MOBILE HEALTH APPLICATION FOR BREAST EXAMINATION AWARENESS USING HEALTH BELIEF MODEL

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MOBILE HEALTH APPLICATION FOR BREAST EXAMINATION AWARENESS USING HEALTH BELIEF MODEL

by

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LIST OF ABBREVIATIONS

BC	Breast cancer
BSE	Breast self-examination
CBE	Clinical breast examination
GPS	Global Positioning System
GUI	Graphical-user interface
HBM	Health Belief Model
USM	Universiti Sains Malaysia
WHO	World Health Organization
CPG	Clinical Practice Guideline
HCP	Health Care Professional

APLIKASI MUDAH ALIH KESIHATAN UNTUK KESEDARAN PEMERIKSAAN PAYUDARA MENGGUNAKAN MODEL KEPERCAYAAN KESIHATAN

ABSTRAK

Kanser payudara (BC) adalah kanser paling utama didiagnos dalam kalangan wanita di Malaysia. Lewat didiagnos dikaitkan dengan latar belakang pendidikan, sejarah sosial BC dan strategi promosi kesihatan yang tidak berkesan. Tujuan kajian ini adalah untuk membangunkan aplikasi mudah alih peribadi dan interaktif menggunakan Model Kepercayaan Kesihatan (HBM) untuk kesedaran pemeriksaan payudara. Penyelidikan kaedah campuran dijalankan di Kampus Kesihatan, Universiti Sains Malaysia (USM) semasa Fasa I dan III. Pensampelan bertujuan digunakan bagi merekrut peserta wanita awam yang mendapatkan servis hospital; pekerja kesihatan profesional Hospital USM yang terlibat dengan pengurusan kanser payudara (jururawat onkologi, kaunselor onkologi dan pakar bedah payudara onkologi) dan pakar perisian Kampus Kesihatan, USM (PPKT)] (n=37) berdasarkan kriteria serta dan singkir. Temujanji diatur mengikut masa dan lokasi pilihan peserta. Masa yang diambil oleh setiap sesi temuramah lebih kurang 30-45 minit. Dalam fasa I, temubual kualitatif secara mendalam dan pemerhatian digunakan untuk mengenalpasti keperluan aplikasi mudah alih. Semasa Fasa II, aplikasi mudah alih (BrAware) direkabentuk dan dibangunkan berdasarkan berdasarkan keperluan utama dan pemerhatian yang diperolehi semasa Fasa I menggunakan HBM. Pada Fasa III, kajian kebolehgunaan dilakukan bagi mengesahkan aplikasi mudah alih BrAware sebagai bahan promosi kesihatan menggunakan kaedah kuantitatif. Tema yang dikenalpasti daripada analisis tematik adalah kerentanan, peramalan, reaktif, pengaruh, hasil dan rintangan. Pemerhatian untuk aplikasi mudah alih menunjukkan

keperluan daripada aplikasi mudah alih adalah infografik, video animasi, infomasi yang sahih, ciri dan reka bentuk yang menarik. Walaubagaimanapun, pengamatan aplikasi sedia ada menunjukkan bahawa tumpuan diberikan kepada tanggapan ancaman dan manfaat tetapi kurang diberi pada tanggapan halangan. Skor min kebolehgunaan BrAware adalah 85.47 (SD 11.84) yang menunjukkan ianya aplikasi mudah alih yang baik. Kajian ini menggunakan data dari wanita awam, pakar kandungan dan pakar perisian untuk merekabentuk dan membangunkan BrAware. Ianya merupakan aplikasi mudah alih yang diintegrasi dengan teori kesihatan untuk mempromosi kesedaran diri mengenai BSE rutin, mendidik mengenai tanda, gejala dan bertindak sebagai alat peringatan bulanan untuk pengesanan awal kanser payudara bagi meningkatkan kelangsungan hidup dan kualiti kehidupan.

MOBILE HEALTH APPLICATION FOR BREAST EXAMINATION AWARENESS USING HEALTH BELIEF MODEL

ABSTRACT

Breast cancer (BC) is the most common cancer diagnosed among women in Malaysia. The late diagnosis is associated with educational background, the social history of BC and ineffective health promotion strategies. The purpose of this study is to develop a personalized and interactive mobile application using the Health Belief Model (HBM) for breast examination awareness. Mixed-method research was conducted in the Health Campus, Universiti Sains Malaysia (USM) during Phase I and III. Purposive sampling was used to recruit participants [public women attending hospital services; Hospital USM breast cancer content experts (oncology nurse, oncology counsellor and breast surgeon); and USM Health Campus software experts (Centre of Knowledge, Communication and Technology staff] (n=37) according to the inclusion and exclusion criteria. An appointment was arranged according to participants' preference time and location. The time taken for each interview session is approximately 30-45 minutes. In Phase I, in-depth qualitative interviews and observation were used to identify the requirements for the mobile application. In Phase II, a mobile application (BrAware) was designed and developed based on the primary need and observation obtained in Phase I using HBM. In Phase III, the usability study was conducted to validate BrAware mobile application as a health promotion tool using the quantitative approach. The themes that emerged from the thematic analysis are vulnerability, forecasting, reactive, influence, outcome and obstacles. It was observed that the mobile application requirements were infographics, video animation, valid information, attractive features, and design. Meanwhile, observation of the available apps revealed that attention was given to

perceived threat and benefit but lacking on the perceived barrier. The mean usability score of BrAware was 85.47 (SD 11.84), which shows a good mobile app. This study utilized data from the public women, content, and software experts in designing and developing BrAware. It is a mobile application integrated with health theory to promote self-awareness on BSE routine, educate on signs, symptoms and act as a monthly reminder device for early detection of breast cancer to improve survival and quality of life.

CHAPTER 1

INTRODUCTION

1.1 Introduction

This study is on the mobile health application for breast examination awareness using Health Belief Model (HBM). The first chapter of this study started with the background of the study, problem statement, research questions, research objectives (general and specific) and the study's scope. Finally, the significance of the study and the operational definition of key terms used in this study were described.

1.2 Background of the study

Breast cancer (BC) is a major health problem and causes cancer-related death. There is an increasing trend of BC incidents (8.3%) and mortality (9.3%) between 2018 and 2020 among females worldwide (WHO, 2020b; Ferlay *et al.*, 2019). BC is also the most commonly diagnosed cancer in Malaysia, accounting for 7593 new cases reported among females in 2018 and 8418 in 2020 (WHO, 2019, 2020a). Changes in health behaviour and availability to and use of screening and treatment services can all help to minimise BC morbidity and mortality (Tollosa *et al*., 2020; Lee *et al*., 2018).

While significant advances have been made in diagnosis and treatment, lack of awareness resulting in late diagnosis and poor survival, one of the most serious challenges facing healthcare systems is creating and enhancing breast awareness in the population. With the rapid development of information science and technology, electronic health (e-health) has become essential for healthcare systems. Lupianez-

Villanueva *et al.* (2018) define e-health as communication tools to disseminate information and transfer health resources and education (Lupiáñez-Villanueva *et al.*, 2018). E-health tools effectively communicate the correct information needed by different audiences at the right time, in the right place and in the best ways to guide healthcare and health promotion. Misinformation among the population is from their social circle or dubious internet sources (Pereira *et al.*, 2020; Rexhepi *et al.*, 2020; Lapointe *et al.*, 2013). Malaysians have access to reliable web resources such as the National Cancer Council Malaysia (MAKNA), National Cancer Society Malaysia (NCSM) and MyHealth Portal – Ministry of Health.

Compared to 2018 with 2020, internet utilisation on smartphones increased from 93.1% to 98.7%, providing a broader audience to reach (MCMC, 2020). Mobile learning applications involve content sharing, communication, storage, creating offline documents, offline reading, management and scheduling system (Kumar *et al.*, 2020). Interestingly, an increase of applications available in Google Play reported in 2017 is more than 2.8M, with more than 50 applications downloaded on each smartphone (Abd Rahman *et al.*, 2020). Moreover, Android's global smartphone market share in 2020 is 84.8% and iOS 15.2% compared to the market share in Malaysia in 2018, which also recorded Android as the highest with 79.6% compared to iOS 19.6% (Ghasempour *et al.*, 2020; Statcounter, 2018). Therefore, based on the demand for Android devices in Malaysia, a smartphone application based on Android is chosen for this study.

1.2.1 Nurses' Role in Health Promotion

Nurses play an essential role in promoting breast examination awareness by offering information, resources, support and navigation to patients, relatives and the public (Li *et al.*, 2020; Loescher, 2004; Bailey, 2000). According to reports, nurses can raise BC awareness among women by encouraging them to get comfortable with their breasts, understand the signs of BC, and seek medical help if they see any unexpected changes (Mccready *et al*., 2005; Bailey, 2000). In addition, they are often involved in developing promotional materials, media communication and health promoters' training (El-kest *et al.*, 2021). Health promotion aims to increase breast cancer screening uptake, reduce the mortality rate of breast cancer, early diagnosis in earlier stages and start early treatment (Masoudiyekta *et al.*, 2018). In contemporary society, the use of mobile health applications is gaining attention in health promotion strategies on breast cancer (Crafoord *et al.*, 2020; Hou *et al.*, 2020; Lee *et al.*, 2017), and the involvement of health professionals, including nurses, are required (Kalke *et al.*, 2020).

Besides nurses, the Malaysian government's initiative in conducting Pink October, the BC awareness campaign has increased BC screening uptake, early detection, chances of survival and reduced the need for aggressive therapies (Mohamad and Kok, 2019; Vazzoller *et al.*, 2017). In informing Malaysian practitioners, a Clinical Practice Guideline (CPG) 2019 Management of Breast Cancer (Third Edition) was used as a reference to standardize the BC management. Furthermore, doctors’ management and recommendation have increased screening,

follow-up, and outcomes (Wu *et al.*, 2020). In contrast with a non-standardized guideline which reported lower adherence (Corbelli *et al.*, 2014).

1.3 Problem Statement

The approach to healthcare services is delivered radically changed during the last decades. The process includes a broad range of implementation such as audio, video, letter, brochure, booklet, telephone counselling, newsletter, workshop, broadcast, lecture, electronic teaching aids, handouts (Ifediora and Azuike, 2019; You, 2016; Austoker *et al.*, 2009), WhatsApp group (Pereira *et al.*, 2020) and mobile applications (Ribeiro *et al.*, 2017), websites, web portals or telehealth (Kreps and Neuhauser, 2010). Mobile technologies can improve access and reduce the cost of quality health care. In addition, mobile health applications have proved helpful in preventive healthcare (Melzner *et al.*, 2014). Yet, neither medical practitioners nor nurse researchers have considered mobile health applications in the context of breast cancer health promotion. Surprisingly, there is no evidence that a theoretical framework supports mobile apps (Kalke *et al.*, 2020; Mobasheri *et al.*, 2014).

The advantage of the Health Belief Model as one of the most widely applied theories of health behaviour posits that six constructs predict health behaviour (Glanz and Bishop, 2010). HBM was chosen because it was proven by several studies to be effective in behaviour intervention through awareness (El-kest *et al.*, 2021; Keshavarz *et al.*, 2020; Mehrnoosh Akhtari-Zavare *et al.*, 2016). However, a review reported the weakness of HBM is the perceived severity component as the weak predictor; meanwhile, perceived barrier and perceived benefit are the strongest

behaviour predictor (Green *et al.*, 2020). Even the weak predictor will be corporated in the app development as the users require it.

Even though smartphone users have an increasing trend, there are a lack of personalized, educational and contextualized elements based on our local culture (Vo *et al.*, 2019). For example, in a recent literature review, the currently available mobile applications on breast health focused on breast cancer symptoms and management (Kalke *et al.*, 2020; Jongerius *et al.*, 2019). The studies as mentioned above revealed the need to improve the personalized profile, information, support, access to experts (Scott *et al.*, 2019; Robinson *et al.*, 2015), tailored culturally appropriate and relevant content to ensure positive users' experience using the app. (H. Lee *et al.*, 2018; Davis and Oakley-Girvan, 2015; Kratzke *et al.*, 2014a). Furthermore, a previous study suggested requirements including content validity such as citation, app security and customisation, such as the option to change the language (Vo *et al.*, 2019).

In Malaysia, a few mobile apps on breast cancer developed by Malaysian developers are available in the store, such as LUDIc by National Cancer Council (MAKNA) and My Pink Health by Pink Ribbon Wellness (L) Foundation. Both apps are available in the App store but not available in Google Play Store. Both apps are available in multiple languages. LUDIc is available in English and Chinese language, My Pink Health is available in English, Malay and Chinese. There is a BSE tutorial available on both apps. However, the BSE tutorial is in the form of a stiff photo that might not be as effective as a 3D video in explaining the BSE tutorial. The LUDIc app BSE stiff photo can be open offline, but the My Pink Health app requires an

internet connection to access the app content. LUDIc have a reminder that requires manual set-up for the next BSE routine check-up, maps and Global Position System (GPS) available in the app to locate the 'Mobile Screening Unit', unlike My Pink Health which does not have the features.

Both apps do not have question and answer, interactive quiz and gaming elements. The involvement of medical personnel in both mobile app developments is unknown and questionable in terms of credibility. In contrast to Heo *et al*.'s (2013) study, National Cancer Information Center (NCIC) supported the credibility and the mobile application developed by Cabatuan *et al*. (2016) is supervised by medical professionals, enabling access of medical practitioners to edit the facts in the contents. Furthermore, the LUDIc's app news and events were updated as it was linked to the main website. On the other hand, the My Pink Health last update was in 2015. Even both mobile apps were not tailored culturally or personalized to the user.

Therefore, the researcher evaluated existing breast awareness mobile apps in PlayStore and AppStore based on the HBM components. Unfortunately, most mobile applications did not cover all the HBM components. Hence, the researcher conducts this study to identify the main requirements for the BrAware mobile application and design and develop the BrAware mobile application drawing on the HBM.

1.4 Research questions

i. What are the main requirements for the mobile health application for breast examination awareness?

ii. How to design and develop the mobile health application for breast examination awareness using HBM?

iii. What is the usability of the developed mobile health application for breast examination awareness?

1.5 Research Objectives

1.5.1 General Objective

The general objective of this study is to develop a mobile application for breast examination awareness.

1.5.2 Specific Objectives

i. To identify the main requirements of the mobile health application for breast examination awareness (Phase I).

ii. To design and develop the mobile health application for breast examination awareness using Health Belief Model (Phase II).

iii. To evaluate the usability of the developed mobile health application for breast examination awareness (Phase III).

1.6 Scope of the study

The scope of the study is identifying the requirement of developing a mobile application for breast examination awareness in Phase I and determining the usability of the developed mobile application in Phase III. A mixed-method study is carried out among public women, software and content experts in Hospital USM.

1.7 Significant of the study

The HBM theory is useful for understanding and predicting early cancer detection behaviours, such as screening practises, clinical exams, and self-examinations, in a variety of cancer types, including BC (Conner and Norman, 2020; Williams *et al*., 2019; Ersin and Bahar, 2017; Zare *et al*., 2016). Therefore, to guide the design and development of the BrAware mobile application, the HBM was used in this study.

BrAware mobile application development can be used in health promotion strategies to promote breast awareness knowledge, empower women to take care of their bodies and access healthcare professionals. In addition, the apps can also overcome one of the barriers of seeking professional consultation whereby the Global Positioning System (GPS) integration will show the nearest centre available in the user's location.

The development of the BrAware mobile application proposed a series of upgraded versions compared to available breast mobile applications in Malaysia and consideration of more upgrades along the development process of the study informed by local participants' experiences and expectations from the public's perspective and experts. In addition, the mobile application development has included content based on local myths and access to local group support with a navigation feature. This present study is similar to a mixed-method on developing the mobile app for diabetic management involving user and software experts (Zhang *et al.*, 2018). Thus, this study aims to develop an innovative way of digitally promoting breast awareness by

checking the breast regularly and understanding the signs and symptoms of the disease whilst entertaining and engaging so that users will want to take part.

1.8 Definition of key terms

The following operational definitions of terms are highly contested notions. Some terms are the subject of the ongoing debate about their theoretical construction, meanings and applications in practice. Therefore, it is necessary to define how the terms are used in this research study. For the study, key terms and phrases are defined.

Table 1.1 Definition of operational key terms

HBM component	**Definition of operational key terms**
Perceived susceptibility	Individual subjective perception of the risk of BC (Rahman and Rahman, 2008).
Perceived severity	Individual evaluation in the seriousness of getting BC, consequences of leaving it untreated (Rahman and Rahman, 2008) or the beliefs in health issues that will cause harm (Lotfi *et al.*, 2012).
Perceived threat	Awareness and care of breast awareness (Dou *et al.*, 2017).
Perceived benefit	The action was taken due to its effectiveness in reducing the threat of BC (Rahman and Rahman, 2008).
Perceived barrier	The negatively valued aspect (Taylor *et al.*, 2007).
Self-efficacy	The users' experience (Anderson *et al.*, 2016) and the ability to use mobile applications (Dou *et al.*, 2017).
Cues to action	Internal or external cues include mobile application usage, reminders, or prompts to take action (Chin and Mansori, 2019).
Breast examination awareness	The technique to examine the breast is performed monthly by inspection and palpation and becoming familiar with the breast to recognise abnormalities (Thornton and Ram, 2008).

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter provides literature reviews on breast examination awareness, mobile health applications based on literature and market availability, integrating theory for health promotion strategy and HBM as the conceptual framework.

Globally, more than two million women were newly diagnosed with breast cancer in 2020 (Sung *et al.*, 2021). In Malaysia, breast cancer (BC) is the most common cancer among women, and it is estimated that the lifetime risk is one for every 27 females (NCI, 2019). Several lifestyle and genetic factors have increased the risk of BC in Malaysian women. For example, a qualitative study on the East Coast of Malaysia found that 72.6% of women were delayed in presentation for more than three months (Cheah *et al.*, 2014). According to Norsa'adah, Rahmah, Rampal, & Knight (2012), the delay in the presentation was poor awareness of BC, fear of cancer consequences, and belief in complementary alternative medicine. In addition, other reasons are sanctioned by others, denial of the disease, the 'wait and see' attitude, and weaknesses in the health care system. Nevertheless, BC has a relatively good prognosis, with a decline in death rate by 38% from 1989 to 2014 due to improvements in early detection (increased awareness and screening) and treatment (American Cancer Society, 2017).

BC screening involves mammograms, clinical breast examination (CBE), and breast self-examination (BSE) to detect early BC signs. A mammogram is the recommended screening procedure for BC. However, an expensive screening method

requires several requisites including professional logistic staffing for implementation (Zehra, 2011). According to Nik Nairan, Norlaili, Rampal & Nabilla (2011), mammographic screening uptake in Malaysia is low. Although mammography screening is an effective tool for early detection and management of breast cancer, women's screening uptake is unsatisfactory (Schliemann *et al.*, 2018; Lim *et al.*, 2015). The reasons could be embarrassment, the presence of a male radiographer, afraid to detect abnormality and accessibility. CBE is the physical examination of breast and axillary lymph nodes by the healthcare worker in the healthcare setting (Farid *et al.*, 2014).

A literature search was conducted in the different electronic databases such as PubMed, Medline, CINAHL and PsycINFO using the search terms "mobile technology", "cancer awareness", "breast cancer", "breast examination awareness", "breast health", "health belief model", "mobile app" and "mobile technologies". The journal articles searched were in English language and published between 2008 and 2021. The journal articles with free access related to any type of mobile technologies intervention towards all types of CA were included. However, the journal articles related to CA prevention, treatment management and CA diagnosis were excluded. Table 2.1 listed the inclusion and exclusion criteria of the literature searched.

Table 2.1 Inclusion and exclusion criteria of literature searched

Inclusion criteria	**Exclusion criteria**
Published in 2008-2021	Published before 2008
Language: English	In other languages than English
Full-text articles	Only abstracts available
Free access	Require purchase
Any type of mobile technologies intervention toward all types of CA	Studies on CA prevention, treatment management and CA diagnosis

2.2 Breast Examination Awareness

Breast examination awareness is defined as a technique to examine breasts performed monthly by inspection and palpation and become familiar with their breast to recognise abnormalities (Thornton and Ram, 2008). BSE is simple, inexpensive, does not require complex technical training, can be carried out by the women themselves, and is considered an acceptable method for breast checks to promote self-awareness and empower women to be responsible for their health (Padmaja *et al.*, 2020; Hassan *et al.*, 2017). Although research and most clinical guidelines concluded that BSE is an ineffective and often harmful screening strategy, there are limited resources for a mammogram in Malaysia. Besides, even Malaysian women had high knowledge about BC and BSE, they did not perform BSE regularly (Myint *et al.*, 2020; Rosmawati, 2010). The most common reasons for not performing BSE were never being taught on performing BSE and not knowing the correct method to do it (Tabari *et al.*, 2017; Rosmawati, 2010).

Facilitation and intervention in breast examination awareness aim to increase awareness among Malaysian women. Many researchers believe that BC screening can help to reduce the mortality rate and outweigh the harm. Routine BC screening leads to a 20% reduction of BC mortality than those not doing any screening (Fierce, 2012). Reduced BC mortality could be due to early detection, allowing women to have more treatment choices, greater survival, a better quality of life, small tumour size and non-metastasized cancer (Sajahan and Omar, 2018). Besides, previous studies reported that most women diagnosed with BC self-detected their lump (Loh and Chew, 2011).

The method of health promotion delivery tools previously used are audio, video, letter, brochure, booklet, telephone counselling, newsletter, workshop, broadcast, lecture, electronic teaching aids, handouts, leaflets, poster and shower card health talks, forums, website, web portals and telehealth (Ifediora and Azuike, 2019; Mohamad Marzuki *et al.*, 2019; Sajahan and Omar, 2018; Kreps and Neuhauser, 2010; Austoker *et al.*, 2009; Mccready *et al.*, 2005; Loescher, 2004; Vogel, 2003), WhatsApp group (Pereira *et al.*, 2020) and smartphone apps (Ribeiro *et al.*, 2017). Previous studies also revealed that SMS was proved effective in reminding regular BSE practice (Khokhar, 2009), and the Snapchat social networking mobile application successfully increases awareness (Alanzi *et al.*, 2018).

2.3 Mobile health application

Mobile health technologies have evolved in recent years and are widely used. It is freely available and easy to access (De *et al.*, 2019) for health information and medical facilities (Lv *et al.*, 2019). Therefore, there was increasing interest in mobile phones as platforms for delivering health behaviour changing interventions to reach the vast majority of the community cost-effectively. A systematic review of smartphone applications for the prevention, detection and management of cancer concluded that the application was practical. However, health promotion efforts need to include self-management skills to translate knowledge into practice, build confidence in performing the desired behaviour and create social support for initiation and adherence (Finch *et al.*, 2016; Bender *et al.*, 2013; Heo *et al.*, 2013). Furthermore, one study found that behaviour tracking, tailored information and reminders are the most desired features in cancer prevention mobile applications (Ribeiro *et al.*, 2016).

Meanwhile, according to a systematic analysis of BC apps conducted by Ginossar et al., 2017, researchers need to identify user expectations for BC apps'. Therefore, this study aims to develop BrAware mobile applications; to promote self-awareness and educate women about breast self-checks importance and timing. The monthly reminder helps them perform their breast check regularly, helps to establish their routine, and approach the breast self-check. Besides, it is essential to develop a mobile application that can engage a wider audience and further raise awareness of the importance of being breast aware for early detection for better treatment outcomes.

2.3.1 Mobile Health Technologies for Breast Examination Awareness based on the literature

Mobile health technologies are gaining attention and are used for breast examination awareness intervention (Kalke *et al.*, 2020). A recent study revealed a positive effect on BSE with mobile application intervention with features such as reminders and social interaction platform (Karadeniz Küçük and Şener, 2021). In addition, a previous study that combined mobile application education with hands-on BSE skills was proven effective (Kang *et al.*, 2020). Meanwhile, another finding supported that information sources combining mobile health applications, the internet and SMS can be powerful methods for health education (Kratzke *et al.*, 2014b). Even studies have reported the effectiveness of other tools such as the Snapchat social networking mobile application in increasing BC awareness (Alanzi *et al.*, 2018) and SMS as a reminder system for regular BSE practice (Khokhar, 2009).

Participants' feedback in cancer prevention mobile technologies intervention included reminder system, tailored information (Ribeiro *et al.*, 2016; Philippa *et al.*,

2015), behaviour tracking or progress record (Ribeiro *et al*., 2016; Bricker *et al*., 2015), persuasive message (Evans and Mays, 2016), self-monitored, graphic reward, social networking support (Bricker *et al.,* 2015), and push notifications (Alanzi *et al*., 2018). Other than that, some of the developed mobile applications have gained credibility by involving the medical personnel or association (Cabatuan *et al.*, 2016; Heo *et al.*, 2013). As supported by finding in earlier studies of health personnel initiatives in raising cancer awareness, mobile technologies approaches will overcome barriers in reaching the general population and impact the larger and broader population (Tao and Edmunds, 2018; Alipour *et al.*, 2014). Moreover, a study by Houghton *et al*. (2019) on a systematic review of the literature: presented ten articles with mobile apps used for primary BC prevention. Three articles are about development, but none integrate theory or use a qualitative approach.

The interventions were conducted for breast examination awareness involving social networking apps, mobile apps and text messages. Table 2.2 revealed mobile technologies interventions which none were conducted in Malaysia. Interestingly, the findings suggest that mobile technologies intervention can raise breast cancer awareness. However, although there was an improvement in behaviour change towards breast cancer awareness, there is a need to improve further for effective delivery of knowledge on BC awareness.

Table 2.2 Articles on mobile technologies for breast examination awareness

No	References	Study design	Population (sample size)	Location	Theory	Mobile technologies' intervention	Outcomes
1.	Alanzi *et al.*, 2018	RCT	Female students n=200	Saudi Arabia	-	Mobile social networking app	Significant improvement in Breast Cancer awareness was found in the intervention group (p=0.001) receiving video, text & pictures The mean knowledge increased from 8.7±2.8 to 14.8±3.01 (mean±SD)
2.	Cabatuan *et al.*, 2016	Development	-	Philippines	-	Android mobile application	Presentation of Diddib App prototype for breast cancer awareness, BSE guidance, and assessment
3.	Heo *et al*., 2013	Longitudinal study	Female n=45	Korea	-	Android mobile application	The use of the developed smartphone application increased BSE in females younger than 30 years The number of participants using BSE increased from 8 to 18 (36.4% to 81.8%, p = 0.002)
4.	Kang *et al.*, 2020	Quasi-experimental design	Nursing students n=86	Korea	Dale's Cone of Experience	Smartphone-based education combined with hands-on practice	Statistically significant mean differences among the three groups' knowledge of BSE A combination of the smartphone application and hands-on practice showed the highest score changes in skills and satisfaction
5.	Karadeniz Küçük and Şener, 2021	Qualitative study	Female N=24	Turkey	-	Android / iOS mobile application	'Before' data (M=2.14, SD=0.50) and 'after' data (M=3.36, SD=0.77) of mobile application's usage shows a highly significant increase in positive affect

Table 2.2 Continued

6.	Khokhar *et al*., 2009	Longitudinal study	Female n= 106	India	-	Text message	SMS as a reminder system for regular BSE practice The practice of BSE increased significantly ($p<0.05$)
7.	Kratzke *et al*., 2014	Cross-sectional study	College women N=546	USA	-	BC prevention apps, texts, or Internet and daughter-initiated information	45% had a high BC prevention risk factor knowledge level, 48.6% had high BSE self-efficacy, and 54.7% conducted BSE. Overall, 34.9% reported a family history of breast cancer, and 18% gave breast cancer prevention information to their mothers Most college women reported they influenced their mothers to focus on screening adherence (mammograms, clinical breast exams, or BSE).

2.3.2 Mobile Health Application for Breast Examination Awareness based on the market availability

A descriptive observation of the available mobile applications in Google PlayStore and Apple AppStore was conducted from August 27 until October 20, 2019. One researcher was involved in the data collection of the available mobile applications (Kassianos *et al.,* 2015). Observation on the available mobile applications that focus on limited keywords “breast cancer”, “breast awareness”, “breast check”, and “breast examination”. The word “breast” was not included in the preliminary search because the researcher wanted to narrow and exclude an unrelated search. Therefore, this search excluded searches that may include mobile applications on breast workout, breast shape photo editor, breastfeeding, breast pumping, breast surgery or implants, including apps focusing only on BC symptoms, support, diagnosis, risk assessment, prevention, and rehabilitation.

Mobile applications were selected based on the following inclusion criteria: (1) English language mobile application; (2) free download and did not require in-app purchasing; (3) mobile application toward BC awareness. Applications were excluded if the mobile applications (1) mainly focus on BC symptoms, support, diagnosis, risk assessment, prevention, and rehabilitation; (2) aimed at HCP or people affected by cancer; (3) if they did not appropriately run after downloading the mobile application.

The mobile applications that appear in Google PlayStore and Apple AppStore were identified independently to account for differences in features supported by various operating systems. In addition, other languages such as Mandarin, Cantonese, Tamil and Malay (Indonesian) were excluded due to the limitation of the researcher’s

proficiency in other languages (Zhao *et al.*, 2019). The researcher downloaded mobile applications that met the inclusion and exclusion criteria onto Android Samsung Galaxy Note4 (running 6.0.1 software; Seoul. South Korea) and iPhone 7 (running iPhone operating system, version 12.3.1; iOS, Apple Inc, Cupertino, CA).

Mobile applications were selected and downloaded from two app stores (87 in Google PlayStore and 38 in Apple AppStore). Only eight mobile applications were available on both platforms. The titles and descriptions were screened for eligibility. Sixty-six mobile applications were excluded because they did not meet the inclusion criteria. Forty mobile applications were not related to breast examination awareness, 17 were excluded for the targeted other population, six were excluded because the content is not English. Three were excluded because they needed to be purchased. Then, a total of seven mobile applications were excluded, where six mobile applications were not assessed due to installation failure, and one mobile application requires an in-app purchase to view the contents. The remaining 52 eligible mobile applications were then identified (Figure 2.1).

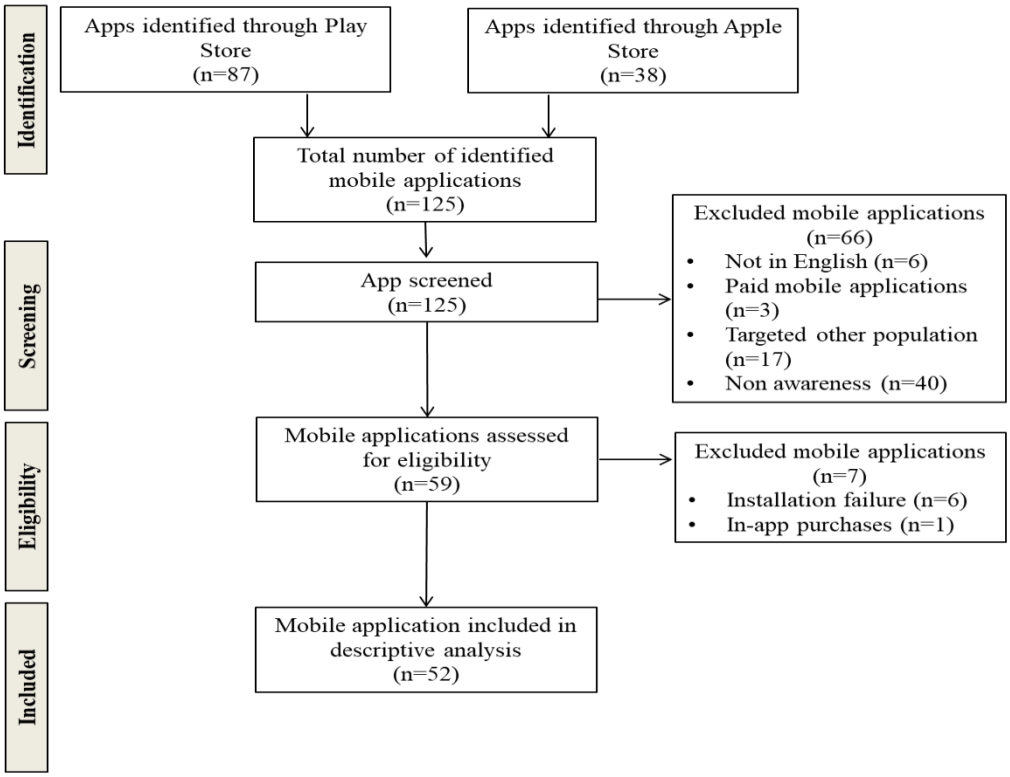

Figure 2.1 Flow diagram of the mobile application search process

Based on the features or contents of the reviewed mobile application, a general description of the observation conducted on the available mobile apps in the market is shown in Table 2.3. Most of the reviewed mobile apps are standalone (n=41) and non-standalone (n=11). A standalone application is defined as an application installed on the device that is readily accessible via its icon without a web browser (Trivedi, 2019; Inupakutika *et al.*, 2018). The categories of the eligible apps reviewed are health & fitness (n=31), lifestyle (n=6), medical (n=11), entertainment (n=2), book & reference (n=1), education (n=3).Moreover, the reviewed mobile application platforms were Android (n=29) and iOS (n=23).

In our observation, in Malaysia, there are two apps: LUDIc and My Pink Health. However, both are non-standalone apps, only available on iOS and no longer

available on the market. Both of these apps lack tailored culturally or personalized to the user and have no reference sources of the content in the mobile apps. However, in another observational study, BSE mobile applications were compared with a user account, calendar, self-exam wizard, history, chat room, location, knowledge, video tutorial and forum, but not even one applications have all the features (Khana *et al.*, 2020). Makna (LUDIc) had the most mentioned features. The features include are calendar, self-exam, location, knowledge and video tutorial. The study by Khana *et al.* (2020) also highlighted the importance to secure user data privacy with user accounts, a calendar to set monthly reminders, medical history records, chat room (for user-physician), location (finding physician consultation) and knowledge of BC prevention.

According to a systematic analysis of available breast cancer applications designed for behaviour change in two major app stores, few apps included theoretical design and a qualitative study. Furthermore, these apps were not related to app development or design (Kalke *et al.*, 2020). Kalke *et al*. (2020) also reported applications containing behaviour change techniques in mobile applications such as customization, information-behaviour relationship, intention, facilitation, self-efficacy, and social influence mostly had star ratings (users engagement).

Table 2.3 General characteristics of breast awareness apps

NO	Apps name	Category	Star rating	Platform availability	Standalone or non-standalone	Country	Current version	Last update	Availability in other languages
1.	ABC of Breast Health (Ushalakshmi Breast Cancer Foundation)	Health & fitness	Rating: 4.6 Feedback & review: Good initiative to spread knowledge	Android	Standalone	India	1.0	21 March 2017	Hindi, Marathi, Gujarati, Punjabi, Bengali, Telugu, Tamil, Kannada, Malayalam, Oriya & Assamese
2.	B4BC – Boarding for Breast Cancer (Black Sun Production)	Lifestyle	Rating: None Feedback & review: None	iOS	Standalone	USA	1.3	2018	-
3.	B4BC – Boarding for Breast Cancer (Black Sun Production)	Health & fitness	Rating: 4.8 Feedback & review: Love the self-exam reminder	Android	Standalone	USA	1.1	17 August 2017	-

Table 2.3 Continued

4.	Beyond The Shock (National Breast Cancer Foundation)	Medical, Health & Fitness	Rating: None Feedback & review: None	iOS	Standalone	NA	1.6.1	27 March 2017	-
5.	Breast and Pec Check (YAP- Young Adult Program)	Medical, Health & Fitness	Rating: None Feedback & review: None	iOS	Standalone	NA	1.0	29 July 2014	-
6.	Breast Aware – BCI (iPLANiT Ltd)	Health & Fitness	Rating: None Feedback & review: None	iOS	Standalone	Ireland	1.6.5	2018	-
7.	Breast Awareness App (Silkpro USA)	Health & Fitness	Rating: None Feedback & review: None	Android	Standalone	USA	1.2.1	20 Mei 2019	-
8.	Breast Awareness App (Power Production Group LLC)	Health & Fitness	Rating: None Feedback & review:	iOS	Non-standalone	USA	1.1	2019	-

Table 2.3 Continued

9.	Breast Cancer (GangareBoy)	Health & Fitness	Rating: None Feedback & review: None	Android	Standalone	NA	1.4	29 September 2018	-
10.	Breast Cancer (Magna Health Solutions)	Medical	Rating: 4.2 Feedback & review: Love it	Android	Standalone	India	1.1	19 September 2014	-
11.	Breast Cancer (Nature Healthy Care)	Entertainment	Rating: 4.7 Feedback & review: None	Android	Standalone	NA	1.0	27 September 2017	-
12.	Breast Cancer (Canada Dev Apps)	Health & fitness	Rating: None Feedback & review: None	Android	Standalone	Canada	1.1	2016	-
13.	Breast Cancer (Starline Techno)	Medical	Rating: 4.9 Feedback & review: Very informative & helpful	Android	Standalone	India	1.0	10 July 2014	-