REVIEW ARTICLE

Mobile Health Application Applying the Health Belief Model for Breast Cancer Awareness: What Is Missing?

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ABSTRACT

Breast cancer (BC) is one of the most common cancer incidents among women and is estimated at around 24.2% worldwide and 32.1% in Malaysia. Accessibility to current breast promotion is limited to those who seek the information, suggesting consideration of an alternative approach using a mobile app. This study aimed to identify existing breast awareness mobile apps based on the Health Belief Model (HBM) components with a descriptive observation review. Fifty-two apps fulfilled the inclusion and exclusion criteria and were reviewed. Eligible apps (N=52) which are standalone (n=41) and non-standalone (n=11). The categories of the eligible apps are health & fitness (n=31), lifestyle (n=6), medical (n=11), entertainment (n=2), book & reference (n=1), education (n=3). The apps focused on perceived susceptibility (n=33/52, 63.5%), perceived severity (n=30/52, 57.7%), perceived threat (n=48/52, 92.3%), perceived benefit (n=46/52, 88.5%), perceived barriers (n=23/52, 44.2%), self-efficacy (n=25/52, 48.1%) and cues to action (n=27/52, 51.9%). Most of the apps focused on perceived threat and benefit but lacking on a perceived barrier. This review could provide information to develop appropriately tailored content supported by health theories to promote breast cancer awareness.

Keywords: Breast cancer, Breast examination awareness, Breast health, Health belief model, Mobile application

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INTRODUCTION

Globally, breast cancer (BC) is one of the most common cancer among women with more than two million new cases and BC death is about 6.9% (1). Similarly, the most commonly diagnosed cancer reported in 2007-2011 among Malaysian women is BC which is around 32.1% (2). According to the National Cancer Institute, five years survival rate for BC in Malaysia by staging within the period of diagnosis 2007 until 2016 is about 87.5% for stage I, 80.7% for stage II, 59.7% for stage III, and 23.3% for stage IV (3).

BC is treatable and has better outcomes with necessary treatment in early-stage if women are familiar and able to report BC if there are any changes in their breast (4). BC awareness among Malaysian is low (5) as demonstrated that BC was detected at an advanced stage around 43.2% (2) and low practice rate of breast self-examination (BSE) among young women in Malaysia (6,7).

The healthcare professionals (HCP) in Malaysia refer to Clinical Practice Guideline: Management of Breast Cancer (2nd Edition) regarding BC screening such as BSE, clinical breast examination (CBE), and mammogram (8). It has been reported that BC awareness promotes women to be familiar with their breast, the symptoms of BC, and seek medical advice for any unusual changes (9,10). In a middle-income country, BSE is essential due to the limited resources as it is free, painless, can be done personally, and does not need special equipment (10). It is highlighted in a study that more attention towards divorced, widowed, or women who have no experience of BSE because they are more likely to delay in seeking medical advice (11). The reason to aim for early detection is that it has more choices of intervention, better chances of survival, small tumour size, and non-metastasized cancer (12). Therefore, promotion material BC awareness should include information, resources, and support to patients, relatives, and public women (10,13). Previously, the health promotion used leaflets, brochures, posters, and shower cards (9,13,14), health talks, forums, websites, web portals, and telehealth (12,15,16) and the current studies have reported the effectiveness of the SnapChat social networking mobile application in increasing BC awareness (17) and SMS as

a reminder system for regular BSE practice (18).

Accessibility to current breast promotion is limited to those who seek the information (16). However, mobile health technologies are evolving and widely being used as it is freely available and easy to access (19) towards health information and medical facilities (20). According to the Hand Phone Users Survey 2017 (HPUS 2017) by the Malaysian Communication and Multimedia Commission (MCMC), the smartphone user rate in Malaysia is increasing from 68.7% to 75.9% in 2017 visualising the movement of users from a basic phone to a smartphone (21). However, mobile applications, require contents evaluation to ensure the educational content is appropriate to the general level of literacy and culturally sensitive (13).

There is lacked evidence that a theoretical framework supported the available mobile applications due to it has not been reviewed so far (22). This study aimed to identify how available mobile applications are supporting breast examination awareness based on the component of the Health Belief Model (HBM). HBM was chosen because it was proven to affect behaviour intervention through awareness and widely used in other studies (23).

MATERIALS AND METHODS

Ethics
Ethics approval for this study was obtained from the Human Research Ethics Committee (HREC) of Universiti Sains Malaysia (USM/JEPeM/18080380).

Study design
The study reviews the mobile applications from descriptive observation of available mobile applications in Google PlayStore and Apple AppStore from August 27 until October 20, 2019. One researcher involved in the data collection of the available mobile applications (24). 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 wants to narrow the search and excluded an unrelated search. This search excluded search 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.

It was conducted based on HBM domains; perceived susceptibility, perceived severity, perceived threat, cues to action, perceived benefit, and perceived barriers. A total of 125 mobile applications were downloaded and identified from Google PlayStore and Apple AppStore. Fifty-two mobile applications fulfilled the inclusion and exclusion criteria and were reviewed. The initial evaluation provides available features and contents based on the HBM component.

Selecting mobile applications for review
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 it did not appropriately run after downloading the mobile application.

The mobile applications that appear in both Google PlayStore and Apple AppStore were identified independently to account for differences in features supported by various operating systems. Other languages such as Mandarin, Cantonese, Tamil and Malay (Indonesian) were excluded due to the limitation of the researcher's proficiency in other languages (25).

Screening and Selection of mobile applications
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).

Health Belief Model (HBM) in mobile application
This study utilized HBM adapted from Janz NK and Becker MH, (1984) (26) (Fig. 1) as a theoretical framework to review available mobile applications in a systematic way. All mobile applications were identified on their contents and features. Items towards BC awareness are further defined to guide the process of reviewing the mobile application contents using HBM focusing on seven items which are perceived susceptibility, perceived severity, perceived benefit, perceived barriers, perceived threat, cues to action, and self-efficacy.
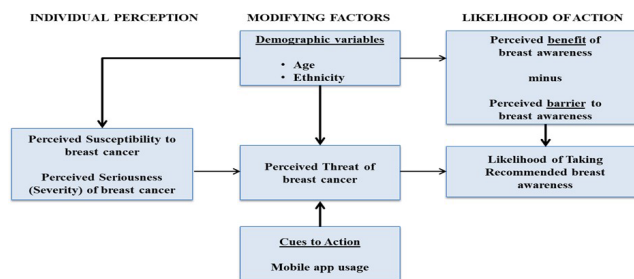
Figure 1: Adopted conceptual framework of Becker & Janz (1984) (26)

The perceived susceptibility is defined as individual subjective perception on the risk of BC (27) such as family history, mutated gene, air pollutant, unhealthy food (28), female gender, age, overweight, alcohol (4), age of first pregnancy, early menarche and nulliparity,

breastfeeding and oral contraceptive pill (OCP) (5). BC awareness topics such as breast anatomy, epidemiology, and symptoms of BC can be included (29).

The perceived severity is defined as individual evaluation in the seriousness of getting BC, consequences of leaving it untreated (27), and the condition caused by disease to the individual (4). Besides, how the individual perception about benign and malignant BC (30) such as curable if treated at an early stage, not curable if detected at a late stage and afraid of losing a breast if they are diagnosed with BC (28) can also be included.

The perceived threat is referred to awareness and care of breast awareness (31). Mobile applications targeting the public women could focus on the care of breast awareness involving engagement to routine BSE, screening examination, and early detection of BC. Other studies on BC screening behaviour revealed low self-efficacy towards BSE, suggesting to focus on teaching the correct technique to promote confidence level (28). The perceived benefit is defined as the action taken due to the effectiveness in reducing the threat of BC (27). It is also perceived as motivation by positive reward (4) in terms of a better quality of life and the benefit of early treatment (29). Some perceived intervention such as screening examination is effective preventive measure including performing BSE as a low cost, simple, quick and effective method (30) and mammogram to diagnose and monitor recurrence (32).

The perceived barrier is defined as perception on the negatively valued aspect (33) such as knowledge deficit in performing BSE technique, fear of detecting abnormality (30), fear of pain during the procedure, could not afford the costly procedure, time constraint, access to facilities (27), lack of encouragement to perform BC screening from a health professional, low priority, cultural beliefs and fear of misdiagnosis (28). Researchers intend to review suggestions on how to deal with the issues and barriers from the available mobile application.

Self-efficacy refers to users' experience (34) and the ability to use mobile applications (31) which in this study refers to users' feedbacks and rating. Some research stated that self-efficacy is referred to as behaviour intentions' motivator (32), such as BSE engagement by the user of mobile application (29). However, since this study could not assess the BSE records of the user, BSE engagement was not identified.

The cues to action refer to mobile application usage or feature such as reminders or prompts to take action. The previous study reported intervention such as letters, short message service, phone calls (32), social media, campaign, health programs (4), and video (29) were used to help to remind women about their routine screening examination.

RESULTS

A total of 125 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. A total of 66 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 targeted other population, six were excluded due to the content are not in the English language, and three were excluded because it needs 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 referring to HBM (Fig. 2).
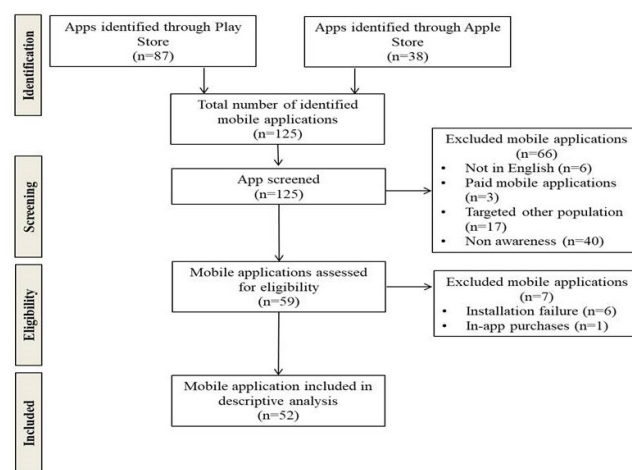
Figure 2: Flow diagram of the mobile application search process

Eligible mobile application (N=52) which are standalone (n=41) and non-standalone (n=11). The categories of the mobile apps are (health & fitness (n=31), lifestyle (n=6), medical (n=11), entertainment (n=2), book & reference (n=1), education (n=3). The selected mobile apps with component of HBM have focused on perceived susceptibility (n=33/52, 63.5%), perceived severity (n=30/52, 57.7%), perceived threat (n=48/52, 92.3%), perceived benefit (n=46/52, 88.5%), perceived barriers (n=23/52, 44.2%), self-efficacy (n=25/52, 48.1%) and cues to action (n=27/52, 51.9%)(see Table I and Table II). Most of the mobile applications on BC awareness were designed and developed focusing on certain components of the HBM, such as perceived threat and perceived benefit.

DISCUSSION

This study aimed to identify how available mobile applications are supporting breast examination awareness based on the component of the Health Belief Model (HBM). The findings revealed 52 eligible mobile

Table I. Frequency of HBM components

Component	PlayStore (N=29)	AppStore (N=23)	Total (N=52)
Perceived susceptibility	23	10	33
Perceived severity	19	11	30
Perceived threat	27	21	48
Perceived benefit	27	19	46
Perceived barrier	15	8	23
Self-efficacy	19	6	25
Cues to action	9	18	27

applications that were mostly standalone and under the Health & Fitness category. The perceived threat and perceived benefit were commonly used, whereas the perceived barrier and self-efficacy were the least used in the mobile apps dedicated for BC education. A standalone application is defined as an application installed to the device that is readily accessible via its icon without a web browser (35,36). According to Lomotey et. al (2013), standalone applications are more favourable by the users as it does not require a frequent update and internet connection to use the app (37).

One of the best mobile application found in this observation due to high rating is the 'Breast Cancer' developed by Starline Techno which was rated 4.9 out of 5 with a total of more than one thousand downloads and it also covered five components of HBM (perceived susceptibility, perceived severity, perceived threat, perceived benefit and perceived barrier). Meanwhile, another mobile application found due to most downloaded is Brexa which only rated 4.2 had more than ten thousand downloads and covered four components of HBM (perceived susceptibility, perceived threat, perceived benefit and perceived barrier). Few studies supported that appropriate font size (large fonts (38)), colour (bright colour), interface design (minimalist & modern) (39) and app's features favoured by users (user account, calendar, self-exam, location, knowledge, video tutorial and forum (40)). From the eligible apps observed from August 27 until October 20, 2019, only two are from Malaysia (LUDIc and My Pink Health) but currently, both are no longer available on the platforms, this is consistent with the study that there is a lack of mobile health app from a local perspective in Malaysia (41).

Other studies supported the HBM to be used in BSE promotion due to its effectiveness in the behavioural intervention (42). It is proven that HBM components could promote knowledge and BSE routine engagement (43) However, a previous study highlighted attention should be given to matters to overcome the barriers and the ability to use the apps (self-efficacy) (44).

There are 33 mobile application included contents related to perceived susceptibility. This finding may help us to understand the previous study which revealed that the knowledge on BC risk factors was low or insufficient

Table II: Descriptive characteristics of breast awareness apps according to HBM

NO	Apps name	Perceived susceptibility	Perceived severity	Perceived threat	Perceived benefit	Perceived barriers	Self-efficacy	Cues to action	Operating system	Total download	Country
1	ABC of Breast Health (Ushalakshmi Breast Cancer Foundation)	Breast anatomy • Gender female • Increase in age • Family history • Sedentary life • Unhealthy food • Smoking • Alcohol • Toxic product	Signs of BC Video about BC progress, signs of BC	Breast cancer screening • CBE • Mammogram	Know the normal to know the changes Report any changes to the doctor without delay	The myth about risk factors of BC • Breast injury • Deodorants • Stress • Nipple piercing • Underwired bra	Rating: 4.6 Feedback & review: Good initiative to spread knowledge	-	Android (Standalone)	100+	India
2	B4BC – Boarding for Breast Cancer (Black Sun Production)	-	-	Stiff image of BSE	Early detection is important	-	Rating: None Feedback & review: None	Reminder	iOS (Standalone)	NA	USA
3	B4BC – Boarding for Breast Cancer (Black Sun Production)	-	-	Stiff image of BSE	Early detection is important	-	Rating: 4.8 Feedback & review: Love the self-exam reminder	Reminder	Android (Standalone)	500+	USA
4	Beyond The Shock (National Breast Cancer Foundation)	Video on the cause of breast cancer • Family history • Early menstruation • Late menopause	Video on: • Cancer growth • Tumours types • Stages of cancer 0-4 / Tumors grade 1-4	Early detection with knowledge of breast awareness	Video: Diagnostic method (Breast health awareness & early detection plan)	-	Rating: None Feedback & review: None	-	iOS (Standalone)	NA	NA

(Continue........)

Table II: Descriptive characteristics of breast awareness apps according to HBM (continue)

NO	Apps name	Perceived susceptibility	Perceived severity	Perceived threat	Perceived benefit	Perceived barriers	Self-efficacy	Cues to action	Operating system	Total download	Country
5	Breast and Pec Check (YAP- Young Adult Program)	-	-	Audio with illustrated images BSE & PSE	Checkup history	-	Rating: None Feedback & review: None	Reminder	iOS (Standalone)	NA	NA
6	Breast Aware – BCI (iPLANiT Ltd)	Anatomy of the breast in the video	Signs of BC in the video	3D video BSE	-	-	Rating: None Feedback & review: None	Reminder	iOS (Standalone)	NA	Ireland
7	Breast Awareness App (Silkpro USA)	-	-	Text with audio on BSE	Knowledge about BSE	-	Rating: None Feedback & review: None	Reminder	Android (Standalone)	NA	USA
8	Breast Awareness App (Power Production Group LLC)	-	-	Text with audio on BSE	Knowledge about BSE	-	Rating: None Feedback & review:	Reminder	iOS (Non-stand-alone)	NA	USA
9	Breast Cancer (GangareBoy)	Anatomy & physiologic text (no image) • Female • Older age • Genetic • Breastfeeding • Hormone level • Obesity • Smoking • Lack of physical activity • Radiation therapy • Alcohol	Symptoms of BC	Text and image on BSE & signs of BC	To find BC early by knowing the normal look & feel Screening finds BC before symptoms appear • CBE • Mammogram • FNAC • Core biopsy • Breast MRI	-	Rating: None Feedback & review: None	-	Android (Standalone)	500+	NA
10	Breast Cancer (Magna Health Solutions)	• Smoking • Increase in age • Family history • Previous breast cancer • Breast density • Biopsy abnormalities • Exposure to radiation • Pregnancy • Breastfeeding • HRT • Obese • Alcohol	BC stages Signs & symptoms of BC	BSE explained in text with images	The goal of the screening exam is to find cancer before they cause symptoms • Mammogram • MRI • CBE • BSE	-	Rating: 4.2 Feedback & review: Love it	-	Android (Standalone)	5K+	India
11	Breast Cancer (Nature Healthy Care)	• Lack of exercise • Alcohol consumption • Smoking • Unhealthy diet	Stages of BC BC Symptoms	Real person video explaining how to perform BSE	Knowledge on how to reduce the risk	Common BC myths	Rating: 4.7 Feedback & review: None	-	Android (Standalone)	1K+	NA
12	Breast Cancer (Canada Dev Apps)	What is BC	BC development Signs & symptoms of BC	Infographic BSE BC screening • Mammogram	Tell your doctor as soon as possible for any breast changes	Request for a female doctor if feel uncomfortable with the male doctor	Rating: None Feedback & review: None	-	Android (Standalone)	50+	Canada

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Table II: Descriptive characteristics of breast awareness apps according to HBM (continued)

NO	Apps name	Perceived susceptibility	Perceived severity	Perceived threat	Perceived benefit	Perceived barriers	Self-efficacy	Cues to action	Operating system	Total download	Country
13	Breast Cancer (Starline Techno)	• Alcohol • Weight • Physically active • Smoking • Breastfeeding	Benign & cancerous lumps	Text & images on how to perform BSE	Early detection • Mammogram	Myth & truth about BC	Rating: 4.9 Feedback & review: Very informative & helpful	-	Android (Standalone)	1K+	India
14	Breast cancer assessment (CompuRx Infotech Pvt Ltd)	• Alcohol intake • Bodyweight • Physical activity • Smoking • Breastfeeding	Benign & cancerous lumps	Text & images on how to perform BSE	Early breast cancer detection	Myth about BC	Rating: None Feedback & review: None	-	Android (Standalone)	100+	India
15	Breast Cancer Awareness (Health Advice Idea)	Risk factors • Alcohol consumption & smoking • Diet intake • Bodyweight • Exercise • Hormone therapy/ medication • Radiation exposure • Night shift work • Family history • Mammogram • Genetic testing • Breastfeed • Menopause • Insulin level	-	Care of breast awareness • Check body weight • Be physically active • Eat fruit/ vegetable & avoid too much alcohol • Don't smoke • Breastfeed if possible • Avoid birth control pills • Avoid post-menopausal hormone • Breast screening	The early detection survival rate is higher	-	Rating: None Feedback & review: None	-	Android (Standalone)	NA	NA
16	Breast Cancer Awareness (The Almighty Dollar)	Risk factors • Radiation exposure • Post-menopausal hormones • Exercise • Breastfeed • Diet intake • Overweight • Smoking • Alcohol consumption • Family history • Breast density • Birth control pills • Hormone therapy	-	Info for Tamoxifen and Raloxifene	Breast cancer screening for early detection	-	Rating: None Feedback & review: None	-	Android (Standalone)	100+	NA
17	Breast Cancer Awareness (Jeann Apps Studio)	Risk factors • Genetic • Radiation exposure • Cancer-causing chemical exposure • Overweight • Smoking • History of breast cancer • Age • Early-onset of the menstrual cycle • Late menopause • First pregnancy at an older age • Race • Hormone therapy • Birth control pills • Smoking • Alcohol consumption • Mammographic breast density	Percentage of survival rate within 5 & 10 years according to the breast cancer stage	BSE stiff photo guide Chemoprevention • Tamoxifen • Raloxifene Preventive surgery • Prophylactic mastectomy • Prophylactic oophorectomy	Knowledge of BSE	-	Rating: None Feedback & review: None	-	Android (Standalone)	NA	NA

(Continue.......)

Table II: Descriptive characteristics of breast awareness apps according to HBM (continued)

NO	Apps name	Perceived susceptibility	Perceived severity	Perceived threat	Perceived benefit	Perceived barriers	Self-efficacy	Cues to action	Operating system	Total download	Country
18	Breast Cancer Awareness (Super Kool Apps)	Risk factors • Age • Genetics • BC history • Dense breast Estrogen exposure &breast feeding • Overweight • Alcohol • Radiation exposure • Hormone treatments	-	-	Knowledge of breast cancer	-	Rating: 5 Feedback & review: The awareness is good & gives hope since many people don't want to talk about it	-	Android (Standalone)	NA	NA
19	Breast Cancer Awareness (Learning Guide Studio)	Risk factors • Age • Genetic • Family history • Age having the first child • BC history • Breastfeed • Early age periods • Radiation exposure • Late menopause • HRT • alcohol	Total death of breast cancer in USA Video link to Youtube explaining breast cancer stages by oncologist/ breast cancer survivor	Video link to Youtube on how to perform BSE	Knowledge of breast cancer	Video link to Youtube on breast cancer myths • Most women who had breast cancer have no family history of BC • BC genes not only inherited from the maternal side only • Antiperspirant • Bra	Rating: 3.7 Feedback & review: None	-	Android (Standalone)	1K+	USA
20	Breast Cancer Awareness SRIOR (Magna Health Solutions)	Risk factors in risk level evaluation (risk calculator) feature questions • Family history • Menstrual cycle • Age giving the birth first child • Alcohol • Exercise • Diet intake • OCP • History of benign breast biopsies • Mammography screening	Breast cancer stages 0-4	Stiff photos of BSE steps	Important of early detection Practice of BSE	Knowledge deficit: Steps to prevent breast cancer: • BMI less than 25 • Limit alcohol con- sumption • Consume fruit & vegetable diet • Regular exercise • Reduce fats in the diet • Consume whole food soy products	Rating: 4.6 Feedback & review: Risk level evaluation feature can easily be used by public women	-	iOS (Standalone)	NA	India
21	Breast Cancer Awareness SRIOR (Magna Health Solutions)	• Bodyweight • Alcohol • Diet • Exercise • Hormone therapy • Breastfeeding	BC types BC stages	Stiff photos of BSE steps	Early detection • Mammogram • BSE • MRI • CBE	Facts about • Breast lump • Deodorant/ antiper- spirant • OCP • Breastfeeding • HRT • BC in male	Rating: 4.4 Feedback & review: Useful app	-	Android (Standalone)	5K+	India
22	Breast Cancer Guide (Expert Health Studio)	• Alcohol • Smoking • Sugar diet • Bodyweight • Active lifestyle • Hormone therapy • Radiation exposure • Night shift work • Family history • Genetic testing • Body fat percentage • Breastfeeding • Heavy metals cosmetics and deodorant • Insulin level	Invasive cancer can be cured DNA damaging estrogen can be controlled by exercise	Medical doctor explain- ing how to do BSE Detect it early for a better prognosis Recommend mammo- gram, CBE and BSE	Knowledge of breast cancer prevention	Belief in non-prescribed supplement The myth of breast cancer: • Only from the mother side • Genes skip generation • Wearing bra or antiperspirant, • Mammogram reduce risk of breast cancer	Rating:3.8 Feedback & review: No video on this app (link to Youtube)	-	Android (Standalone)	NA	NA

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Table II: Descriptive characteristics of breast awareness apps according to HBM (continued)

NO	Apps name	Perceived susceptibility	Perceived severity	Perceived threat	Perceived benefit	Perceived barriers	Self-efficacy	Cues to action	Operating system	Total download	Country
23	Breast Cancer Guide (Free Mobile Shop Apps)	• Alcohol • Family history • Being a woman • Age over 55 • Being caucasian • Period before age 12 • Menopause after age 55 • Dense breast • Carrying certain gene mutation • Sedentary lifestyle • Poor diet • Obese • Alcohol • Smoking • Radiation therapy • Taking certain hormone	Signs & symptoms of breast cancer	Text explaining BSE	Early detection is key for early treatment and better survival	Reach out for support	Rating: None Feedback & review: None	-	Android (Standalone)	NA	NA
24	Breast Check Now (Breast Cancer Now)	-	-	Stiff photo and 35 video link with a real person on how to check and symptom of breast cancer and record check	Personal planning of breast check	-	Rating: 5 Feedback & review: None	Personal plan breast check (manually set up)	iOS (Standalone)	NA	NA
25	Breast Cancer Prevention (AhorrecompArando)	-	-	BSE real person video & illustrated image	-	-	Rating: None Feedback & review: None	Alarms	iOS (Standalone)	NA	NA
26	Breast Cancer: Information about breast cancer (Doctor Apps)	Audio on BC signs that often ignored. • Drinking alcohol • Obese • Physical activity • Having children after age 30 • Birth control • Hormone therapy • Breastfeeding • Being a woman • Getting older • Family history • Personal history	Tumour and malignant Breast cancer progress	Early detection • Mammogram • CBE • BSE	The benefit of breast reconstruction	-	Rating:4.7 Feedback & review: Informative. Font too small	-	Android (Standalone)	NA	NA
27	Breast Check Now (Breast Cancer Now)	-	-	Stiff image/ video of BC signs:	-	-	Rating:4.0 Feedback & review: The reminders are not working	Reminder	Android (Standalone)	10K+	England
28	Breast Self Check- Become an expert (The Agency Company Limited)	Video with German audio and English subtitle of: • Breast anatomy	Visible and tactile aberrations	Video with German audio and English subtitle of: • BSE	Early detection has greater chances to be cured	-	Rating: None Feedback & review: None	Reminder	iOS (Standalone)	NA	Switzerland
29	Breast Self Exam (Dev Galaxy Store)	• BRCA gene • History of BC • Family history • Had radiation of the chest	-	Text & images step by step on how to perform BSE	The regular examination allows the user to detect any changes	-	Rating: None Feedback & review: None	-	Android (Standalone)	NA	NA

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Table II: Descriptive characteristics of breast awareness apps according to HBM (continued)

NO	Apps name	Perceived susceptibility	Perceived severity	Perceived threat	Perceived benefit	Perceived barriers	Self-efficacy	Cues to action	Operating system	Total download	Country
30	Brexa	Who's at high risk • Mother or sister with breast cancer <50 years • Relatives with ovarian cancer • BRCA1/ BRCA2 • Age above 50 • Early menstrual period • Late menopause • No pregnancy. late delivery after 30 • Physical inactivity • Overweight • Combination hormone therapy • BC history • Radiation therapy • Alcohol	-	3D video BSE Check your breast cancer risk	Knowledge of BSE Order breast cancer gene test BRCA1 & BRCA2 Order test: Mammogram screening & access to nearest mammogram lab Book an appointment with a specialist doctor	A false sense of security after breast screening session & did not do a future checkup Fear of finding out they have breast cancer	Rating: None Feedback & review: None	-	iOS (Non-standalone)	NA	India
31	Brexa	Who's at high risk • Mother or sister with breast cancer <50 years • Relatives with ovarian cancer • BRCA1/ BRCA2 • Age above 50 • Early menstrual period • Late menopause • No pregnancy. late delivery after 30 • Physical inactivity • Overweight • Combination hormone therapy • BC history • Radiation therapy • Alcohol	-	3D video BSE Check your breast cancer risk	Knowledge of BSE Order breast cancer gene test BRCA1 & BRCA2 Order test: Mammogram screening & access to nearest mammogram lab Book an appointment with a specialist doctor	A false sense of security after breast screening session & did not do a future checkup Fear of finding out they have breast cancer	Rating: 4.2 Feedback & review: Informative & helpful	-	Android (Non-standalone)	10K+	India
32	Check Mate Breast Cancer (Benzamin Basher)	Text about BC signs	-	2D video of BSE & signs of BC	My notes	-	Rating: None Feedback & review: None	Reminder	iOS (Standalone)	NA	Bangladesh
33	Check yourself (To Keep A Breast Foundation)	-	-	GIF photo of BSE steps	-	-	Rating: None Feedback & review: None	Automatic monthly reminder (manually set up)	iOS (Standalone)	NA	NA
34	CheckMate (Bagher Bachcha Digital)	-	Symptoms to check	BSE in text and illustrated images.	Go to the doctors for anything unusual Link to make an appointment with a doctor	Available in Bengali language	Rating: 4.7 Feedback & review: Could use menu item on the action bar to switch English / Bangla version	Reminder	Android (Standalone)	5K+	Bangladesh
35	Dear Mamma fights breast cancer (seracom GmbH)	• Family history • Smoking • Alcohol • Obesity • Older age	• Curable • Not contagious • Without treatment can lead to death	Real person video on BSE Text & stiff image on the signs of BC	Early detection had better chances of survival	• Overcoming shame • Calls for knowledge of BC • Calls for openness • Calls for awareness	Rating: 4.5 Feedback & review: None	Reminder My history (History of self-check)	Android (Standalone)	5K+	Switzerland
36	Dear Mamma fights breast cancer (seracom GmbH)	• Family history • Smoking • Alcohol • Obesity • Older age	• Curable • Not contagious • Without treatment can lead to death	Real person video on BSE Text & stiff image on the signs of BC	Early detection had better chances of survival	• Overcoming shame • Calls for knowledge of BC • Calls for openness • Calls for awareness	Rating: None Feedback & review: None	Reminder My history (History of self-check)	iOS (Standalone)	NA	NA

(Coninue.........)

Table II: Descriptive characteristics of breast awareness apps according to HBM (continued)

NO	Apps name	Perceived susceptibility	Perceived severity	Perceived threat	Perceived benefit	Perceived barriers	Self-efficacy	Cues to action	Operating system	Total download	Country
37	iCheck (Julie Sprakel)	-	Images on signs & symptoms of BC	BSE 2D video with audio	Be proactive about your health & seek advice from a medical practitioner or breast specialist	Myth • Wearing a bra cause BC • BC contagious • Deodorant cause BC	Rating: None; Feedback & review: None	Reminder	iOS (Standalone)	NA	Bahrain
38	Know Your Lemons (Worldwide Breast Cancer)	• Age • Estrogen • Breast type • Overweight • Alcohol • Smoking • Lack of exercise	Symptoms of BC; Risk calculator	Audio on how to perform BSE with images	Know your body & report changes; Screening plan	-	Rating: 3.9; Feedback & review: Great tool for awareness	Reminder	Android (Non-standalone)	1K+	USA
39	Know Your Lemons (Worldwide Breast Cancer)	• Age • Estrogen • Breast type • Overweight • Alcohol • Smoking • Lack of exercise	Symptoms of BC; Risk calculator	Audio on how to perform BSE with images	Know your body & report changes; Screening plan	-	Rating: None; Feedback & review: None	Notification; Reminder	iOS (Nnon-standalone)	NA	UK
40	LUDic (National Cancer Council (MAKNA))	-	Video on breast cancer symptoms; Video on breast cancer progression & staging	BSE steps in stiff photos	Knowledge of BSE; Video on breast cancer prevention; Access GPS to mobile screening unit locator	-	Ratings: 4.5; Feedback & review: Helpful to understand BC & prevent by BSE practice	Reminder	iOS (Non-standalone)	NA	Malaysia
41	Mamocare (Sonix Apps)	• Menstruation • Motherhood • Hormones • Lifestyles • Family history & genetic • Getting older • Radiation treatment on the chest area • Breast cancer or other breast problem in the past	Symptoms of BC	Text & images on how to perform BSE	Monitor period status, BSE details	Myths & facts	Rating: 4.5; Feedback & review: Really helpful app	Reminder	Android (Standalone)	NA	NA
42	My Pink Health (Pink Ribbon Wellness (L) Foundation)	Risk factors • Age • Family history • Personal history • Hormones • Radiation treatment • High-fat diet intake exercise • Alcohol • Estrogen replacement therapy • Obesity • Prolonged OCP use • Long term HRT • Breastfeed	Text explaining about malignant tumour	BSE with explanation text & stiff photos of BSE steps	Knowledge of BSE; Breast care – To do list; Information on early detection	Myth – Thinking they are not at risk due to no family history of breast cancer	Rating: None; Feedback & review: None	-	iOS (Non-standalone)	NA	Malaysia
43	Pandekha – Breast Cancer Self Examination (Virtual Tech Malawi)	• Age • Gender • Family history • Smoking • Alcohol • Obesity • High fats diet • Breastfeeding • Not having children • Physical inactivity • Exposure to estrogen	-	Text with illustrated images on BSE; BSE video with a real person explaining and 2D image to show the steps	-	-	Rating: None; Feedback & review: None	Reminder	Android (Standalone)	100+	Malawi
44	Pink Bra	Lower the risk • Family history • Alcohol intake • Diet • Bodyweight • Exercise • Breastfeeding	-	3D video BSE; Early detection; Engage BSE routine	Routine BSE can self-detect breast cancer; Knowledge of BSE can promote early detection	-	Rating: None; Feedback & review: None	Reminder manual set up (For every week, every 2 weeks and every 4 weeks)	iOS (Standalone)	NA	USA

(Conitue........)

Table II: Descriptive characteristics of breast awareness apps according to HBM (continued)

NO	Apps name	Perceived susceptibility	Perceived severity	Perceived threat	Perceived benefit	Perceived barriers	Self-efficacy	Cues to action	Operating system	Total download	Country
45	Pink Drive (Elula Online)	-	Signs & symptoms of BC	Text & images of BSE	A monthly self-examination could lead to early detection	Myth & Fact of BC, mammogram; Educational leaflet or poster available in English, Afrikaans, Tswana, Venda Xhosa & Zulu	Rating: None; Feedback & review: None	-	Android (Standalone)	NA	NA
46	Pink Knight (Zulekha Hospitals)	-	-	-	News & event	Target women across UAE & India; Access to specialist	Rating: None; Feedback & review: None	Free checkup offer by app registration	Android (Non-standalone)	1K+	UAE
47	Pink Knight (Zulekha Hospitals)	-	-	-	News & event	Target women across UAE & India; Access to specialist	Rating: None; Feedback & review: None	Free checkup offer by app registration	iOS (Non-standalone)	NA	UAE
48	Pinkypromise-Alnoor (Stackon Technologies)	-	BC can be prevented	Text & images on how to perform BSE	Monthly self-exam & regular checkup are key in early detection; Consult a doctor for any changes; Share with friends	Available in English & Arabic language	Rating: None; Feedback & review: None	Reminder	iOS (Standalone)	NA	Oman
49	Pre Check (Colenso BBDO)	-	Signs of breast cancer	Visual, tactile & audio cues for signs of BC; BSE illustrated guide	Know BC signs	Consult a doctor	Rating: None; Feedback & review: None	Reminder	iOS (Standalone)	NA	NA
50	Sensifemme breast self-examination glove (Kavisha Pharma sl)	• Age • Family background • Personal background • No tumour breast lesion • First early menstruation • Late menopause • Pregnancies • Hormone therapy • Lifestyle	Warning signs of BC	Text & images step by step on how to perform BSE with Sensifemme glove	Early detection increases the healing chances; Early detection is a combination of mammogram, CBE & BSE	-	Rating: 5.0; Feedback & review: None	-	Android (Non-standalone)	100+	Spain
51	Sensifemme breast self-examination glove (Kavisha Pharma sl)	-	-	-	Increase sensitivity & early detection	-	Rating: None; Feedback & review: None	Notification	iOS (Non-standalone)	NA	Spain
52	SqueezeDay (Dynamo)	-	-	Text & images on how to perform BSE	-	-	Rating: None; Feedback & review: None	Reminder	iOS (Standalone)	NA	Sweden

among Malaysian (45) as health education and awareness probably did not include enough topic related to BC risk. Hence, consideration to emphasise the importance of the topic should be conducted, and educational programs such as continuing education with integration of mobile application must be developed and practised by health promoters. The health education conducted can be further reinforced by the mobile application as the user can revise again at any time and only limited by internet access. Furthermore, emphasise lifestyle changes of related risk can only reduce the risk and not zero the risk meaning routine screening still needs to be done (46).

Observation of HBM component perceived severity revealed that only 30 mobile applications included such contents in their mobile application. As previous research also holds the view to focus on symptom recognition due to well-informed users would engage towards the health behaviour (5). Future health education programs could influence women's decision-making by exposing them to chances of survival, body image, and metastatic of BC (5). In this context, focus on the chances of survival is essential due to the finding in the previous study which stated that women perceived the severity of BC as fatal (32).

Another important finding was that 48 mobile applications were found with perceived threat component which utilizes medium such as audio, images (stiff, GIF or infographic) or video (2D, 3D or real person). This could promote regular BSE routine engagement by using interactive learning method and animated learning content (34). A consistent BSE routine is essential for early diagnosis and treatment as supported by findings that most women detected lump by themselves (47,48) if it was done correctly (49). So, women need to become familiar with the breast tissue to detect any changes in their breasts (49). This is important for their survival and quality of life (29).

In the previous study, the mobile application was found to be very convenient for the users to adapt breast awareness health behaviour (31). Meanwhile, findings of this study have observed that 46 mobile applications have incorporated the perceived benefit component, such as the importance of early detection and the urge to report any changes to their doctor without any delay. Another study revealed that their participants would go for mammogram screening as recommended by their doctors (27), indicating the involvement of HCP is crucial in the mobile application development to ensure the right message was delivered to the users for engagement of health behaviour. Moreover, the development of an interactive mobile application with a feature that enables users to interact with HCPs in the future enables direct communication between HCP and user. In this context, emphasization the benefit of early detection for women to engage with the behaviour (4).

From the observation of the perceived barriers component, only 23 mobile applications included contents related to a barrier such as how to get support or request for a female doctor if they are embarrassed. It also emphasizes the facts of BC to correct misconception or myth and some of the mobile applications are bilingual and available in the local language. However, this observation found the lacking of contents related to some belief which some researchers have reported that Malaysian women believe in traditional medicine and supplements (5) and this context should be taken into consideration by adding it as a barrier to BC awareness in the future. Besides, Malaysian women's belief in the fatalistic of cancer prevention also is one of the barriers towards cancer prevention behaviour (50). However, it has been reported that women will perform screening examinations if they are aware of the risk, have knowledge of BSE skills, know the behaviour benefit and reduce the barrier (9,51).

The findings for the self-efficacy (n=25) component may be somewhat limited as it seems users using the Android operating system would rate and give feedbacks compared to iOS users. These somewhat unexpected findings were also observed whenever the same mobile applications that were available in both operating systems would receive good ratings in PlayStore however does not receive any rating in the AppStore. Generally, self-efficacy towards mobile applications provides a good support system in delivering breast awareness which could facilitate the user in deciding to adopt health behaviour such as routine screening examination (28). In order to ensure acceptance of smartphone technology, assessment and preparation of the education content should be related to how women perceived threat, benefit, and self-efficacy (31).

The current study suggested that HCP should develop support services or reminder alerts on medical education (50), this is consistent with the need of this study finding which reveals that only 27 current available mobile applications included cues to action component such as reminder. Mobile application with reminder feature can be developed in the future, as the previous study revealed that mobile application intervention could help in reminding about BC, guide the technique of BSE, breast screening examination options to the users, and the importance of treatment in the early stage of BC (4). The previous study also agrees that reminder is one of the selling points even if it requires manually set by the user (52). Other than the reminder feature, mobile application development can consider including a feature such as sharing to others (28) via email, message, or social media account. Feature such as recording behaviour or tailoring feedback is also proven to change behaviour and enable the user to provide live experience data (53,54).

The knowledge about BSE is usually delivered by

others (such as family, friends, or HCPs), through communication devices, reading materials, or the internet (55). Even though a study by Roh et al. (2018) found that talking about breast health and BC is culturally sensitive and suggested for future research to identify appropriate methods in raising awareness (50,56). It is possible to recommend mobile applications as a medium to revise or share about BC with others. Another study has suggested that the mobile application's users prefer features that are informative, customisable, networking, and relevant to their needs (53). However, it is essential to bear in mind the appropriate scope of information to include in the health education session as Bluethmann et al. (2017) suggested that the application of theory during intervention development, implementation, and evaluation may contribute to the effectiveness of behavioural interventions and reinforce women empowerment to fight BC (9).

LIMITATIONS

This review only includes mobile applications that are accessible in the PlayStore and the AppStore Malaysia overviews. There is a probability the researcher would experience different functionality and mobile application description due to the utilisation of different devices and operating system versions. These study findings are based on the mobile application version that was downloaded and identified at that time. This review did not use Mobile Application Rating Scale (MARS), future study may use MARS to evaluate the mobile applications. Moreover, we excluded mobile apps that are not in English due to limited proficiency.

CONCLUSION

The mobile application is an interactive and personalised health education device that has the potential to reinforce breast cancer awareness. The review could provide information and reference of available mobile applications to develop appropriately tailored content supported by health theories to promote breast cancer awareness. The integration of mobile technologies in education sessions requires adding on the missing contents in some of the available mobile applications. Besides, these reviews will provide information for the researcher to focus on mobile application content development based on HBM in the future. This study found that perceived threat has been widely used and perceived barrier was the least utilised in mobile health app of BC.

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