Breast Disease **43** (2024) 135–144
DOI 10.3233/BD-249004
IOS Press

Systematic Review

Early detection of self-breast examination using smartphone breast application

Nur Indah[a], Andi Nilawati Usman[b,*], Yusring Sanusi Baso[c], Syafruddin Syarif[d], Mardiana Ahmad[e] and Andi Agus Mumang[f]
[a]*Department of Midwifery, Graduate School, Hasanuddin University, Makassar, Indonesia*
[b]*Department of Midwifery, Graduate School, Hasanuddin University, Makassar, Indonesia*
ORCID: https://orcid.org/0000-0002-1136-1704
[c]*Learning Media Center, Learning Resources and E-Learning, Hasanuddin University, Makassar, Indonesia*
ORCID: https://orcid.org/0000-0003-0266-6909
[d]*Department of Engineering, Hasanuddin University, Makassar, Indonesia*
ORCID: https://orcid.org/0000-0003-1285-1323
[e]*Department of Midwifery, Graduate School, Hasanuddin University, Makassar, Indonesia*
ORCID: https://orcid.org/0000-0002-0798-0457
[f]*Graduate School, Hasanuddin University, Makassar, Indonesia*
ORCID: https://orcid.org/0000-0003-1050-8812

Abstract.
INTRODUCTION: Breast self-examination (BSE) is a screening method that can help empower, raise awareness, and detect breast abnormalities in women. The use of smartphone applications for breast cancer early detection is able to overcome some of these barriers. This study aimed to conduct a systematic review to assess the effectiveness of the effect of using smartphone application-based technology on breast cancer.
METHODS: Google Scholar, PubMed, Proquest, and ScienceDirect were searched for "breast self-examination" and "smartphone application" literature. This literature's study designs were quasi-experimental, prospective cohort, qualitative, and systematic review. The study contained five unique research projects with 828 varied participants.
RESULTS: The use of smartphones was seen to have advantages in terms of increased knowledge, perceived vulnerability, barriers to breast self-examination (BSE), self-efficacy, health motivation, and BSE practices.
CONCLUSIONS: The utilization of smartphone apps related to BSE is shown through the availability, accessibility, and focus of information and is in line with the Health Belief Model (HBM).

Keywords: Breast cancer, smartphone application, BSE

1. Introduction

Globally, breast cancer is the leading cause of death for women [1–3]. The World Health Organization's Global Breast Cancer Initiative (GBCI), to realize the common goal of reducing breast cancer by 2.5% per year to save 2.5 million lives in the next 20 years, implemented three main strategies to achieve this goal, including health promotion and early detection [4].

Early detection is paramount in the fight against breast cancer, as it enables timely intervention and treatment, leading to improved prognosis and increased survival rates [1,2,5,6]. Empowering women with

*Corresponding author: Andi Nilawati Usman, Department of Midwifery, Graduate School, Hasanuddin University, Goa ria Street, Villa Pelita Asri, Makassar, South Sulawesi, 90242, Indonesia. Tel.: +62 85240093168; E-mail: andinilawati@pasca.unhas.ac.id.

knowledge about breast health and early detection methods is critical to achieving these goals [5,7–9]. A number of studies suggest that breast cancer early detection education can improve knowledge and awareness of early detection methods [10] and can increase utilization of screening services such as clinical breast examination [11].

Early detection can be done by individual breast self-examination or clinical breast examination by a doctor or nurse, and both are screening methods that have long been recommended for early detection and have detected many breast cancers [9,12]. Breast self-examination (BSE) is a screening method that can help empower, raise awareness, and detect breast abnormalities in women [8].

Among the barriers or challenges in performing breast self-examination (BSE), the most dominant is low knowledge accompanied by negative attitudes and perceptions about BSE [8,13–16]. Nevertheless, the utilization of smartphone applications for breast self-examination, termed smartphone breast application, can overcome some of these barriers. Aprianti and colleagues found that using an android-based breast cancer early detection application for adolescent girls can increase their knowledge [10]. Furthermore, a quasi-experimental study found that the scores of perceived vulnerability, BSE barriers, self-efficacy, and health motivation regarding breast self-examination were significantly higher in the intervention group (i.e., using a smartphone application) compared to the control group [17]. The use of smartphone apps accompanied by hands-on practice is an effective method for breast self-examination [18]. Based on these findings, this study aimed to conduct a systematic review to assess the effectiveness of smartphone application-based technology on breast self-examination.

2. Methods

2.1. Search strategy and inclusion criteria

Several databases, including Google Scholar, PubMed, Proquest, and ScienceDirect, were used to search for the desired literature using the keywords "breast self-examination" and "smartphone application". This study included literature published within the last five years in English or Indonesian and open-access.

2.2. Population

This study generally included women in the general population, clinic referrals, hospital attendees, breast cancer, and adolescent girls.

2.3. Study design

Study designs in this literature included quasi-experimental, prospective cohort, qualitative, and systematic reviews.

2.4. Study selection and data extraction

Two independent reviewers were engaged in selecting literature search results and data extraction. All articles that met the inclusion criteria were deposited into Mandeley software. Any disagreements were resolved through discussion. Data extraction included study characteristics such as title, objective, author, year of publication, study design, sample, instrument, and outcome.

3. Results

3.1. Journal research

A number of databases obtained from the Google Scholar database of as many as 967 studies, Pubmed database of as many as 8 studies, Proquest database of as many as 39 studies, and ScienceDirect database of as many as 31 studies with a total of 1045 studies were identified. A total of 1004 studies were excluded due to duplication and other reasons. Furthermore, out of 41 studies, 34 had to be excluded, leaving 7 studies that were successfully included in this study (Fig. 1).

3.2. Study inclusion characteristics

3.2.1. Study setting

A number of literature with observational and experimental studies were conducted in Indonesia with 1 study, Iran with 1 study, Malaysia with 2 studies, and Poland with 1 study. The remaining two studies were systematic review studies. All studies were conducted from 2019–2022, with details of 1 study in 2019, 2 in 2021, 3 in 2022, and 1 in 2023. The purpose of the research in this literature was to test the effectiveness of smartphone application-based technology on breast self-examination.

3.2.2. Population

This study involved literature with a diverse population with an overall sample of 828 people in 5 original research studies. The studies by Yusuf et al. and Bladja et al. used populations of 41 and 500 general women, respectively, which were involved [19,20]. Shakery et al. used women referred to therapy clinics totaling 150 people [17]. Aprianti et al. used 100 adolescent girls [10]. Nasution et al. involved general women attending hospital services plus 37 software and content experts [21]. Systematic review studies by Kanodia et al. and Cruz et al. included general women and women with breast cancer [22,23].

3.2.3. BSE apps

In general, the apps used are mobile or smartphone apps. The study by Shakery et al. used a smartphone application consisting of BSE reminders, training, alarms, therapy feedback, educational movies, and self-assessment [17]. Yusuf et al. used the BrAware app to improve knowledge of BSE risk factors, awareness of warning signs, and confidence in performing breast self-examination [19]. Bladja et al. used a proprietary mobile medical app based on a conditioned algorithm containing personalized education on breast cancer [20]. Aprianti et al. used an android-based adolescent breast cancer early detection application that contained breast health education [10]. Nasution et al. used a mobile application based on Health Belief Model (HBM) components to be integrated with health promotion strategies [21]. Based on their alleged interactive features, Kanodia et al. selected a database using AppAgg and Google Play Store apps [23]. Cruz et al. selected the use of mobile apps for self-care management of side effects of toxicity due to breast cancer therapy [22].

3.2.4. Outcome

All studies reported that smartphone-based mobile apps were effective in breast self-examination (Table 1). The effectiveness of smartphone apps can be perceived through app utilization and perceived app benefits. Study 5 reported that 84.7% of BSE-related smartphone apps focused on disseminating information about breast cancer. A qualitative study (Study 4) also reported that themes and subthemes related to BSE app utilization generally supported the Health Belief Model (HBM). The perceived benefits of using the app included an increase in participants' knowledge after the intervention (Studies 2 and 7), differences in scores on perceived vulnerability, BSE barriers, self-efficacy, and health motivation (Study 1), and BSE practices (Study 3). In addition, for breast cancer patients, smartphone-based BSE applications can be a readily accepted source of information and can improve patient well-being (Study 6).

4. Discussion

This cytatic review study found that smartphone apps were effective for breast self-examination. Of the seven included literature [10,17,19–23], it was reported that the effectiveness of the application was seen along with the perceived benefits. Smartphone apps have practical and versatile functions that are currently difficult to separate daily, so they are more easily integrated into communication and learning [24]. The availability of multimedia content, including images, text, or videos on smartphones that facilitate education, has been associated with improved health and disease screening [24,25]. Yusuf et al. also support the idea that mobile apps have positively impacted health-related behaviors and clinical health outcomes and can be used for educational and personal health purposes [21]. Therefore, the effectiveness of smartphone apps is seen in the availability and accessibility that facilitate learning anytime and anywhere and cannot be replaced by simply reading a textbook [25–27].

Kanodia et al. mentioned in their findings that the use of smartphone apps related to breast self-examination predominantly focuses on disseminating information about breast cancer. This is in line with Coughlin et al., who explained that breast cancer applications generally provide information on breast cancer early detection guidelines [28]. Effective utilization of smartphone applications, according to a study by Nasution et al., is in line with the health belief model (HBM) [21], supported by Yusuf et al. [19]. Shakery et al. [17]. This model can explain a person's beliefs about the perceived susceptibility of a disease such as breast cancer, benefits and severity, barriers to prevention such as breast self-examination and hospital examination, so that it can affect behavior (self-efficacy) and health outcomes [19,28], and is considered the most popular related to disease prevention and identification of effective determinants in screening behavior [29,30].

Furthermore, the effectiveness of using smartphone apps in breast cancer detection can be perceived through their benefits to early detection, such as breast

Table 1
Characteristics of inclusion studies

No	Title	Research purposes	Country/Year/ Author	Study design	Sample	Types of intervention & duration	Application	Outcomes
1	The effect of a smartphone application on women's performance and health beliefs about breast self-examination: a quasi-experimental study [17]	This study aims to determine the effect of smartphone applications on women's performance and health beliefs regarding BSE.	Iran/2021/ Shakery et al.	quasi-experimental study (two-group pre- and post-test	Women referred to therapy clinics Intervention: 75 people Control: 75 people Total: 150 people	Intervention: access to BSE smartphone app Duration: 6 months	The BSE smartphone application includes an alarm system, reminders (in the form of text messages), accurate BSE training video clips, four videos about breast cancer, and feedback to the therapist.	After the intervention, the mean difference in scores of perceived susceptibility (1.03 ± 2.65 versus 0.01 ± 0.42, $p = 0.001$), BSE barriers (2.80 ± 5.32 versus 0.04 ± 1, 43, $p = 0.001$), self-efficacy (10.75 ± 7.63 versus −2.75 ± 2.44, $p = 0.001$), and health motivation (2.77 ± 3.70 versus −0.29 ± 0.63, $p = 0.001$) was significantly higher in the intervention group compared to the control group.
2	Breast awareness mobile apps for health education and promotion of breast cancer [19]	This study aims to assess the efficacy of the BrAware Application in increasing knowledge about BSE risk factors, awareness of warning signs, and confidence in carrying out breast self-examination (BSE).	Malaysia/2022/ Yusuf et al.	quasi-eksperimental study (one-group pre- and post-test	41 women are common in the population	Participants are to download the BrAware Application and are expected to become familiar with the BrAware Application. Duration: 2 months	The mobile application BrAware, from the acronym Breast Awareness, was developed by researchers based on the Android platform.	The mean score of participants' knowledge about BC warning signs was different before using BrAware (mean 70.62, SD 11.74) and after using the BrAware application (mean 79.83, SD 10.15) at the level of significance <0.001.
3	Application of Personalized Education in the Mobile Medical App for Breast Self-Examination, [20]	This study aimed to assess the use of personalized education based on conditions-based algorithms in a mobile medical application for breast self-examination.	Poland/2022/ Bladja et al.	Prospective cohort	Women are common in the population. Intervention: 250 people Control: 250 people Total: 500 people	Subjects received comprehensive, personalized information about breast cancer prevention and breast self-examination.	Mobile medical application for breast self-examination through the use of personalized education based on algorithms	The area most frequently examined in Test I in both groups was the middle area of the mammary glands with the nipples. After intervention in Test II, women from the study group marked significantly larger areas on the tactile Test than women from the control group ($\chi^2 = 99.733$; df = 6; $p < 0.0001$). The average result in the research group was 22.10, while in the control group, it was 9.10. It was found that the breast area marked in both tests depended only on women's knowledge of breast cancer ($p < 0.001$).

Table 1 (Continued)

No	Title	Research purposes	Country/Year/ Author	Study design	Sample	Types of intervention & duration	Application	Outcomes
4	Development of Mobile App for Breast Examination Awareness Using Health Belief Model: A Qualitative Study, [21]	This paper aims to identify requirements for developing a breast examination awareness mobile application based on Health Belief Model (HBM) components to be integrated with health promotion strategies.	Malaysia/2021/ Nasution et al.	Qualitative approach using semi-structured in-depth interviews	General female attending hospital services, software, and content experts at a tertiary teaching hospital. Total: 37 participants		Mobile application based on Health Belief Model (HBM) components	The themes from the analysis were vulnerability, forecasting, reactivity, influence, outcomes, and barriers. Subtheme findings that support the HBM component in terms of need are risk factor infographics, videos (symptoms, self-examination), info (metastasis, survival, screening, three-stage assessment, treatment, myths, and facts, benefits of early treatment, support groups), features (screening reminders, share buttons, prompts) and mobile app design.
5	Categorization and Analysis of Primary Care mHealth Apps Related to Breast Health and Breast Cancer: Systematic Search in App Stores and Content Analysis, [23]	The main aim of this review is to categorize selected mobile health apps related to breast health and breast cancer prevention based on features such as BSE training and reminders and analyze their current distribution.	Paris/2023/ Kanodia et al.	Systematic review	The database consists of applications from AppAgg and Google Play Store. Only 85 applications met the inclusion criteria.		Mobile health apps related to breast health and breast cancer prevention, based on features such as BSE training and reminders	The selected applications were categorized based on the following features: education, BSE training, reminders, and recording. Of the 85 apps selected, 72 (84.7%) focused on disseminating breast cancer information. BSE training is only provided by 47% (n = 40) of applications, and only a few have reminder (n = 26, 30.5%) and recording (n = 11, 12.9%) features.

Table 1 (Continued)

No	Title	Research purposes	Country/Year/ Author	Study design	Sample	Types of intervention & duration	Application	Outcomes
6	Evidence on the Use of Mobile Apps During the Treatment of Breast Cancer: Systematic Review, [22]	This study was to identify available evidence regarding the use of mobile applications to provide information and facilitate communication regarding self-care management related to side effects of toxicity due to breast cancer therapy.	Brazil/2019/ Cruz et al.	Systematic review	A total of 9 studies met the eligibility criteria—3 randomized clinical trials and six non-randomized studies; 396 patients with breast cancer, 40 experts in medical and nursing fields, and 3 software engineers.		Use of mobile applications regarding self-care management regarding side effects of toxicity due to breast cancer therapy	Evidence from the studies included in this systematic review is currently limited but suggests that mobile apps for women with breast cancer may be an acceptable source of information that can improve patient well-being. The app can also be used to report treatment-related symptoms and side effects and promote self-care.
7	Effect of Breast Cancer Detection Application on Improving Knowledge of Early Detection of Breast Cancer (BSE) among Adolescents	This study aims to determine the effect of implementing early breast cancer detection on increasing knowledge about early detection of breast cancer in adolescents.	Indonesia/2022/ Aprianti et al.	pre-experimental design with one group pre-test and post-test	100 young women	Researchers shared an application for early detection of breast cancer via a link and explained it to respondents. Then, respondents were asked to use this application and practice breast self-examination. Duration: 3 days	Android-based application for early detection of breast cancer in adolescents	The results of the alternative Wilcoxon test comparing the level of knowledge before and after using the Android-based breast cancer early detection application obtained a p-value = 0.000 < (0.05) where there is an influence of the breast cancer early detection application in increasing knowledge about early detection of breast cancer in adolescents.

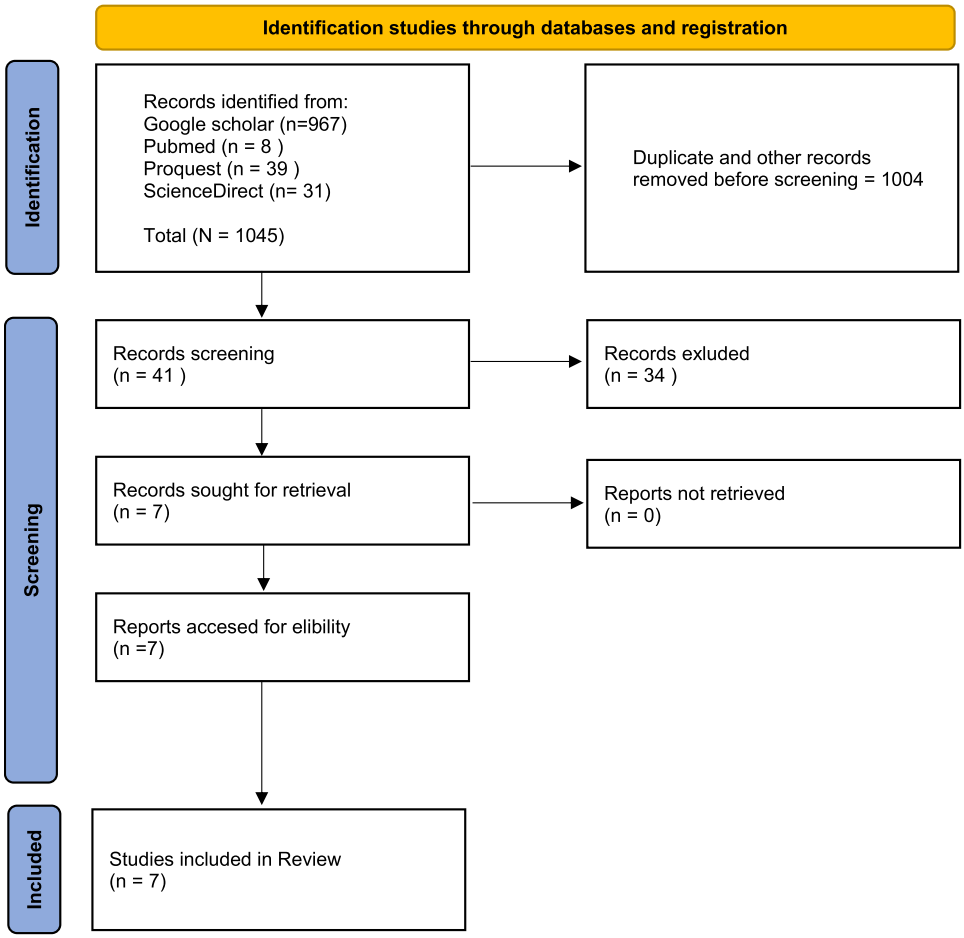

Fig. 1. Selection and inclusion study flow (PRISMA diagram).

self-examination. Two studies concluded that there was an increase in participants' knowledge about breast cancer early detection after interventions using smartphone apps [10,19]. In general, mHealth apps offer education to users [31], containing easily accessible and personalized information associated with increased confidence in decision-making [32], so one of the benefits that will be felt may be increased knowledge. Aprianti et al. reported that the reason participants never performed BSE was because they had never been exposed to information about breast cancer and BSE, which impacted their knowledge about it. Thus, using mobile applications containing practical and multimedia educational content will likely increase knowledge better than controls who do not use it [10].

Another benefit of smartphone applications is increased health-related behaviors, including perceived vulnerability, BSE barriers, self-efficacy, and health motivation. A study by Shakery et al. found that participants with smartphone app interventions scored higher on these behaviors than controls [17]. This increase in behavioral scores is related to the use of applications that are in line with the health belief model (HBM), which emphasizes efforts to increase perceptions of vulnerability, benefits and severity, barriers, efficacy, and motivation for a health behavior [1,17,19,21,29,30].

Furthermore, the use of smartphone applications in the Bladja et al. study can increase the practice of breast self-examination (BSE) [20], and this finding is in line with previous studies that found an increase in the percentage of respondents practicing BSE after receiving interventions through smartphone applications [25,33]. The increase in BSE practice resulted from users' increased knowledge after using the application. In addition, the knowledge already possessed by users

and then exploited with more practical and relevant knowledge from using applications will further encourage the implementation of behavior [25,34]. With their design and content suitability to user needs, smartphone applications can also drive behavioral applications [35]. McKay et al. concluded that there are at least three components of the reason mobile applications can encourage behavior change, including application functions, criticism of application potential, and the quality of content provided by the application [36].

Furthermore, for breast cancer patients, using smartphone applications as a source of information can also improve their well-being [22]. Women who gain knowledge about early detection of breast cancer up to the point of testing positive after screening and follow-up examinations will be better able to promote successful self-care, patient empowerment, and patient well-being. Appropriate app content, high design quality, and satisfaction with the app user experience are among the reasons for such success, which can be demonstrated through increased self-efficacy, decreased symptom distress, and improved quality of life [22,37,38].

The current study has limitations regarding the literature that was included. However, studies related to the effectiveness of smartphone use on early detection of breast cancer are still relatively lacking [19]. In addition, methodological variations in the inclusion studies were not a concern of the researchers but instead focused on the effectiveness of the effect based on the findings, so although the overall inclusion studies point to the effectiveness of using smartphone applications on early detection of breast cancer, potential methodological limitations need to be considered. This research is limited to the findings of studies related to effectiveness through significant effects both originally and analyzed from a number of previous studies but cannot illustrate the magnitude of the effect. In addition, some inclusion studies could not provide a clear picture of the validity of the analyzed application instruments.

5. Conclusion

The use of smartphone applications for early detection of breast cancer by breast self-examination was found to be effective through the utilization of applications along with the benefits felt both as an effort to prevent and improve breast cancer treatment. The utilization of smartphone applications related to BSE is shown through the availability, accessibility, and focus of information and is in line with the Health Belief Model (HBM). Increased knowledge, perceived susceptibility, BSE barriers, self-efficacy, health motivation, and BSE practices show the effectiveness through perceived benefits. Especially for breast cancer patients, this application facilitates the receipt of information and is able to improve patient well-being.

Acknowledgements

The author would like to Publication Management Unit of the Graduate School for assistance in reviewing this article.

Ethics committee

Not applicable.

Conflict of interest

The authors state that the publishing of this paper does not include any conflicts of interest.

Data availability statement

The data described in this study are accessible upon request from the corresponding author.

Funding

No external funding was used to conduct this article.

Authors contribution

All authors drafted and reviewed the manuscript; NI, ANU, YSB, SS, MA, AAM: design of the work, data collection, and data analysis and interpretation; AAM, NI, and ANU: design of the work, final approval, and supervision; ANU, MA: data collection, and data analysis and interpretation; NI and AAM: final approval and supervision; YSB, SS, MA: supervision.

References

[1] Dewi TK, Massar K, Ruiter RAC, Leonardi T, Determinants of breast self-examination practice among women in Surabaya, Indonesia: An application of the health belief model, *BMC Public Health [Internet]*, 19(1)2019. [cited 2024 Mar 30]. Available from: /pmc/articles/PMC6882356/.

[2] Shah R, Rosso K, David Nathanson S, Pathogenesis, prevention, diagnosis and treatment of breast cancer, *World J Clin Oncol [Internet]*, 5(3): 283, 2014. [cited 2024 Mar 30]. Available from: /pmc/articles/PMC4127601/.

[3] Khalid A, Mehmood A, Alabrah A, Alkhamees BF, Amin F, AlSalman H et al., Breast cancer detection and prevention using machine learning, *Diagnostics [Internet]*, 13(19): 3113, 2023. [cited 2024 Mar 30]. Available from: https://www.mdpi.com/2075-4418/13/19/3113/htm.

[4] *The Global Breast Cancer Initiative [Internet]* [cited 2024 Mar 30]. Available from: https://www.who.int/initiatives/global-breast-cancer-initiative.

[5] Ginsburg O, Yip CH, Brooks A, Cabanes A, Caleffi M, Yataco JAD et al., Breast cancer early detection: A phased approach to implementation, *Cancer [Internet]*, 126(Suppl 10): 2379, 2020. [cited 2024 Mar 30]. Available from: /pmc/articles/PMC7237065/.

[6] Dillner J, Early detection and prevention, *Mol Oncol [Internet]*, 13(3): 591, 2019. [cited 2024 Mar 30]. Available from: /pmc/articles/PMC6396346/.

[7] Knowledge summary early detection: Breast health awareness and early detection strategies.

[8] Abo Al-Shiekh SS, Ibrahim MA, Alajerami YS, Breast cancer knowledge and practice of breast self-examination among female university students, Gaza, *Sci World J [Internet]* 2021. [cited 2024 Mar 30]. Available from: /pmc/articles/PMC8100409/.

[9] Anastasi N, Lusher J, The impact of breast cancer awareness interventions on breast screening uptake among women in the United Kingdom: A systematic review, *J Health Psychol [Internet]*, 24(1): 113–124, 2019. [cited 2024 Mar 30]. Available from: https://journals.sagepub.com/doi/10.1177/1359105317697812.

[10] Aprianti S, Erika KD, Effect of breast cancer detection application on improving knowledge of early detection of breast cancer (BSE) among adolescents, *Int J Nurs Heal Serv [Internet]*, 5(5): 437–445, 2022. [cited 2024 Mar 30]. Available from: https://ijnhs.net/index.php/ijnhs/article/view/637.

[11] Li M, Wang H, Qu N, Piao H, Zhu B, Breast cancer screening and early diagnosis in China: A systematic review and meta-analysis on 10.72 million women, *BMC Womens Health [Internet]*, 24(1): 1–11, 2024. [cited 2024 Mar 30]. Available from: https://bmcwomenshealth.biomedcentral.com/articles/10.1186/s12905-024-02924-4.

[12] Kösters JP, Gøtzsche PC, Regular self- examination or clinical examination for early detection of breast cancer, *Cochrane Database Syst Rev [Internet]*, 2003(2)2003. [cited 2024 Mar 31]. Available from: /pmc/articles/PMC7387360/.

[13] Al-Dubai SAR, Ganasegeran K, Alabsi AM, Manaf MRA, Ijaz S, Kassim Saba S, Exploration of barriers to breast-self examination among urban women in Shah Alam, Malaysia: A cross sectional study, *Asian Pac J Cancer Prev [Internet]*, 13(4): 1627–1632, 2012. [cited 2024 Mar 31]. Available from: https://pubmed.ncbi.nlm.nih.gov/22799379/.

[14] Baloushah S, Salisu WJ, Elsous A, Muhammad Ibrahim M, Jouda F, Elmodallal H et al., Practice and barriers toward breast self-examination among Palestinian women in Gaza City, Palestine, *Sci World J*, 2020, 2020.

[15] Taleghani F, Kianpour M, Tabatabaiyan M, Barriers to breast self-examination among Iranian women, *Iran J Nurs Midwifery Res [Internet]*, 24(2): 108, 2019. [cited 2024 Mar 31]. Available from: /pmc/articles/PMC6390439/.

[16] Hussein D, Gashaw K, Geleta TA, Girma D, Geleta LA, Oyato BT, Exploring enablers and barriers to breast self-examination among women in the north Shewa zone, Oromia, Ethiopia: A qualitative study, *Sci Rep [Internet]*, 13(1): 1–9, 2023. [cited 2024 Mar 31]. Available from: https://www.nature.com/articles/s41598-023-44808-x.

[17] Mitra Shakery MM, Khademian Z, The effect of a smartphone application on women's performance and health beliefs about breast self-examination: A quasi-experimental study, *BMC Med Inf,* 53–55, 2021.

[18] Kang SR, Shin H, Lee JM, Kim SJ, Effects of smartphone application education combined with hands-on practice in breast self-examination on junior nursing students in south Korea, *Japan J Nurs Sci [Internet]*, 17(3): e12318, 2020. [cited 2024 Apr 1]. Available from: https://onlinelibrary.wiley.com/doi/full/10.1111/jjns.12318.

[19] Yusuf A, Iskandar YHP, Hadi ISK, Lean AN, Breast awareness mobile apps for health education and promotion for breast cancer, *Front PublicHealth,*2022.

[20] Joanna Błajda BE, Kucab A, Application of personalized education in the mobile medical app for breast self-examination, *Int J Environ Res Public Health*, 19, 2022.

[21] Nasution A, Yusuf A, Keng SL, Rasudin NS, Iskandar YHP, Hadi ISA, Development of mobile app for breast examination awareness using health belief model: A qualitative study, *Asian Pacific J Cancer Prev*, 22: 3151–3263, 2021.

[22] Cruz Foam VRA, Ferreira EB, Melo NS, Reis PED Dos, Evidence on the use of mobile apps during the treatment of breast cancer: Systematic review, *J Med Internet Res,* 2019.

[23] Kanodia S, Thalabard JC, Lhoste K, Categorization and analysis of primary care mHealth apps related to breast health and breast cancer: Systematic search in app stores and content analysis, *J Med internet Res*, 7(9)2023.

[24] Wang JC, Hsieh CY, Kung SH, The impact of smartphone use on learning effectiveness: A case study of primary school students, *Educ Inf Technol [Internet]*, 28(6): 6287–6320, 2023. [cited 2024 Apr 4]. Available from: https://link.springer.com/article/10.1007/s10639-022-11430-9.

[25] Heo J, Chun M, Lee KY, Oh YT, Kyu Noh O, Park RW, Effects of a smartphone application on breast self-examination: A feasibility study, *Healthc Inform Res [Internet]*, 19(4): 250, 2013. [cited 2024 Apr 4]. Available from: /pmc/articles/PMC3920037/.

[26] Lepp A, Barkley JE, Karpinski AC, The relationship between cell phone use, academic performance, anxiety, and satisfaction with life in college students, *Comput Human Behav*, 31(1): 343–350, 2014.

[27] Zhang MWB, Ho CSH, Ho RCM, Methodology of development and students' perceptions of a psychiatry educational smartphone application, *Technol Heal Care*, 22(6): 847–855, 2014.

[28] Coughlin SS, Thind H, Liu B, Wilson LCC, Towards research-tested smartphone applications for preventing breast cancer, *mHealth [Internet]*, 2: 26–26, 2016. [cited 2024 Apr 4]. Available from: /pmc/articles/PMC4933519/.

[29] Noman S, Shahar HK, Rahman HA, Ismail S, Al-Jaberi MA, Azzani M, The effectiveness of educational interventions on breast cancer screening uptake, knowledge, and beliefs among women: A systematic review, *Int J Environ Res Public Heal 2021 [Internet]*, 18(1): 263, 2020. [cited 2024 Apr 4]. Available from: https://www.mdpi.com/1660-4601/18/1/263/htm.

[30] Naz MSG, Simbar M, Fakari FR, Ghasemi V, Effects of model-based interventions on breast cancer screening behavior of women: A systematic review, *Asian Pac J Cancer Prev [Internet]*, 19(8): 2031, 2018. [cited 2024 Apr 4]. Available from: /pmc/articles/PMC6171373/.

[31] Schliemann D, Tan MM, Hoe WMK, Mohan D, Taib NA, Donnelly M et al., mHealth interventions to improve cancer screening and early detection: Scoping review of reviews,

J Med Internet Res [Internet], 24(8): e36316, 2022. [cited 2024 Apr 4]. Available from: https://www.jmir.org/2022/8/e36316.

[32] Al Husaini MAS, Habaebi MH, Islam MR, Gunawan TS, Self-detection of early breast cancer application with infrared camera and deep learning, *Electron [Internet]*, 10(20): 2538, 2021. [cited 2024 Apr 4]. Available from: https://www.mdpi.com/2079-9292/10/20/2538/htm.

[33] Adiyasa RP, Wirata RB, BECA: An android aplication to increase breast self-examination (BSE) practice, *Int J Nurs Heal Serv [Internet]*, 4(1): 82–88, 2021. [cited 2024 Apr 4]. Available from: https://www.ijnhs.net/index.php/ijnhs/article/view/399.

[34] Shin KR, Park HJ, Kim M, Practice of breast self-examination and knowledge of breast cancer among female university students in Korea, *Nurs Health Sci [Internet]*, 14(3): 292–297, 2012. [cited 2024 Apr 4]. Available from: https://pubmed.ncbi.nlm.nih.gov/22672532/.

[35] Fitzgerald M, McClelland T, What makes a mobile app successful in supporting health behaviour change? , *Health Edu J [Internet]*, 76(3): 373–381, 2016. [cited 2024 Apr 4]. Available from: https://journals.sagepub.com/doi/full/10.1177/0017896916681179.

[36] McKay FH, Cheng C, Wright A, Shill J, Stephens H, Uccellini M, Evaluating mobile phone applications for health behaviour change: A systematic review, *J Telemed Telecare*, 24(1): 22–30, 2016. [cited 2024 Apr 4]. Available from: https://journals.sagepub.com/doi/abs/10.1177/1357633X16673538.

[37] Lee H, Uhm KE, Cheong IY, Yoo JS, Chung SH, Park YH et al., Patient satisfaction with mobile health (mHealth) application for exercise intervention in breast cancer survivors, *J Med Syst [Internet]*, 42(12)2018. [cited 2024 Apr 4]. Available from: https://pubmed.ncbi.nlm.nih.gov/30402781/.

[38] Petrocchi S, Filipponi C, Montagna G, Bonollo M, Pagani O, Meani F, A breast cancer smartphone app to navigate the breast cancer journey: Mixed methods study, *JMIR Form Res [Internet]*, 5(5): e28668, 2021. [cited 2024 Apr 4]. Available from: http://www.ncbi.nlm.nih.gov/pubmed/33970120.