Development of a Mobile-Based Self-care Application for Patients with Breast Cancer-Related Lymphedema in Iran

Maryam Ahmadi[1]   Seyedeh Nafiseh Shahrokhi[1]   Morteza Khavaninzadeh[2]   Jahanpour Alipour[3,4]

[1] Department of Health Information Management, School of Health Management and Information Sciences, Iran University of Medical Sciences, Tehran, Iran
[2] Department of General Surgery, School of Medical Sciences, Iran University of Medical Sciences, Tehran, Iran
[3] Health Promotion Research Center, Zahedan University of Medical Sciences, Zahedan, Iran
[4] Department of Health Information Technology, School of Paramedical, Zahedan University of Medical Sciences, Zahedan, Iran

Address for correspondence Jahanpour Alipour, School of Paramedical Sciences, Zahedan University of Medical Sciences, Khalij Fars Avenue, Zahedan 00982, Iran
(e-mail: Jahanpour.alipour@zaums.ac.ir).

Abstract

Background   Due to the chronic, progressive, and debilitating nature of breast cancer-related lymphedema (BCRL), it is necessary to observe and maintain self-care management accordingly. This study was conducted to develop a mobile application based on the Android operating system for self-care management of Iranian patients with BCRL.

Methods   An applied developmental study was conducted in 2020. The users' information needs assessment as well as design, development, implementation, and evaluation of the mobile app for self-care management of patients with BCRL was done by searching the literature, reviewing the existing mobile applications, and surveying the users' needs. The mobile app was designed using the Android Studio environment and Java programming language in the Android operating system. The usability of the app was evaluated by 30 patients with BCRL using the questionnaire for user interface satisfaction-seventh version (QUIS 7).

Results   The mobile app for BCRL included demographic information, clinical information, lifestyle and system functions (drug use, nutrition, exercise, smoking cessation, communication, and test time reminder). User usability evaluation of the app content and functions confirmed that it was appropriate and satisfactory for the self-management of women with BCRL.

Conclusion   The mobile app was appropriate in terms of the content, function, and quality for improving the patients' lifestyle and education and self-management of BCRL symptoms according to its usability evaluation from the end-users' (patients) perspective. It is suggested that studies should be performed to confirm the effectiveness and identify the clinical significance of the app.

Keywords
► breast cancer-related lymphedema
► self-care
► mobile applications
► breast cancer
► smartphone

Background and Significance

Breast cancer is the most common cancer and one of the most common leading causes of death in females[1–6] with increasing incidence and mortality across the world.[7,8] About one-eighth of women experience breast cancer during their lifetime.[9] According to the Global Cancer Incidence, Mortality and Prevalence (GLOBOCAN), breast cancer ranked first in incidence and second in the most common causes of cancer death worldwide in 2020.[10] This cancer has been identified as the most common cancer and the fifth cause of mortality in Iranian women.[8] According to the GLOBOCAN estimates, breast cancer accounted for approximately 13% of new cancers in both men and women and 28% of cancers in women in Iran in 2020.[11]

Some breast cancer therapies, such as axillary lymph node dissection, can cause lymphedema after treatment.[4] Lymphedema is a chronic, progressive, and debilitating complication and one of the most common side effects of breast cancer treatment, which results from the fluid accumulation in the interstitial tissue due to damage to the lymphatic system following surgery, radiography, or tumor.[12–15] Breast cancer-related lymphedema (BCRL) symptoms impose high costs on patients and increase their distress, reduce the quality of life (QOL), and lead to disability.[16] More than one-fifth of women who survive breast cancer develop lymphedema after breast cancer treatment, affecting more than 40% of the three million breast cancer survivors in the United States.[17]

Self-care is a very important issue in the management of chronic diseases.[18,19] Self-care programs play a critical role in controlling chronic diseases by improving collaborative cooperation between patients and physicians, managing disease symptoms, treatments, and patient lifestyle.[20–22] Lymphedema self-care behaviors are important to prevent further progression of the disease and the severity of symptoms as well as its psychological and societal consequences. Effective self-care in BCRL includes various behaviors that require continuous implementation to minimize symptoms and slow the progression of the disease, some of which include wearing a compression garment, proper exercise, hygiene and skin care, preventing damage to the affected area and reducing the risk of infection, and maintaining a normal body mass index.[23,24]

In recent years, adoption and widespread use of mobile phone technologies have opened new horizons for improving health and providing health care.[19,25–29] Today, people are increasingly using mobile health (m-health) applications to manage chronic illnesses, mental health, and fitness[30] because these apps can reduce self-care costs, increase care accessibility,[31,32] and improve the health outcomes, social support, and QOL of patients with chronic diseases.[33–35]

The use of m-health apps makes it possible to perform routine assessments and effective interventions that are key to self-care to improve the management of lymphedema symptoms[15,25] and access to health care for people with disabilities related to BCRL.[36] Due to the lack of definitive treatment for patients with lymphedema and the impor-

tance of self-care in reducing the symptoms of the disease, teaching self-care strategies via mobile apps can greatly reduce the risk of lymph fluid accumulation.[15,37,38] Long-term self-care reduces the effects of lymphedema on the patients' health status, lessens the severity of inflammation, and ultimately prevents disease progression, thereby reducing health care costs. In addition, the lack of care and treatment services for these patients shows the importance of following self-care tips for patients with BCRL; therefore, m-health is a key solution that can be used for all or some aspects of their care.[39] However, the acceptance and satisfaction of the end users of an application is an integral part of its successful implementation because the evaluation of usability and user satisfaction makes it possible to redesign the application (if needed) to ensure the benefits and leads to its success implementation.[40,41] In Iran, limited studies have focused on the design and use of mobile applications for preventive measures and care of breast cancer patients.[42,43]

Objective

To the best of our knowledge, no mobile-based applications have yet been developed to manage the symptoms of BCRL disease in Iran. Thus, a study was conducted to develop a mobile app for self-care management of Iranian patients with BCRL and evaluate its usability.

Methods

An applied developmental study was conducted to develop and test the usability of a mobile application based on the Android operating system for self-care management of Iranian patients with BCRL in 2020. This study was conducted in three main stages.

Stage 1: Pre-development (Information Needs of Patients and Experts, Content, and Functions of the App)

The needs assessment survey was conducted from June 1 to June 30, 2020 to determine the required information needs for the BCRL self-care mobile application from the participants' perspectives (experts and patients).

The contents of the application were organized using a literature review. In this stage, all publications until May 2020 were searched in PubMed and Scopus databases for related clinical guidelines and medical literature. The applied search terms were a combination of "breast neoplasm*" OR "breast cancer" OR "Breast Cancer Related Lymphedema" OR "Breast Cancer Lymphedema" OR "Breast Cancer Lymphedema" OR "Post-mastectomy Lymphedema" OR "Breast Cancer-Related Arm Lymphedema" OR "Breast Cancer Treatment-Related Lymphedema" AND "Smartphone Apps" OR "Mobile Apps" OR "Mobile Applications" OR "Portable Software Apps" OR "Portable Electronic Apps" OR "Portable Software Applications" OR "Portable Electronic Applications."

The inclusion criteria were full-text articles in English language related to the research topic. The articles published

in languages other than English, the articles whose full-text were impossible to access, reports and forms retrieved from personal weblogs, and letters to editors were excluded from the study. A total of 220 papers were extracted of which 27 papers were duplicates and were therefore removed. Of the 193 remaining papers, 156 and 27 articles were excluded after reviewing their titles and abstracts, respectively. The remaining 10 papers were scrutinized for eligibility, and all of them met the inclusion criteria.[21,44–51]

A questionnaire was constructed to determine the information content and functions of the mobile-based self-care application for patients with BCRL based on literature review. The questionnaire was composed of four main parts, including (1) the participants' demographic characteristics (i.e., age, marital status, and education for patients and age, gender, work experience, work experience in lymphedema clinic, and specialist field for experts), (2) 14 and 21 administrative and clinical information, (3) 19 items about lifestyle educational needs, and (4) 35 items concerning the functions (i.e., drug use, nutrition, communication, exercise, smoking cessation, and test time reminder) for participants (patients and experts). At the end of each main section, an open-ended question was considered so that participants could add their suggested data elements other than those in the questionnaire. The questionnaire was composed of three columns with "necessary" and "unnecessary" in front of each data element. The participants were asked to determine the necessity of the data elements and functions proposed in the app.

The content validity of the questionnaires was evaluated by six experts, including three PhD holders in health information management and three PhD holders in medical informatics. The criteria for selecting experts at this step included knowledge and experience in designing self-care management applications and publishing at least one scientific article in this area. The Kuder and Richardson Eq. 20 (KR20) was used to estimate the reliability of the questionnaires. Cronbach's α coefficients were 0.72 and 0.74 for the patients and experts' questionnaires, respectively.

Purposive sampling was used to select 30 experts (i.e., six vascular surgery specialists, five breast surgery specialists, six gynecologists, six oncologists, six physiotherapists, and a psychologist).The criterion for the selection of experts was knowledge and experience about lymphedema. Convenience sampling was used to select 30 patients with BCRL presenting to two teaching hospitals (i.e., Rasul-e Akram and Firoozgar) affiliated with Iran University of Medical Sciences. The criterion for the selection of patients was a positive history of breast cancer. The criterion for the acceptance of data elements in the app was set by the researchers, so that if 75% or more of the participants (patients and experts) on average considered an item as necessary, the item was included in the app.

Stage 2: Design and Translation of Pre-development Output into an Android-Based Mobile Application
In this stage, the conceptual modal of the app was designed by drawing unified modeling language (UML) diagrams.
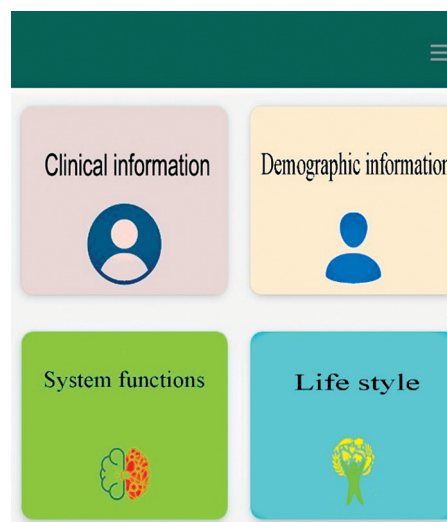
Fig. 1 The main menu of the BCRL self-care app. BRCL, breast cancer-related lymphedema.

Microsoft Visio ver. 2019 was used for illustrating UML diagrams. Then, the mobile app was designed and programmed using the Android Studio environment and Java programming language for Android devices. SQLite was used to design the application database. The main menus of the BCRL self-care app consist of four demographic information, clinical information, system functions, and life style sections (►Fig. 1). In the patient demographic information section, the users enter their demographic data (i.e., patients' name, family name, age, sex, education, employment status, height, weight, attending physician name and surname, etc.). The clinical data section of the application includes 21 data, such as history, symptoms, duration, and severity of the disease, drugs used, drug sensitivities, medical procedures (including chemotherapy, radiotherapy, and hormone therapy), the number and type of surgical procedures performed, type of lymph node inflammation, number of involved lymph nodes, number of lymph nodes removed, the average change in arm volume, and midwifery care and recommendations (►Table 1).

The lifestyle section contains self-care recommendations on nutrition, physical activity, smoking, stress, ways to prevent and control lymphedema, post-surgical care, health tips for lymphedema, how to use lymphedema drugs, possible complications of lymphedema drugs, importance of regular use of drugs, expression of drug interactions, and necessary actions when forgetting to use medications (►Table 2). The application includes the following six functions (►Fig. 2).

Drug use management: The patients can enter the names of the drugs and their dosage, the number of drugs provided, the start and end dates of the period of use, the side effects of the drugs, and a reminder for drug use. The patients can enter their daily consumption until the end of the treatment period and then complete the treatment period through the option "finish consumption and calculate the forgotten number" to see the number of forgotten drugs.

Table 1 Frequency distribution of participants' responses regarding the necessity of proposed administrative and clinical data elements

Category	Data elements	Respondents	Necessary		Unnecessary	
			N	%	*N*	%
Administrative data elements (*n* = 14)	Patient name	Experts	22	73	8	27
		Patients	27	90	3	10
	Patient last name	Experts	24	80	6	20
		Patients	24	80	6	20
	Patient marital status	Experts	27	90	3	10
		Patients	20	67	10	33
	Employment status	Experts	13	**43**	17	**57**
		Patients	21	**70**	9	**30**
	Being the head of the household	Experts	15	**50**	15	**50**
		Patients	21	**70**	9	**30**
	Education level	Experts	24	80	6	20
		Patients	22	73	8	27
	Number of children	Experts	13	**43**	17	**57**
		Patients	21	**70**	9	**30**
	National ID code	Experts	26	87	4	13
		Patients	25	83	5	17
	Age	Experts	25	83	5	17
		Patients	24	80	6	20
	Weight	Experts	25	83	5	17
		Patients	22	73	8	27
	Hight	Experts	24	80	6	20
		Patients	24	80	6	20
	Name and surname of the attending physician	Experts	**12**	**40**	**18**	**60**
		Patients	**23**	**77**	**7**	**23**
	Patient address	Experts	**17**	**57**	**13**	**43**
		Patients	**10**	**33**	**20**	**67**
	Phone number	Experts	22	73	8	27
		Patients	24	80	6	20
Clinical data elements (*n* = 21)	Disease history	Experts	26	87	4	13
		Patients	28	93	2	7
	Disease symptoms	Experts	26	87	4	13
		Patients	26	87	4	13
	Duration of illness	Experts	28	93	2	7
		Patients	27	90	3	10
	Names of medications being taken	Experts	28	93	2	7
		Patients	26	87	4	13
	Dosage of drugs taking	Experts	28	93	2	7
		Patients	27	90	3	10
	Disease stage (e.g., stage 1, stage 2, or stage 3)	Experts	28	93	2	7
		Patients	27	90	3	10
	History of radiotherapy (radiation therapy)	Experts	28	93	2	7

Table 1 (*Continued*)

Category	Data elements	Respondents	Necessary		Unnecessary	
			N	%	N	%
		Patients	27	90	3	10
	History of chemotherapy	Experts	28	93	2	7
		Patients	27	90	3	10
	History of hormone therapy	Experts	28	93	2	7
		Patients	26	87	4	13
	Family history of breast problems	Experts	28	93	2	7
		Patients	29	97	1	3
	History of severe trauma or injury to the organ involved	Experts	28	93	2	7
		Patients	25	83	5	17
	History of infection at the surgical site	Experts	28	93	2	7
		Patients	27	90	3	10
	History of drug allergy	Experts	28	93	2	7
		Patients	25	83	5	17
	Type of breast cancer surgery	Experts	28	93	2	7
		Patients	26	87	4	13
	Type of lymph node inflammation	Experts	28	93	2	7
		Patients	25	83	5	17
	Type of lymph node surgery	Experts	28	93	2	7
		Patients	26	87	4	13
	Number of affected lymph nodes	Experts	28	93	2	7
		Patients	25	83	5	17
	Number of lymph nodes removed	Experts	28	93	2	7
		Patients	24	80	6	20
	Average change in arm volume	Experts	28	93	2	7
		Patients	24	80	6	20
	Underlying disease	Experts	28	93	2	7
		Patients	25	83	5	17
	Midwifery care and advice	Experts	28	93	2	7
		Patients	24	80	6	20

Nutrition management: This function consists of two subfunctions. The calorie calculation subfunction enables the patients to estimate the required daily calorie by entering the gender, age, height, and weight and selecting the amount of daily activity. In the food management subfunction, the patients can enter the days of the week they are on a diet and then select their daily food consumption from a list of available foods as well as its amount using appropriate units (grams, number, and glasses). The application then displays the daily calorie intake in general and also the calorie intake for each food per 100 g, the number of calories consumed, and the amount of consumption of each food selected by the user separately so that the patients can compare their calorie intake with the number of calories they need.

Smoking cessation management: This function comprises two subfunctions. Logging into the cessation planning sub-function enables the users to enter the number of cigarettes smoked per day, price of each cigarette, duration of smoking in years, and the desired target in terms of the number of cigarettes smoked per day. Besides, logging into the cessation management section allows the patients to enter the name of each month after which the list of that month is shown and the purpose for each day is displayed in this section; hence, the patients can select the number of cigarettes they smoke per day and compare their use with the target number.

Exercise management: This function consists of four sub-functions. In the starting exercise section, sports movements are divided into three categories: stretching movements of BCRL, movements after breast surgery, and yoga moves. By logging into each of these sections, the patients can view a list of their movements. Then, they can select different movements by clicking on its image. Moreover, they can
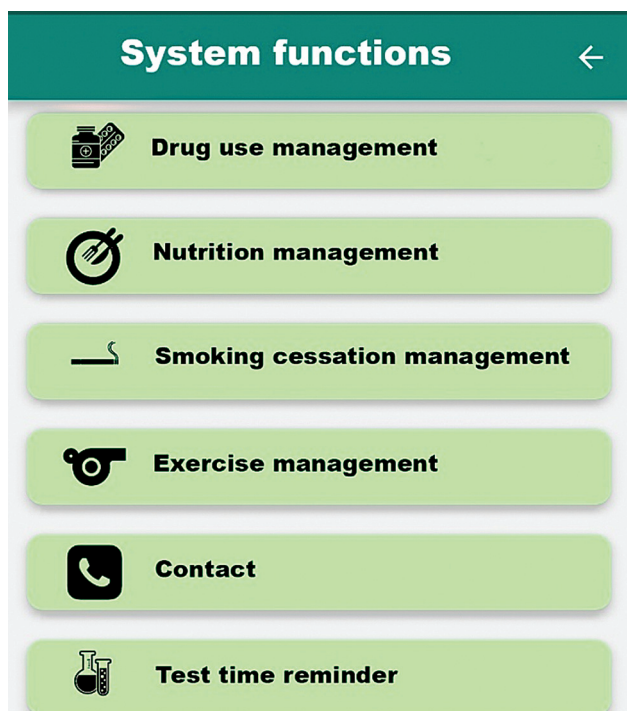
Table 2 Frequency distribution of participants' responses about the lifestyle educational needs of the application

Lifestyle educational needs	Respondents	Necessary		Unnecessary	
		N	%	N	%
Definition of lymphedema	Experts	26	87	4	13
	Patients	26	87	4	13
Prevalence of lymphedema	Experts	26	87	4	13
	Patients	26	87	4	13
Causes and risk factors of lymphedema	Experts	25	83	5	17
	Patients	26	87	4	13
Symptoms of lymphedema	Experts	26	87	4	13
	Patients	26	87	4	13
Diagnosis of lymphedema	Experts	26	87	4	13
	Patients	26	87	4	13
Complications of lymphedema	Experts	26	87	4	13
	Patients	27	90	3	10
Treatment of lymphedema	Experts	26	87	4	13
	Patients	27	90	3	10
The effect of exercise on lymphedema	Experts	27	90	3	10
	Patients	25	83	5	17
The effect of nutrition on lymphedema	Experts	27	90	3	10
	Patients	27	90	3	10
The effect of smoking on lymphedema	Experts	27	90	3	10
	Patients	27	90	3	10
The effect of stress management on lymphedema	Experts	27	90	3	10
	Patients	27	90	3	10
Ways to prevent and control lymphedema	Experts	26	87	4	13
	Patients	26	87	4	13
Postoperative breast care	Experts	26	87	4	13
	Patients	29	97	1	3
Health tips for lymphedema	Experts	26	87	4	13
	Patients	28	93	2	7
Patient knowledge of how to take drugs	Experts	28	93	2	7
	Patients	23	77	7	23
Complications of medications/drugs	Experts	28	93	2	7
	Patients	26	87	4	13
The importance of regular medication taken	Experts	28	93	2	7
	Patients	26	87	4	13
Expression of drug interactions	Experts	27	90	3	10
	Patients	24	80	6	20
Necessary measures when forgetting to take medications	Experts	27	90	3	10
	Patients	21	70	9	30

activate a 3-minute timer by selecting the start option at the bottom of the screen. In the daily exercise time section, the patients can enter the duration of their exercise on a daily basis in hours and minutes. In the daily activity chart section, the patients can view the daily activity chart of the week separately for each day and the duration of exercise by selecting the desired week. Furthermore, in the daily reminder section, the users can activate the daily exercise

System functions

- Drug use management
- Nutrition management
- Smoking cessation management
- Exercise management
- Contact
- Test time reminder

Fig. 2 The main functions of the BCRL self-care app. BRCL, breast cancer-related lymphedema.

reminder by selecting the exercise reminder time in hours and minutes and activating the daily reminder option.

Communication/contact: This function includes four sub-functions. In contact with the doctor section, the patients can search the name of the desired doctor. In the patient contact section, the users can view and search the patients' names along with their contact numbers. In communication with the pain clinic section, a list of pain clinics located in Tehran city along with their addresses and telephone are available which can be used by patients to contact them if necessary. In the reminder for appointment with the doctor section, the patients can record a new reminder by selecting the date, time, and name of the doctor.

Test time reminder: In this function, the patients can record a new reminder by selecting the date and name of the test.

Stage 3: Usability Testing of Application

In this stage, 30 patients with a history of lymphedema presenting to the Lymphedema Clinic of Motamed Cancer Institute, Tehran, Iran were selected through convenience sampling to assess the usability of the application. This center is a referral clinic and accepts patients from other provinces of Iran.[52]

The participants were individually contacted and provided with information about the app and the ultimate aim of its development. Informed consent was obtained from all patients prior to participation in the study. Since the app was developed only on an Android platform, the main criterion for patients entering this stage was access to phones with the Android operating system. Then, the application along with its installation guide was sent to the participant's

mobile phones. After confirming the successful installation of the application, they were asked to use the application for 2 weeks. To ensure that the patients use the application, a daily message with the content "please use the application" was sent to them and they were asked to give feedback on their daily use of the application.

The usability of the app and the users' satisfaction with the interface were evaluated using QUIS Version 7 developed by a multi-disciplinary team of researchers in the Human–Computer Interaction Laboratory at the University of Maryland, College Park. Due to the translation of the original questionnaire into Persian language, we re-evaluated the validity and reliability of the Persian version. The questionnaire consists of two main parts: (1) The users' demographic characteristics (i.e., age and education level) and (2) 32 questions divided into six factors including overall reaction to software ($n = 6$), screen design and layout ($n = 4$), terminology and system information ($n = 6$), learning ($n = 6$), system capabilities ($n = 5$), and usability and user interface ($n = 5$). The Part B of the questionnaire was scored on a 10-point scale from zero to nine. After calculating the mean score of the measured factors, the following divisions were used to evaluate the level of the users' satisfaction. A mean score of 6.1 (out of nine) or higher indicated a good level of satisfaction. Besides, a mean score of 3.1 to 6 showed average satisfaction, and a mean score of 3 or lower indicated a weak level of satisfaction.

Statistical Analysis

The SPSS for Windows ver. 22.0 was used for data analysis. Descriptive statistics (number, percentage, mean, and standard deviation) are used to present general characteristics (e.g., age, education level, occupation, and work experience, etc.) as well as the usability responses of experts and patients.

Results

Predevelopment Stage Findings Participants' Demographics

The experts participating in the needs assessment phase included 30 experts with experience in the lymphedema department. Fifty-three percent of the them were male and the rest were female. Half of the experts were over 50 years old and had more than 25 years of work experience. The majority of them (70%) had more than 5 years of experience in the field of lymphedema. The highest frequency of experts was related to specialists of vascular surgery, gynecologists, oncologists, and physiotherapists (20% each) followed by breast surgery specialists (17%) and psychologists (3%). The patients participating in this stage included 30 women with lymphedema after treatment for breast cancer. More than half of them had a high school diploma or lower degrees (53%) followed by associate degree (30%) and bachelor's degree (10%). Only 7% of the patients had a master's degree or higher. Furthermore, the highest frequency of age range was related to the age group 50 to 59 years (53%) followed by 60 to 69 (27%) and 40 to 49 (13%) years. Only 7% of the patients were 30 to 39 years old.

The participants identified nine administrative data elements as necessary and five data elements as unnecessary (i.e., patient's employment status, number of children, address, being head of household, and name and surname of attending physician). Besides, they recognized all of the 21 clinical data elements as necessary. No new data elements were proposed by the participants (►Table 1).

All lifestyle educational needs were recognized as necessary from the participants' perspective (►Table 2).

According to ►Table 3, the participants identified one function as unnecessary (i.e., send hopeful and reassuring sentences as a message to the patient's cell phone). Besides, the participants suggested one new function (i.e., introducing different types of diets). The necessity of the data element was inquired from all participants, of whom more than 75% considered it as necessary.

Development and Implementation of Phase Findings

The application was developed in the Android software platform. The app menus were divided into four main parts, including demographic information, clinical information, lifestyle, and system functions (►Fig. 1).

The app consists of six functions of drug use management, nutrition management, exercise management, smoking cessation management, and test time reminder (►Fig. 2). Besides, pilot implementation of the developed app was done at this stage. Participants were asked to install the application on their cell phones. The patients were required to use the application for 2 weeks from September 1 to 14, 2020.

Usability Testing Findings

All participants completed the questionnaires at this stage of study. The highest mean scores of the app usability were achieved in "screen design and layout" and "system capabilities" areas with 8.5 ± 0.56 and 8.5 ± 0.55, respectively. Moreover, the lowest mean score was founded in the terminology and system information area with 7.61 ± 1.16. However, all mean usability evaluation scores of the assessed areas were between 6 and 9, which indicates that the usability of the application was evaluated at a good level from the patients' perspective (►Table 4). However, the patients were less satisfied with the terminology and information of the system compared with other evaluated areas, which should be taken into consideration. In this regard, considering the two components "program messages to complete user tasks" and "screen message to record necessary data" because of obtaining a lower average score from the patients' point of view compared with the other four components of this area, seems necessary.

Discussion

The BCRL app was developed based on two main stages and its usability was evaluated by the patients. In the first stage, using a literature review and needs assessment survey from experts and the patients, the content and functions of the app were determined. In the second stage, design and translation of pre-development output into an android-based mobile application was done. In the third stage, the usability of the app was evaluated from the patient's perspective.

Management of the QOL of patients with lymphedema, as a chronic progressive debilitating condition, following breast cancer plays a key role in managing care and reducing its consequences,[14] which can improve the clinical outcomes and QOL of the patients.[53] In the designed application, lifestyle, diet, smoking, exercise, and daily activities management functions enable patients to promote self-care management, which leads to improved care management and QOL. Similar to our findings, Temur and Kapucu[24] revealed that exercise and massage activities through a self-care program have a positive effect on preventing the progression of lymphedema after breast cancer treatment. Furthermore, the sections of the designed app in our study were similar to the functions in the study by Taheri et al[54] for the self-care of cancer patients undergoing chemotherapy and contained clinical information, lifestyle, and medication reminders sections.

Shahsavari et al[55] found that self-care educational programs improved the QOL of breast cancer patients. In addition, Temur and Kapucu.[24] showed that 61% of the patients with lymphedema who did not receive the necessary self-care training experienced disease progression, and patients who received training had higher QOL and fewer symptoms, which indicate the educational needs of the patients and the importance of self-care education. The present study answered many educational needs related to physical and mental self-care. Patient education is one of the most effective principles for the management of BCRL.[14] Educating patients by health care professionals can increase the effectiveness of self-care management[56,57] and decrease the economic, social, and psychological consequences of BCRL.[58] Patient education function included in the developed application empowers the patients to perform exercise and daily activities and control the BCRL symptoms. Functions of our developed app are relatively similar to the app designed by Hou et al,[21] which has treatment, physical activity, diet, emotional support, health records, social resources, experience sharing, and expert consultation sections.

Ostby and Armer[59] found that complex congestive therapy, symptom burden, right time for treatment, and lack of patient education and support could seriously affect their self-management of BCRL condition. The drug management functionality of the designed application encourages the patients to adhere to the drug consumption and thus reduces the burden of psychological and physiological symptoms of BCRL.

The results of a study conducted by Luz et al[60] showed that strengthening exercise can be performed by patients with lymphedema without worry or risk of increased upper limb volume. In the self-care application of BCRL, some exercises are also presented as training examples, which help the patients through providing examples and reminding them of performing the exercises. Shaw et al[61] compared the effectiveness of two types of dietary interventions on arm volume in patients with lymphedema after breast cancer

Table 3 Frequency distribution of participants' responses about the required functions for the application

Functions needs	Respondents	Necessary		Unnecessary	
		N	%	N	%
Reminder time to take medication	Experts	28	93	2	7
	Patients	27	90	3	10
Entry of medications	Experts	28	93	2	7
	Patients	25	83	5	17
Entry of complications caused by medication	Experts	28	93	2	7
	Patients	26	87	4	13
Entry of the dose of the drug	Experts	28	93	2	7
	Patients	25	83	5	17
Display the number of times the drug is forgotten at different time intervals	Experts	28	93	2	7
	Patients	27	90	3	10
Show forgotten drug name	Experts	28	93	2	7
	Patients	25	83	5	17
Entry of the number of drugs provided	Experts	25	83	5	17
	Patients	25	83	5	17
Proper diet planning	Experts	25	83	5	17
	Patients	26	87	4	13
Entry of fluid intake	Experts	24	80	6	20
	Patients	27	90	3	10
Determine the calories of food consumed	Experts	24	80	6	20
	Patients	25	83	5	17
Entry of the amount of food consumed in each meal	Experts	23	77	7	23
	Patients	25	83	5	17
Compare the nutritional status with the set goal and show it to the patient	Experts	24	80	6	20
	Patients	27	90	3	10
Communicate the patient by contacting your doctor.	Experts	26	87	4	13
	Patients	26	87	4	13
Set an online appointment with physician	Experts	28	93	2	7
	Patients	28	93	2	7
Send entered information to the doctor	Experts	29	97	1	3
	Patients	27	90	3	10
Communicate in the form of messages and contacts with other patients	Experts	28	93	2	7
	Patients	29	97	1	3
Remind the patient time to meet with the treating physician	Experts	28	93	2	7
	Patients	28	93	2	7
Contact the pain clinic	Experts	27	90	3	10
	Patients	28	93	2	7
Plan to do regular exercise and physical activity to control illness and overcome stress	Experts	27	90	3	10
	Patients	26	87	4	13
Entry of the duration of physical activity	Experts	26	87	4	13
	Patients	27	90	3	10
Show a graph of the progress of physical activity in improving the patient's condition	Experts	25	83	5	17
	Patients	28	93	2	7

(*Continued*)

Table 3 (Continued)

Functions needs	Respondents	Necessary		Unnecessary	
		N	%	N	%
Exercise reminders	Experts	22	73	8	27
	Patients	28	93	2	7
Planning to smoking cessation	Experts	25	83	5	17
	Patients	22	73	8	27
Entry of the number of cigarettes consumed per day	Experts	25	83	5	17
	Patients	22	73	8	27
Displays the number of cigarettes consumed at different time intervals	Experts	24	80	6	20
	Patients	23	77	7	23
Compare the number of consumed cigarettes in each month with the previous months	Experts	24	80	6	20
	Patients	27	90	3	10
Reminders to perform diagnostic tests and imaging	Experts	22	73	8	27
	Patients	27	90	3	10
Registration of complications and problems associated with lymphedema	Experts	22	73	8	27
	Patients	21	70	9	30
Search for educational content related to lymphedema	Experts	26	87	4	13
	Patients	20	67	10	33
Provide addresses and contact telephone numbers of specialist physicians	Experts	26	87	4	13
	Patients	22	73	8	27
Search for doctors' addresses	Experts	26	87	4	13
	Patients	20	67	10	33
Search for medical centers	Experts	26	87	4	13
	Patients	21	70	9	30
Send hopeful and reassuring sentences as a message to the patient's cell phone	Experts	**26**	**87**	**4**	**13**
	Patients	**16**	**53**	**14**	**47**
Technical support	Experts	27	90	3	10
	Patients	22	73	8	27
Use the application usage guide	Experts	27	90	3	10
	Patients	24	80	6	20
Introducing different types of diets	*Experts*	**23**	**77**	**7**	**23**
	Patients	**27**	**90**	**3**	**10**

Table 4 Usability evaluation of the app by patients

Row	Assessment areas	Mean ± SD
1	Overall reactions to the app	8.36 ± 0.63
2	Screen design and layout	8.5 ± 0.56
3	Terminology and systems information	7.61 ± 1.16
4	Learning	8.32 ± 0.79
5	System capabilities	8.5 ± 0.55
6	Usability and user interface	8.2 ± 0.48

Abbreviation: SD, standard deviation.
Note: All questions were scored in a range of 0 to 9.

treatment and found that weight loss by any method could be useful in treating lymphedema associated with breast cancer. The developed application also included nutrition tips and tutorials and diet planning. Thus, the application has the potential to relieve the symptoms of the BCRL condition. Similar to the app designed by Lozano-Lozano et al,[50] which focused on monitoring healthy lifestyles in cancer survivors based on the two functions of diet and physical activity, the app designed in the present study also has nutrition management and exercise management functions which can lead to a healthier lifestyle for patients and prevent the progression of disease symptoms. However, the app designed in our study has more functions than the app designed by

Lozano-Lozano et al. This difference can be explained through the purpose of designing apps in these studies.

Fu et al.[15] found that mobile-based systems have the potential to manage the pain and symptoms associated with lymphedema. The results of the present study revealed that the patients considered the app as a valuable and satisfactory tool for supporting self-care management of BCRL. However, complete evaluation of the effectiveness of app in the self-care management of BCRL symptoms requires the implementation of the app in a wider community of patients over a longer time.

Usability evaluation showed that the application was good from the patients' perspective. Our findings were in line with previous studies that have been conducted on the design and development of breast cancer-related self-care management applications.[15,46,54,62] Adopting a socio-technical approach could increase the usability and acceptance of mhealth applications because a techno-centric factor without consideration of socio-technical factors could negatively affect users' engagement.[47,63] Considering human factors in the designing of health information technology (IT) can help understand the needs of stakeholders and design health IT interfaces that are customized to their needs and therefore play a pivotal role in the more usable and safer health IT.[41,63–66] Furthermore, the ergonomic factor in the design of mobile-based applications also has a vital influence on the practical convenience of use and acceptance of applications by users.[63,67]

Study Limitations

Lymphedema can develop following treatment for several cancers such as breast, head and neck, and female genital cancers. This study focused solely on designing an application to manage the symptoms associated with breast cancer-related lymphedema. Thus, the findings can be generalizable only to the target community. The lack of comparison between the designed app and the applications available in the Play Store and the App Store is one of the other limitations of this study because if there is such a comparison, it could help to improve the usefulness of the designed app. In addition, in this study, application usability evaluation was performed by a limited number of patients. It is suggested that the usability of the application be evaluated in a larger sample of patients with BCRL so that a more comprehensive and accurate judgment can be made about its usability.

Conclusion

The BCRL app provides educational, nutritional, drug use, exercise management, and lifestyle functions for patients with BCRL and has the potential to improve patients' lifestyle, education, symptom management, and the continuation of self-care and treatment measures, access to information to enhance self-care management and promote the QOL of Iranian patients with BCRL. The mobile app was found to be appropriate in terms of the overall reactions to the app, screen design and layout, terminology and system information, learning, app capabilities, and usability and

user interface from the end users' (patients') perspective. It is suggested that further studies be performed to confirm the effectiveness and identify the clinical significance of the app.

Clinical Relevance Statement

Breast cancer is the most common life-threatening cancer in females with increasing incidence and mortality worldwide. Lymphedema is one of the most common side effects of breast cancer treatment. Mobile-based self-care management applications make it possible to perform routine assessments and effective interventions that are key to self-care to improve the management of lymphedema symptoms. The developed mobile app for BCRL in Iran is recognized as an appropriate tool for improving the patients' lifestyle and education and self-management of BCRL symptoms according to its usability evaluation from the patients' perspective.

Multiple Choice Questions

1. Which of the following users is the main user of BCRL application?
   a. Patients.
   b. Physicians.
   c. Policy-makers.
   d. Patients' family.

   Correct Answer: The correct answer is option a. The main users of the BCRL application are patients with BCRL condition.

2. What is the main application of the BCRL application?
   a. Communication with caregivers.
   b. Perform sports movements.
   c. Weight control.
   d. Self-care management.

   Correct Answer: The correct answer is option d. The main purpose of development of the BCRL application is self-care management in patients with BCRL condition.

3. Application of BCRL is designed to manage the symptoms of which of the following cancers?
   a. Lung cancer.
   b. Lymph node cancer.
   c. Breast cancer.
   d. Skin cancer.

   Correct Answer: The correct answer is option c. The BCRL application was designed to improve the management of lymphedema symptoms of breast cancer treatment.

Protection of Human and Animal Subjects

The present study was reviewed and approved by Ethics Committee of Iran University of Medical Sciences (ethical code: IR.IUMS.REC.1399.046). All participants provided written informed consent for this study. Research Ethics Committees Certificate available from: https://ethics.

research.ac.ir/ProposalCertificateEn.php?id=124445&-Print=true&NoPrintHeader=true&NoPrintFooter=-true&NoPrintPageBorder=true&LetterPrint=true

Author Contributions

M.A. and S.N.Sh. conceived the study. J.A. and S.N.Sh. wrote the first and final draft of the manuscript. M.A. and M.Kh. contributed substantially to the manuscript. All authors participated in the design of the study, revised the manuscript critically for intellectual content, and have read and approved the final manuscript.

Availability of Data and Materials

The data used and analyzed during the current study are not publicly available due to Iran University of Medical Sciences policy but are available from the corresponding author on reasonable request.

Conflict of Interest

None declared.

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