Additionally, with advancements in virtual development techniques, many features of mobile apps can now be highly personalized, reducing undesirable characteristics [23]. Nonetheless, the subjective dimension of mobile apps received relatively low scores in the present study. Maga et al. [23] similarly found that the subjective dimension scored the lowest in their evaluation of an app related to breastfeeding [33]. Comparing our findings with the other investigations, it appears that the subjective aspect of mobile apps remains significantly below the desired standard, underscoring the need for more rigorous evaluation and refinement in this area.

Similarly, Aydin et al. [13] systematically evaluated breast cancer-related mobile health applications using the MARS tool and reported findings comparable to ours [13]. Their study highlighted that while most breast cancer apps demonstrated strong functionality, engagement and subjective ratings were notably lower—consistent with our observations. However, unlike our study, which incorporated both MARS and FARM tools for a more comprehensive assessment, Aydin et al. primarily relied on MARS, limiting their evaluation to engagement and information quality while overlooking other usability factors, such as the absence of undesirable features and the presence of essential functionalities.

Our findings reinforce the importance of a multidimensional evaluation approach, as technical functionality alone does not guarantee high engagement or user satisfaction. Both studies suggest that while many breast cancer apps offer well-developed core functionalities, they often fail to provide an engaging and personalized user experience. This highlights a critical gap in mobile health applications, where usability, interactivity, and patient-centred design must be prioritized alongside technical performance.

To address these shortcomings, future app development should integrate adaptive personalization, gamification, and improved accessibility features. Personalization through AI-driven recommendations can enhance user engagement by tailoring content to individual patient needs and disease progression. Gamification elements,

Table 6 Apps with the highest scores

Tools	Google Play Apps	Score (Sum of scores)	App Store Apps	Score (Sum of scores)
MARS	1- Surviving Breast Cancer	21.52	1- Breast Self-Check	19.60
	2- The Breasties Cancer Community	20.78	2- B well	19.20
	3- Owise	20.53	3- I Check	18.57
	4- Breast Cancer Club	19.95	4- Pink Bra	17.45
	5- Keep a Breast	19.40	5- Pinky Promise	15.71
	6- ACS Reach	18.55	6- Breast health	15.62
	7- Feel for your life	17.58	7- Fighting Breast cancer united	15.12
	8- Dear mama	17.26	8- MBC Connect	14.61
	9- BCSC	17.16	9- Sentinel node	14.01
	10- Breast care breast awareness	16.71	10- B4BC	14
	11- Young breast cancer warriors	16.35	11- Breast center	13.73
	12- Becca	16.02	12- Breast MAT	13.67
	13- Bezzy Breast cancer	15.81	13- Breast TNM	13.33
	14- Breast Advocate	14.84		
	15- Breast cancer causes and diagnosis	14.69		
	16- Breast cancer1	14.03		
	17- GBCC	13.68		
	18- Breast cancer awareness	13.10		
	19- NIH breast cancer	12.92		
	20- Boot Out breast cancer	12.75		
	21- Breast cancer guide	12.63		
	22- Breast aware	12.19		
	23- Breast cancer	11.91		
	24- AGO	11.72		
	25- Nextgen breast cancer	11.13		
	26- SABC	11.08		
	27- Tips for breast cancer	10.76		
	28- Breast cancer192	10.75		
	29- Breast disorders	10.60		
	30- Symptoms of breast cancer	10.38		
	31- Breast health care	9.07		

Table 6 (continued)

Tools	Google Play Apps	Score (Sum of scores)	App Store Apps	Score (Sum of scores)
FARM	1- NIH Breast Cancer	9.55	1- Breast MAT	10
	2- Breast Cancer Club	9.45	1- Breast Self-Check	10
	3- Breast Advocate	9.26	1- Breast TNM	10
	4- ACS Reach	9.18	1- Breast Center	10
	5- Owise	9.16	1- Pink bra	10
	6- Young breast cancer warriors	9.11	6- Sentinel node	9.83
	7- Breast care breast awareness	9.06	7- Fighting Breast cancer united	9.82
	8- Tips for breast cancer	9	8- I check	9.67
	9- AGO	8.93	8- B well	9.67
	10- Breast aware	8.83	10- B4BC	9.47
	11- BCSC	8.81	11- Pinky promise	9.22
	12- The Breasties Cancer Community	8.8	12- Breast health	9
	13- SABC	8.76	13- MBC Connect	4.89
	14- GBCC	8.75		
	15- Becca	8.42		
	16- Nextgen breast cancer	8.33		
	17- Bezzy Breast cancer	8.01		
	18- Dear mama	8		
	19- Breast health care	7.58		
	20- Breast cancer	7.55		
	21- Breast cancer causes and diagnosis	7.42		
	22- Keep a breast	7.39		
	23- Breast disorders	7.33		
	24- Boot Out breast cancer	7.23		
	25- Surviving breast cancer	6.94		
	26- Feel for your life	6.81		
	27- Breast cancer1	6.78		
	28- Breast cancer awareness	6.56		
	29- Breast cancer guide	6.12		
	30- Breast cancer192	5		
	31- Symptoms of breast cancer	4.78		

such as reward-based tracking for self-examination or treatment adherence, could further improve motivation and long-term use. Moreover, accessibility remains an overlooked aspect in most breast cancer apps, as they primarily target a general female audience while neglecting male breast cancer patients and individuals with disabilities. Universal design principles can help bridge this gap and expand usability across diverse patient demographics.

Another critical aspect identified in both studies is the lack of clinically validated applications. Many apps lack expert endorsement and evidence-based guidelines, reducing their credibility and reliability in clinical settings. Future development efforts should prioritize collaborations with healthcare professionals and integrate standardized medical guidelines to enhance trust and effectiveness.

These findings suggest that while technical advancements in breast cancer apps continue to improve, a pressing need remains to enhance user engagement, accessibility, and clinical validation. By incorporating user-centered design, interactive features, and stronger medical oversight, future apps can become more effective tools for patient education, symptom tracking, and adherence to treatment protocols, ultimately improving the overall digital health landscape for breast cancer management.

The findings revealed that four apps from the Google Play Store—ACS Reach, Breast Cancer Club, Owise, and The Breasties Cancer Community—achieved ratings above 4 on the MARS scale. In support of these findings, Wright et al. also utilized the Owise app and reported its strong effectiveness in breast cancer self-care [34]. However, to the authors' knowledge, no research has yet focused on using this particular *set of mobile* apps from the Google Play Store for breast cancer management. Similarly, the apps BWell, Icheck, Breast Self-Check, and Pink Bra in the Apple Store received ratings exceeding 4 (based on the MARS scale). Additionally, Harder et al. demonstrated that the BWell app—a novel program designed for arm and shoulder exercises—was collaboratively developed by breast cancer patients, healthcare professionals, and academics, and it shows significant potential for effectiveness among breast cancer patients [35].

Regarding the Pink Bra and Breast Self-Check apps, Nasution et al. found that these applications have considerable potential for the timely detection of breast cancer. Notably, their study, which, like the present research, aimed to evaluate mobile apps in the context of gastric cancer, indicated that most apps concentrated on perceived threats and benefits but lacked a focus on perceived barriers. This evaluation could provide valuable insights for developing content that aligns with health theories to enhance breast cancer awareness [36]. Overall, these results suggest that, in the future, the insights gained from this study could be instrumental in developing and improving apps guided by health theories focused on managing and preventing breast cancer. However, further testing and validation of these applications are necessary.

Furthermore, the present study highlights the role of mobile apps as an essential digital health intervention in breast cancer management. The findings emphasize that while many breast cancer apps demonstrate technical functionality, a gap remains in user engagement and subjective perception [37]. This suggests that future app development should focus on technological aspects and improving user experience and perceived value. By addressing these deficiencies, breast cancer apps could become more effective tools for patient education, symptom tracking, and adherence to treatment protocols.

Moreover, according to the FARM scale, the apps evaluated in the Apple Store exhibited several desirable features, such as GPS functionality, customizable settings, communication tools, data import/export capabilities, and note-taking options. One potential explanation for the observed differences between app stores may stem from the distinct development standards and regulatory frameworks imposed by Apple and Google. Apple's App Store enforces stricter review processes and higher standards for app functionality, security, and privacy compliance, which may contribute to the presence of more polished apps with fewer undesirable features. In contrast, the Google Play Store allows for greater flexibility in app submissions, leading to a higher number of available apps but with more variation in quality [13].

Our findings support this trend. As shown in Table 1, the average overall score for apps in the App Store (3.5 ± 0.22) was higher than in the Google Play Store (3.2 ± 0.18). Moreover, Table 6 indicates that among the top five highest-rated apps on MARS, three belong to the App Store (BWell, Breast Self-Check, and ICheck), reinforcing that iOS apps tend to be better optimized and provide higher functionality. In contrast, only two of the highest-rated apps in Table 6 are from the Google Play Store (Owise and The Breasties Cancer Community), suggesting that while some Android apps achieve high ratings, they are less consistent in quality.

The differences in quality can also be observed in specific MARS dimensions. As seen in Table 1, Apple apps had a higher average functionality score (4.5 ± 0.13) than Android apps (3.9 ± 0.16), demonstrating that stricter App Store regulations might lead to better user experience and interface optimization. For instance, BWell (iOS) received the highest MARS score for functionality (4.6), whereas Owise (Android) scored lower (4.3) despite being a well-regarded app. This suggests that iOS apps

are often designed with better interface integration and technical stability.

In contrast, despite their higher availability, Android apps contained more technical flaws, such as broken links, inactive buttons, and misleading advertisements. This was evident in the FARM assessment, where undesirable features were more frequently identified in Android than iOS apps. For example, Breast Cancer Club (Android) exhibited technical issues related to UI stability, contributing to a lower overall FARM score than similar iOS apps.

These discrepancies can be attributed to fundamental differences in Apple and Google's development policies. Apple requires all apps to undergo manual review before approval, ensuring compliance with UI/UX standards, security, and performance metrics. Additionally, iOS apps must adhere to Human Interface Guidelines (HIG), a set of best practices that promote consistent design, smooth navigation, and accessibility features. On the other hand, Google Play Store relies more on automated screening, allowing developers to push updates more frequently but at the cost of quality control. This flexibility leads to more Android apps but increases the risk of inconsistencies and technical issues.

These findings highlight the need for cross-platform optimization and stricter quality control measures in mobile health application development to ensure consistency and reliability across different operating systems. Developers should consider adapting the higher design standards enforced by Apple to enhance app usability and overall performance on all platforms. Moreover, Android app developers should implement better testing and quality assurance practices before launching their apps to minimize user experience issues and maintain functionality over time.

Furthermore, this discrepancy in quality affects user adoption and trust. Users may perceive iOS apps as more reliable and professional, whereas Android apps may be seen as more experimental but less polished. Future research should explore how these quality differences impact user engagement and adherence to breast cancer self-care practices.

These features significantly enhance user engagement and facilitate the management of health-related information. For example, GPS can help users locate nearby healthcare facilities or quickly find routes to medical services [38]. Additionally, importing and exporting data enables users to synchronize their health information across multiple devices or applications, which is of considerable value [39]. Conversely, the lowest ratings were assigned to apps with undesirable features, such as broken links, inactive buttons, and apps advertised as free but requiring payment for basic functionalities. These issues compromise the user experience and risk undermining users' trust in the applications. For instance, broken links or inactive buttons can hinder users from accessing essential information, leading to frustration and dissatisfaction.

Similarly, offering an app for free but charging for basic features can create a sense of deception, potentially causing users to abandon the app entirely [13]. The findings also reveal that the evaluators demonstrated a generally high level of agreement when ranking the apps using the FARM and MARS tools. This agreement was especially pronounced in the overall MARS scores, with a strong concordance also observed in the FARM tool. Furthermore, an analysis of the correlations between various dimensions of these tools showed that some dimensions were more closely related, such as the connection between the subjective dimension and engagement in the MARS tool. On the other hand, dimensions like information quality and functionality in MARS and absence and desirability in FARM exhibited weaker correlations.

These results suggest that certain features and dimensions of these tools are more closely aligned while others are less so. In line with this, Raeesi et al. [31] found a moderate to high correlation between the scores assigned to apps using the MARS and FARM tools [32]. Therefore, a high MARS score can indicate the presence of desirable features and the absence of undesirable ones in an app. However, relying on a single tool for app evaluation may not provide a complete picture. Using multiple tools offers a more detailed and comprehensive assessment of the apps.

Additionally, while most breast cancer mobile health applications are designed with female patients in mind, the study identifies a gap in addressing male breast cancer. Given that male breast cancer, though rare, presents distinct challenges such as delayed diagnosis and unique psychosocial needs, future app development should consider incorporating resources tailored to male patients. Expanding digital health solutions to be more inclusive could enhance awareness, early detection, and targeted support for all individuals affected by breast cancer.

Potential clinical and public health implications

The findings of this study have significant implications for both clinical practice and public health. For patients, the availability of high-quality mobile health applications for breast cancer management can empower them to take an active role in their self-care, improving disease management and potentially enhancing their quality of life. Apps with desirable features, such as GPS functionality, customizable settings, and data synchronization, can provide practical tools for patients to monitor their health, access resources, and communicate with healthcare providers. These features can also facilitate early detection of breast cancer, as seen with apps like Pink Bra

and Breast Self-Check, which have shown potential for timely diagnosis.

For clinicians, these apps can serve as valuable adjuncts to traditional care, offering a platform to deliver personalized health information, track patient progress, and encourage adherence to treatment plans. Integrating apps like BWell, which was developed collaboratively by patients, healthcare professionals, and academics, demonstrates the potential for such tools to bridge the gap between clinical care and patient self-management. However, the presence of undesirable features, such as broken links or hidden costs, highlights the need for clinicians to guide patients in selecting reliable and effective apps.

From a public health perspective, the widespread adoption of high-quality breast cancer apps could contribute to increased awareness, early detection, and better management of the disease. By aligning app content with health theories, developers can create tools that address perceived threats and benefits and tackle perceived barriers, promoting sustained engagement and behavior change. This could ultimately reduce the burden of breast cancer on healthcare systems and improve outcomes at the population level.

In conclusion, while the current study highlights the potential of mobile apps in breast cancer self-care, it also underscores the need for ongoing evaluation, refinement, and validation of these tools. By addressing the limitations identified, such as the low scores in the subjective dimension and undesirable features, future apps can better meet the needs of patients and clinicians, ultimately contributing to improved breast cancer management and prevention [40]. Most mobile health applications for breast cancer management are designed with female patients in mind, reflecting the higher prevalence of the disease among women. Features such as self-examination guides, symptom tracking, and community support networks are often tailored to women's experiences. However, given that male breast cancer, while rare, presents unique challenges—including delayed diagnosis and distinct psychosocial needs—there is a potential gap in digital health solutions for male patients. Developing or adapting existing apps to include resources specific to male breast cancer could improve awareness, early detection, and support for affected individuals.

Strengths and limitations

The study thoroughly evaluated breast cancer apps using MARS and FARM tools, offering a well-rounded look at their functionality, user engagement, and potential issues. The selection of evaluators with a background in health information technology ensured a standardized and unbiased assessment based on validated tools. Their expertise enabled a consistent application of MARS and FARM, reducing variability in subjective ratings. The research provided a nuanced understanding of app quality by including apps from major app stores. Structured break intervals were implemented during the evaluation sessions to mitigate the risk of evaluator fatigue. After each hour of assessment, evaluators took a 15–20 min break to rest, ensuring that fatigue did not affect the scoring process and maintaining the integrity of the evaluations. Prior research has indicated that prolonged cognitive tasks, such as systematic app evaluations, can lead to decreased attentional control and increased variability in subjective ratings [26]. By incorporating structured breaks, we aimed to minimize potential fluctuations in scoring accuracy and reduce the likelihood of bias introduced by evaluator fatigue.

Additionally, ensuring that all assessors resumed the evaluation only when they confirmed their readiness helped maintain consistency across assessments. This methodological approach improved the reliability of the MARS and FARM ratings and contributed to greater inter-rater agreement, as reflected in the high ICC values reported in Table 4. Future studies should further explore the impact of fatigue on digital health app assessments and consider implementing additional strategies, such as rotating evaluators or using shorter assessment sessions, to optimize scoring reliability.

However, certain limitations should be acknowledged. The exclusion of non-English apps and reliance on keyword searches may have restricted the scope, potentially omitting valuable apps that could offer unique insights into breast cancer management. Additionally, while the study focused on apps available in Iran, which might limit the generalizability of the findings to other regions, it still provides critical insights applicable to broader contexts. Another limitation is the absence of direct patient perspectives, which may limit the interpretability of app features that could be more relevant to end-users than experts. While our approach ensured methodological rigor, future studies should consider incorporating patient feedback to complement expert evaluations and provide a more holistic assessment of app usability and impact. Despite these challenges, the study offers important insights that can help improve breast cancer management apps moving forward by identifying key areas for enhancement and ensuring that future developments align with expert and patient needs.

Conclusions

In the present study, breast cancer apps from the Google Play Store and App Store were evaluated by four reviewers using the MARS and FARM tools. The results showed that most apps did not have issues like broken links or inactive buttons, which earned them the highest scores. However, some apps struggled with delivering accurate and reliable information, with lower scores in user

experience and information quality. While features such as medication management and search functionality performed well, there is room for improvement in offering more engaging and informative content to enhance the user experience.

The study's strengths lie in the standardized evaluation process conducted by experts in health information technology, which ensured consistency and minimized subjective biases. However, limitations such as excluding non-English apps, reliance on keyword searches, and the absence of direct patient perspectives should be considered when interpreting the results. Incorporating patient feedback in future research could provide a more comprehensive understanding of app usability and effectiveness.

Finally, these findings can help patients choose better apps for managing their health. For doctors and specialists, these apps could be valuable tools for tracking patient progress and providing additional resources. Researchers can use these results to pinpoint the strengths and weaknesses of the apps and explore ways to improve health app development. Future apps can better serve patients and healthcare providers in breast cancer management by addressing identified limitations and enhancing user engagement and information quality.

Abbreviations

mHealth	Mobile health
WHO	World Health Organization
MARS	Mobile Application Rating Scale
FARM	Feature-based Application Rating Method
ICC	Internal correlation coefficient

Supplementary Information

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Supplementary Material 1.

Supplementary Material 2.

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Authors' contributions
RKH, and MRMH designed the study. MRMH supervised the project. GHM, ZE, and FZB contributed to the app's evaluation. MRMH, NN and GHM analyzed and interpreted the data. RKH, MRMH, and NN wrote the final manuscript. All authors read and approved the final manuscript.

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Data availability
The dataset and statistical analysis plan are available upon reasonable request from the corresponding author.

Declarations

Ethics approval and consent to participate
In this study, all apps were downloaded directly from the Google Play Store and Apple Store, and no apps were downloaded illegally. We confirm that all methods were performed following the relevant guidelines, regulations, and Declaration of Helsinki. Our study was submitted to the ethical committee of Mashhad University of Medical Sciences (IR.MUMS.REC), and approval was waived. We confirm that informed consent to participate was obtained from all the study participants.

Consent for publication
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Competing interests
The authors declare no competing interests.

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References

1. Friede A, Reid JA, Ory HW. CDC WONDER: a comprehensive on-line public health information system of the centers for disease control and prevention. Am J Public Health. 1993;83(9):1289–94.
2. Calys-Tagoe BN, Aheto JM, Mensah G, Biritwum RB, Yawson AE. Cervical cancer screening practices among women in Ghana: evidence from wave 2 of the WHO study on global ageing and adult health. BMC Womens Health. 2020;20:1–9.
3. Emeka AC, Anthonia ON, Omowunmi OF. Self-efficacy of breast self-examination among female adolescents. Pharmacology. 2024;4(2):36–45.
4. Waks AG, Winer EP. Breast cancer treatment: a review. JAMA. 2019;321(3):288–300.
5. DeSantis CE, Ma J, Gaudet MM, Newman LA, Miller KD, Goding Sauer A, et al. Breast cancer statistics, 2019. Cancer J Clin. 2019;69(6):438–51.
6. Francies FZ, Hull R, Khanyile R, Dlamini Z. Breast cancer in low-middle income countries: abnormality in splicing and lack of targeted treatment options. Am J Cancer Res. 2020;10(5):1568.
7. Barlow WE, Lehman CD, Zheng Y, Ballard-Barbash R, Yankaskas BC, Cutter GR, et al. Performance of diagnostic mammography for women with signs or symptoms of breast cancer. J Natl Cancer Inst. 2002;94(15):1151–9.
8. Singletary SE. Rating the risk factors for breast cancer. Ann Surg. 2003;237(4):474–82.
9. Wright A. Evaluation of two mobile health apps for patients with breast cancer using the mobile application rating scale. Mhealth. 2021;7:60.
10. Peng C, He M, Cutrona SL, Kiefe CI, Liu F, Wang Z. Theme trends and knowledge structure on mobile health apps: bibliometric analysis. JMIR mHealth uHealth. 2020;8(7):e18212.
11. Cai T, Huang Y, Zhang Y, Lu Z, Huang Q, Yuan C. Mobile health applications for the care of patients with breast cancer: a scoping review. Int J Nurs Sci. 2021;8(4):470–6.
12. Afra P, Bruggers CS, Sweney M, Fagatele L, Alavi F, Greenwald M, et al. Mobile software as a medical device (SaMD) for the treatment of epilepsy: development of digital therapeutics comprising behavioral and music-based interventions for neurological disorders. Front Hum Neurosci. 2018;12:171.
13. Aydin A, Gursoy A. Breast cancer-related apps in Google play and app store: evaluate their functionality and quality. J Cancer Surviv. 2023;17(4):1251–7.

14. Stoyanov SR, Hides L, Kavanagh DJ, Zelenko O, Tjondronegoro D, Mani M. Mobile app rating scale: a new tool for assessing the quality of health mobile apps. JMIR mHealth uHealth. 2015;3(1):e3422.
15. Çınar D, Karadakovan A, Erdoğan AP. Effect of mobile phone app-based training on the quality of life for women with breast cancer. Eur J Oncol Nurs. 2021;52:101960.
16. Hearst M. Search user interfaces. Cambridge University Press; 2009.
17. Charbonneau DH, Hightower S, Katz A, Zhang K, Abrams J, Senft N, et al. Smartphone apps for cancer: a content analysis of the digital health marketplace. Digit Health. 2020;6:2055207620905413.
18. Mohammadzadeh Z, Eghtedar S, Ayatollahi H, Jebraeily M. Effectiveness of a self-management mobile app on the quality of life of women with breast cancer: a study in a developing country. BMC Womens Health. 2022;22(1):446.
19. Carvalho C, Prando BC, Dantas LO, da Silva Serrão PRM. Mobile health technologies for the management of spine disorders: a systematic review of mHealth applications in Brazil. Musculoskelet Sci Pract. 2022;60:102562.
20. Choi SK, Yelton B, Ezeanya VK, Kannaley K, Friedman DB. Review of the content and quality of mobile applications about Alzheimer's disease and related dementias. J Appl Gerontol. 2020;39(6):601–8.
21. Schmeelk S, Davis A, Li Q, Shippey C, Utah M, Myers A, et al. Monitoring symptoms of COVID-19: review of mobile apps. JMIR mHealth uHealth. 2022;10(6):e36065.
22. Abbasi M, Lopes A, Rodrigues D, Saraiva J, Martins P, Sá F, et al. editors. In-depth analysis of mobile apps statistics: a study and development of a mobile app. 2023 18th Iberian Conference on Information Systems and Technologies (CISTI). IEEE; 2023. https://doi.org/10.23919/CISTI58278.2023.10211912.
23. Maga G, Magon A, Pedrina D, Pappalardo M, Del Bo E, Conte G, et al. Mobile health applications (mHealth apps) for breastfeeding: a qualitative review using the mobile application rating scale. Recenti Prog Med. 2024;115(3):138–47.
24. Sadare O, Melvin T, Harvey H, Vollebregt E, Gilbert S. Can Apple and Google continue as health app gatekeepers as well as distributors and developers? NPJ Digit Med. 2023;6(1):8.
25. Fetterman D, Bowman C. Experiential education and empowerment evaluation: Mars Rover educational program case example. J Experiential Educ. 2002;25(2):286–95.
26. Reeder B, Drake C, Ozkaynak M, Jones W, Mack D, David A, editors. Usability inspection of a mobile clinical decision support app and a short form heuristic evaluation checklist. Augmented Cognition: 13th International Conference, AC 2019, Held as Part of the 21st HCI International Conference, HCII 2019, Orlando, FL, USA, July 26–31, 2019, Proceedings 21. Springer; 2019. https://doi.org/10.1007/978-3-030-22419-6_23.
27. Deveci Z, Karayurt Ö, Bilik O, Eyigör S. Development of the breast cancer related lymphedema self-care scale. Clin Nurs Res. 2023;32(1):221–32.
28. Yang S, Bui CN, Park K. Mobile health apps for breast cancer: content analysis and quality assessment. JMIR mHealth uHealth. 2023;11(1):e43522.
29. Haghparast A, Okhovvat M, Khoddam H, Khandashpour M, Kolagari S. A mobile-based self-care application for patients with chronic obstructive pulmonary disease: a protocol for design, implementation, and evaluation. Health Sci Rep. 2024;7(7):e2259.
30. Flaucher M, Zakreuskaya A, Nissen M, Mocker A, Fasching PA, Beckmann MW, et al. Evaluating the effectiveness of mobile health in breast Cancer care: a systematic review. Oncologist. 2023;28(10):e847–58.
31. Raeesi A, Khajouei R, Ahmadian L. Evaluating and rating HIV/AIDS mobile apps using the feature-based application rating method and mobile app rating scale. BMC Med Inf Decis Mak. 2022;22(1):281.
32. Al Farsi G, Tawafak RM, Alyoussef IY, Al-Rahmi WM. Systematic literature review for smart mobile learning in programming courses. Int J Interact Mob Technol. 2024;18(12).
33. Harder H, Holroyd P, Burkinshaw L, Watten P, Zammit C, Harris PR, et al. A user-centred approach to developing bWell, a mobile app for arm and shoulder exercises after breast cancer treatment. J Cancer Surviv. 2017;11:732–42.
34. Nasution A, Yusuf A, Iskandar YHP, Hadi ISA. Mobile health application applying the health belief model for breast cancer awareness: what is missing? Malaysian J Med Health Sci. 2021;17(4). https://medic.upm.edu.my/upload/dokumen/2021100810115551_MJMHS_0118.pdf.
35. Ascione R. The future of health: how digital technology will make care accessible, sustainable, and human. Wiley; 2021.
36. Kharrazi H, Chisholm R, VanNasdale D, Thompson B. Mobile personal health records: an evaluation of features and functionality. Int J Med Informatics. 2012;81(9):579–93.
37. Saevarsdottir SR, Gudmundsdottir SL. Mobile apps and quality of life in patients with breast cancer and survivors: systematic literature review. J Med Internet Res. 2023;25:e42852.
38. Jones N, Moffitt M. Ethical guidelines for mobile app development within health and mental health fields. Prof Psychol Res Pract. 2016;47(2):155.
39. Alhuwail D, Alhouti A, Alsarhan L. Assessing the quality, privacy, and security of breast cancer apps for Arabic speakers: systematic search and review of smartphone apps. JMIR Cancer. 2024;10(1):e48428.
40. Song SS, Kang S, Park S. Association of estrogen-related polygenetic risk scores with breast cancer and interactions with alcohol intake, early menarche, and nulligravida. Asian Pac J Cancer Prev. 2022;23(1):13.

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