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Development and Evaluation of a Self-Care Smartphone Application for Cirrhotic Patients

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Abstract

Background: It is generally accepted that cirrhosis is a global health problem, and cirrhotic patients need to perform self-care activities. Smartphone applications are effective tools for the self-management education of diseases.

Aim: This study aimed to develop a self-care smartphone application for cirrhotic patients.

Method: This study was conducted to develop a mobile application to provide cirrhotic patients with self-care management. The application was designed using two educational models of Analysis, Design, Development, Implementation, and Evaluation as well as Driscoll and Alexander models. Its efficiency was evaluated by 5 software technicians and 74 cirrhotic patients. The tools utilized in this study included heuristics and the Mobile Application Rating Scales. The evaluation results were employed to modify the application and prepare a final version.

Results: An android application was developed under the name of "My Liver" in this study. The results of experts' evaluation included 12 corrective suggestions that were applied to the development of the application. According to the participants' evaluation, aesthetics (68.60%) and engagement (71.36%) received the first- and second-lowest scores, respectively. However, the items that obtained the highest scores included the adaptation of content to the user requirements, ease of use, suitable quality and quantity of information, the presence of visual information, validity and acceptability, and evidence-based content. The star grading indicated a relatively high quality of this application.

Implications for Practice: Smartphone applications can be useful tools for cirrhotic patients to perform self-care without the direct presence of the nurse.

Keywords: Application, Liver cirrhosis, Self-care, Smartphone

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Introduction

The liver disease accounts for approximately 2 million deaths per year worldwide, 1 million due to complications of cirrhosis and 1 million due to viral hepatitis and hepatocellular carcinoma. Cirrhosis is currently the 11th most common cause of death globally and liver cancer is the 16th leading cause of death. In total, they account for 3.5% of all deaths worldwide (1). Unfortunately, this disease is among the five major causes of death resulted from digestive diseases in Iran due to high incidence of hepatitis B (2, 3). Patients with cirrhosis have different limitations on their food diet. They also have to use multiple medications, do frequent laboratory tests, and visit their physicians frequently. In addition, patients with decompensated cirrhosis frequently suffer from debilitating complications (4), such as ascites, hepatic encephalopathy, bleeding from varicose veins, and liver cancer (5), which affect their quality of life and everyday activities (6).

Cirrhosis in the compensated phase (i.e., no symptom or minimal symptoms) has a 5-year survival rate of about 91%. On the contrary, it has a survival rate of less than 50% in the decompensated phase with encephalopathy, bleeding from esophageal varices, or ascites (7). In general, 90% of chronic illness care is provided outside clinical visits (4), whereas these patients lack sufficient knowledge to effectively manage their illness (8). In this regard, the successful management of cirrhosis requires training these patients.

Smartphones are effective tools for healthcare interventions, especially the self-management education of diseases (9). It is expected that 1.6 billion people, approximately 70% of the world's population, will use smartphones and at least 50% of smartphone users will use health-related mobile applications by 2020 (9). Health-related smartphone applications have been recently used to provide self-care in various diseases (10); however, a few of them are related to self-care education in cirrhotic patients. Accordingly, there are three studies by Jeon. et al (2016) on designing and validating a Korean self-care smartphone program and its application in the self-care of patients with non-cirrhosis hepatitis B (9).

Since the cirrhotic patients were excluded from this study, the research findings could not be utilized for cirrhotic patients. In the same line, Jobrani et al. conducted a study to design and validate a self-care smartphone application in patients with valve heart disease. It should be noted that those applications were produced only for physicians and nurses, and none of them addressed patient education and self-care promotion. Moreover, the applications were rarely used probably due to the lack of evidence-based knowledge and their insufficient features. Therefore, the present study aimed to design a smartphone application that enabled cirrhotic patients to increase their self-care abilities by improving their knowledge and self-care resources.

Methods

This methodological study was conducted to develop a mobile application to help cirrhotic patients to perform self-care activities.

The study protocol was approved by the Ethics Committee of Mashhad University of Medical Sciences, Mashhad, Iran. After obtaining the required permission, the application was designed and evaluated using the help of hospitalized patients in Qaem and Imam Reza hospitals, Mashhad, Iran, from 2017 to 2018.

Development process

The application design process was performed using two educational design models, namely Analysis, Design, Development, Implementation, and Evaluation (ADDIE) (11) as well as Driscoll and Alexander models (12). The ADDIE model has a structure that flows in one direction and does not allow revisiting previous stages. On the other hand, the Driscoll and Alexander model takes the characteristics of an Internet-based design into consideration, allows other stages to be checked at each stage, and emphasizes modifiability when necessary. Therefore, our model was constructed with five developmental stages so that the stages could be checked and modified at each stage if necessary (13).

1- Analysis

The cirrhotic patients' application needs were analyzed in the analysis step that provided search and analysis of other applications and evidence-based documents for organizing the application content.

To find the available liver cirrhosis applications, a search was conducted in Google Play and Apple App Store in August 2017 using the keywords, such as "Liver Cirrhosis", "Cirrhosis", and "Liver Disease". There were 56 liver-related applications (in English and Arabic) among which only 6 cases were related to liver cirrhosis, and none of them was in Persian.

The assessment of the patients' needs was performed by reviewing the valid studies conducted on the analysis of cirrhotic patients' educational needs (4, 5, 14, 15). The content was organized according to the desk study, research papers, and authoritative resources of internal and external patient training. Moreover, the searched databases included ProQuest, Science direct, Clinical Key, Up to date, Medline Plus, SCOPUS, SID, Magiran, Iranmedex, and Google Scholar. The search process was conducted using the keywords, including "Cirrhosis", "Liver Disease", "Educational Software", "Education", and "Smartphone", regarding the limitations of empirical research of the last 15 years from August to October 2017.

In total, about 198 studies were found; however, only 18 articles were about self-care education in cirrhotic patients. Subsequently, the content of each article was analyzed line by line. The extracted data were categorized according to the main topics of cirrhotic patients' education contents that were situated in the application.

Eventually, the extracted healthcare needs from the literature were listed and provided to 74 cirrhotic patients who were selected by conventional sampling. They were then requested to prioritize their needs in the list to develop and prepare the content of the application.

2- Design

In the design step, functional requirements, necessary user interface screens, and software database design were created in a three-step process.

During the functional design, syllabuses were first designed based on the results of suggestions for patient healthcare needs and related studies, and then the content of each syllabus was organized through a review of texts.

The interface design is a process through which the software is installed on the patients' smartphones to run the application, and patients complete their registration while connecting to the Internet (Figure 1).

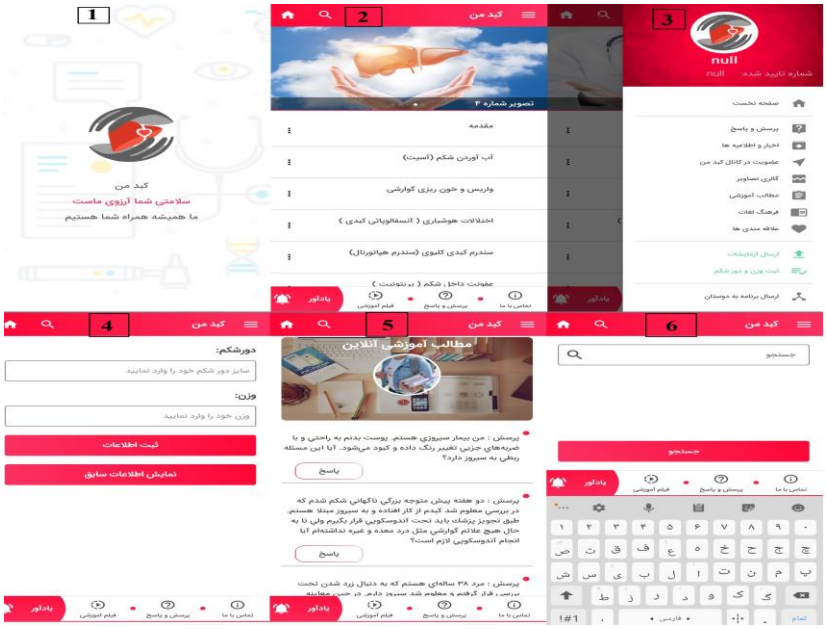

Figure 1. "My liver" software screen on smartphone application
Start screen (1.1),
Main Screen (1.2),
Main screen drop-down menu (1.3),
Weight and waist circumference recording menu (1.4),
Common frequently asked questions menu (1.5),
Search menu (1.6)

Following that, their phones are registered in the server and their registration IDs are saved in the liver cirrhosis software server. My Structured Query Language (SQL), which is an open-source database management system and uses a popular computer language (i.e., SQL) and covers android, was used to design a database considering android software as the operating system.

3- Development

A database and a real application were developed and designed in the development step. The application development was conducted from November 27, 2017, to March 1, 2018. The application was designed under the name of "My Liver".

4- Implementation

The implementation step was, in fact, an attempt to develop an application for self-care management in cirrhotic patients. The necessary operating environment was from the minimum version of android (i.e., 2.2) up to android 4.4. The original version was distributed among five software development experts and 74 cirrhotic patients who were asked to test the application for a certain period.

5- Evaluation

Finally, the evaluation step was conducted in two sections by experts and participants as follows.

During the evaluation process by experts, the application was introduced to five experts who had experience in the application development and had master's degrees or higher in medical informatics, computer, or information technology (16) disciplines. They were then requested to use the application. The data were collected using a questionnaire after utilizing the application. Moreover, the experts employed heuristics to assess the application. This tool was a combination of eight questions about mobile application evaluation principles by Bertini et al., as well as Nielsen's five-point Severity Ranking Scale. The eight heuristics were as follows: 1) The mobile device ability to be lost/found and the system status visibility, 2) the coordination of system and the real world, 3) mapping and consistency, 4) suitable ergonomics and minimalism design, 5) ease of input and the ability to read and review the screen, 6) flexibility, usefulness, and customization, 7) aesthetics, privacy, and social contracts, and 8) management of realistic errors.

During the evaluation by participants, the Mobile Application Rating Scale (MARS) (17), which was designed by Stoyanov et al.,(18) was used to evaluate the efficiency of application in cirrhotic patients. The MARS consisted of 23 questions in five domains, namely Engagement, Functionality, Aesthetics, Information, and Subjective quality. The items are scored based on a five-point Likert scale.

In total, 74 cirrhotic patients were selected using the convenience sampling method from those referred to Imam Reza and Qaem hospitals, Mashhad, Iran. The inclusion criteria were: 1) a definitive diagnosis of liver cirrhosis in steps A and B according to CHILD classification, 2) ages between 20 and 65 years, 3) lack of participation in previous or current self-care program, and 4) access to android smartphone and the ability to use the application.

On the other hand, the patients who were unwilling to continue the study, and those how were candidate for transplantation and suffered from exacerbation of disease in a way that they were unable to perform self-care activities, as well as the dead patients were excluded from the study.

Initially, the research objectives and procedures were explained to the patients. Moreover, they were all informed of the confidentiality of their personal information and the right to withdraw from the study at any time. It should be noted that written informed consent was obtained from the participants, and they were asked to use the application and answer the survey questions. The application performance was evaluated after providing the experts and cirrhotic patients with the original version of the application. The results of this evaluation were used to modify the software and prepare a final version.

Results

The results of the present study led to the production of an android application with a designed screen and the help of Microsoft 2013. The home screen involved 24 menus, namely Introduction; Ascites; Varicose veins and Gastrointestinal bleeding; Liver encephalopathy; Hepato-Renal syndrome; Peritonitis; Nutrition; Drug therapy; activities and rest; sexual activity; Skincare; Self-care while facing complications; Prevention of infection; Prevention of liver cancer; Liver transplantation; Liver

ultrasound; Computerized liver imaging; Liver scan; Liver fibro scan; Liver biopsy; Reminder; Educational videos; Questions and Answers (Q&A); Contact Us; Newsletter; Membership in My Liver channel; Useful content; Vocabulary; Posting tests; Sending weight and abdominal circumference; and Interests (Figure 1, Table 1)

Furthermore, the results obtained from the heuristic evaluation of the application by experts indicated that if any of them gave scores of 3 to 4 to each relevant menu, they helped improve the system performance. In this regard, 12 correction suggestions, which received scores of 3 or 4 from the evaluators' suggestions, were selected for correlation of system, and then the modifications were carried out in this study.

Table 2 presents the results where ΣA refers to the total number of corrective suggestions for each

Table 1. Demographic characteristics of the participants

Variable	Results (n=74)	
Age	M±SD	
	48.8± 12.6	
Gender	n (%)	
	Male	47 (63.51)
	Female	27(36.4)
Marital status	n (%)	
	Married	49(66.21)
	Single	5 (6,75)
	Divorced	8 (10.81)
	Spouse death	12(16.21)
Education level	n (%)	
	Elementary	58 (78.37)
	Diploma	11 (14.86)
	University	5 (6.7)
Disease duration time	M±SD	
	3±3.44	

Table 2. Distribution of Frequency and Severity Scores by Heuristics

Heuristic Principle	ΣA[1]	ΣB[2]	Severity ranking scale									
			0		1		2		3		4	
			A	B	A	B	A	B	A	B	A	B
1-The mobile device ability to be lost/found and the system status visibility	7	5	-	-	2	2	2	1	3	2	-	-
2-The coordination of system and the real world	7	6	-	-	1	1	4	3	2	2	-	-
3-Mapping and consistency	3	2	1	1	-	-	2	1	-	-	-	-
4-Suitable ergonomics and minimalism design	7	3	5	2	2	1	-	-	-	-	-	-
5-Ease of input and the ability to read and review the screen	9	4	3	1	2	1	4	2	-	-	-	-
6-Flexibility, usefulness, and customization	9	7	-	-	1	1	1	1	4	3	3	2
7-Aesthetics, privacy and social contracts	6	3	4	1	2	2	-	-	-	-	-	-
8-Management of realistic errors	7	4	-	-	-	-	2	1	-	-	5	3
Total	55	34	13	5	10	8	15	9	9	7	8	5

1-A=Number of comments; 2-B=Number of kinds of comments (Number of comments with the removal of duplicates)

heuristic item (n=54). In addition, ΣB is the same as ΣA; however, it was classified by eliminating duplicate suggestions, which included 34 different suggestions by combining duplicate suggestions and matching them with the severity scale.

The evaluation was conducted by participants with a mean age of 46.2 years using the MARS that included 23 questions to assess the engagement, performance, aesthetics, information, and subjective quality of the application. Totally, 20 questions (87%) received scores above 3.5. According to the results obtained from the evaluation of scores in five subgroups, the aesthetics with a score of 10.29 (68.60%), and engagement with a score of 17.84 (71.36%) obtained the first and second-lowest scores, respectively (Table 3).

Furthermore, out of the measured scores by the MARS, Item 1 (i.e., the entertainment as the subset of engagement) received the lowest score. In the present study, the star rate (item 23) was 3.97 that was equivalent to a score of 79 out of 100. Therefore, it seems that patients considered the developed application with relatively high quality. Regarding the efficiency evaluation by the participants, they were asked to write their suggestions or recommendations freely for application modification. Out of all recommendations (n=6), 4 suggestions were applied to improve the system.

Table 3. Mean and standard deviation results obtained form mobile application rating scales

Subscales	Number	Item	Mean	SD
Engagement	1	Entertainment	2.10	0.41
	2	Interest	3.89	0.75
	3	Customization	4.03	0.21
	4	Interactivity	3.98	0.83
	5	Target group	3.84	0.47
Functionality	6	Performance	4.61	0.78
	7	Ease of use	4.02	0.68
	8	Navigation	4.50	0.59
	9	Gestural design	3.90	1.14
Aesthetics	10	Layout	3.63	0.47
	11	Graphics	3.42	0.59
	12	Visual appeal: How well does the app look?	3.24	0.45
Information	13	Accuracy of app description	4.05	0.63
	14	Goals	3.98	1.10
	15	Quality of information	4.66	0.43
	16	Quantity of information	4.02	0.98
	17	Visual information	3.94	0.10
	18	Credibility	4.63	0.21
	19	Evidence base	4.41	0
Subjective quality	20	Would you recommend this app?	4.11	0.40
	21	How many times do you think you would use this app?	4.56	0.84
	22	Would you pay for this app?	4.13	0.82
	23	What is your overall star rating of the app?	3.97	0.64
		Total	3.98	0.59

Subscales	Number of Items	Actual Scores(A)		Possible Scores(B)	Percentage of A/B Scores
		Mean	SD	Mean	
Engagement	5	17.84	2.67	25	71.36
Functionality	4	17.03	3.19	20	85.15
Aesthetics	3	10.29	1.48	15	68.60
Information	7	29.69	3.45	35	84.82
Subjective quality	4	16.77	2.7	20	77.45
Total	23	91.62	13.49	115	79.67

Discussion

In the present study, an android smartphone application under the name of "My Liver" was designed for cirrhotic patients with different sections. The results obtained from the expert evaluation indicated 12 corrected suggestions with the scores of greater than 3 that needed to be corrected followed by making necessary corrections in the software. Moreover, according to the results of the evaluation by the participants, aesthetics and engagement received the first and second-lowest scores, respectively, indicating the need for necessary changes and corrections of these sections.

Based on the obtained results, among the strengths of this application, one can name the adaptation of content with user needs, ease of use, quality and quantity of the information, the presence of visual information, validity, acceptance, and evidence-based content.

The weaknesses of the application included the lack of entertainment and visual environments as well as medium layout. Several participants were dissatisfied with the application due to the lack of the IOS version and the impossibility to install it on phones with this operating system.

The scientifically-developed applications in Iran for those who need the medical care include educational applications for preventing complications of chemotherapy in cancer patients (19), educational software for patients with acute myocardial infarction (20), and self-care education software for patients undergoing heart valve replacement (21). The problems that most of these applications share are the lack of interaction and dynamism, the impossibility of patient communication with the therapy team, and low graphics.

For instance, the compensated self-care education (2016) application for patients who underwent heart valve replacement mainly acts as a reminder for patients, and they are not active in the learning process. In addition, there is no menu for saving the patient test results or the possibility to make relationships with the healthcare team. On the other hand, in the application designed in the present study, it was attempted to provide the patients with a reminder menu and allow interactions between the patients and the research team to exchange ideas. With the help of the test reminder menu in the application, the patients are able to send the test results to the healthcare team and receive feedback.

In the same line, G application (2016) was developed in Korea to evaluate the self-care performance in patients with chronic hepatitis B. The great strengths of this application include the presence of a coherent content for patient education, the patient ability to communicate with the researcher, the ability to examine patients in terms of software usage, the existence of alarms for patient reminders and tracks. It is worth mentioning that these strengths were used in the preparation of the application in the present study.

However, its weaknesses included the lack of attention to patients' psychological aspects and quality of life, the elimination of cirrhotic patients from the target group, and lack of compatibility with the Iranian culture and language which made it difficult to be used in Iran for patients with severe liver cirrhosis.

In this study, it was attempted to overcome all these problems, and ultimately the patients were provided with an application in a native language (i.e., Persian) by taking into account all aspects of health in cirrhotic patients. The analysis was performed by the literature review and analysis of relevant applications in the analysis step of the current application (22). The results obtained from the analysis facilitated the planning process to achieve the necessary content and performance in order to reach the purpose of the software.

Implications for Practice

A smartphone application was developed in this study for cirrhotic patients based on their needs so that they could help themselves with self-care. The application design process followed through the analysis, design, development, implementation, and evaluation steps with the help of a systematic development process. The system completion was done by identifying its problems through evaluating its usefulness in collaboration with experts as well as real patients. Therefore, it is expected that it will be useful in performing self-care management.

One of the limitations of the present study is the applicability of this program under the android operating system; accordingly, it cannot run in all smartphones. Therefore, more studies should be conducted on other operating systems, especially IOS smartphones, to make it applicable for more patients. Based on the results of the present study, further studies are suggested conducting more investigations on the effects of developed smartphone applications on disease-related knowledge, self-

care, and self-care performance in cirrhotic patients. "My Liver" application can be proposed with the help of Gastroenterology Nurses to guide the patients continuously. The utilization of a self-care application is the best way for cirrhotic patients to take care of themselves according to their own needs and requirements.

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Conflicts of Interest
There is no conflict of interest in this study.

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