International Journal of Multimedia and Ubiquitous Engineering
Vol.11, No.12 (2016), pp.341-350
http://dx.doi.org/10.14257/ijmue.2016.11.12.31

Development of a Smartphone Application for Self-Care Performance of Patients with Chronic Hepatitis B

Jaehee Jeon[1] and Kyunghee Kim[2*]

[1]*Faculty of Nursing, Semyung University, 65 Semyung-ro, Jecheon, Chungbuk, 390-711, Korea*
[2]*Faculty of Red Cross College of Nursing, Chng-Ang University 221 Heukseok-dong, Dongjak-gu, Seoul, 156-756, Korea*
[1]*E-mail anesjjh@naver.com,* [2]*E-mail kyung@cau.ac.kr*

Abstract

This study developed a smartphone application (app), based on user demand, for the self-care performance of patients with chronic Hepatitis B. The smartphone app was developed in five stages. In the analysis stage, we surveyed the demand for the app among 187 patients with chronic Hepatitis B, analyzed several other apps, and conducted a literature review. In the design stage, the app's purpose was established, and the necessary functions, system interface, database, and screens were designed. In the development stage, the app was developed. In the implementation stage, the master version of the app was used by four specialists and five participants with chronic Hepatitis B. In the evaluation stage, we conducted a heuristic evaluation and a mobile app rating scale evaluation, with these nine subjects. As a result of the evaluations, 19 aspects of the system were modified to further improve the app. This smartphone app is expected to be helpful in performing self-care, serve as a disease-related knowledge source, and promote self-efficacy in chronic Hepatitis B patients.

Keywords*: Hepatitis B, Self-Care, Smartphone, Application, Development*

1. Introduction

Congratulations! Your paper has been accepted for journal publication. Please follow the steps outlined below when submitting your final draft to the SERSC Press. These guidelines include complete descriptions of the fonts, spacing, and related information for producing your proceedings manuscripts. Please follow them and if you have any questions, direct them to the production editor in charge of your journal at the SERSC, sersc@sersc.org.

One-fourth of chronic Hepatitis B patients know that they are infected [1], but in many cases, they neither get regular hospital checkups nor perform self-care with the excuses of having no symptoms or being too busy [2]. Approximately 20-30% of all chronic Hepatitis B patients die due to the progression of the disease to more serious diseases such as liver cirrhosis and hepatocellular carcinoma [1]. Therefore, chronic Hepatitis B patients can prevent progression to severe liver diseases by actively performing self-care such as regular hospital checkups and the management of their daily lives [3].

Recently, health-related smartphone apps have been used to help with self-care in various diseases [4], and for management of chronic noninfectious diseases worldwide [5]. There were 23 smartphone apps related to viral Hepatitis worldwide, of which 20 were Hepatitis B-related. Due to the low ratings of the developed apps, however, most of their usage is low [6]. There are hardly any apps developed for chronic Hepatitis B in South Korea. In case of chronic Hepatitis B patients, since vertical transmission from mother to child is frequent, age of onset is low, and lifetime self-care due to the

ISSN: 1975-0080 IJMUE

characteristics of the disease is required [1], the efficiency will be high if a smartphone app for patient management is developed.

Knowledge of the disease and self-efficacy have been identified as the two factors that influence the self-care performance of Hepatitis B patients [2, 7]. Therefore, improvement in these two factors is needed in order to improve self-care performance [8]. This study has developed a smartphone app that will enable chronic Hepatitis B patients to perform self-care by improving their knowledge and self-efficacy of the disease.

In the remainder of this paper, we use the word 'app' to refer to the 'smartphone app', for the sake of brevity.

2. Development Process

The app was developed by using both the ADDIE instructional design model [9] and the Driscoll and Alexander model [10]. The ADDIE model is composed of five stages of analysis, design, development, implementation, and evaluation. It 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 Internet-based design into consideration, allows checks of other stages at each stage and emphasizes modifiability when necessary. Therefore, our model was constructed with five developmental stages so that at each stage, the stages can be checked and modified if necessary.

2.1. Analysis

The app was developed by using both the ADDIE instructional design model [9] and the Driscoll and Alexander model [10]. The ADDIE model is composed of five stages of analysis, design, development, implementation, and evaluation. It 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 Internet-based design into consideration, allows checks of other stages at each stage and emphasizes modifiability when necessary. Therefore, our model was constructed with five developmental stages so that at each stage, the stages can be checked and modified if necessary.

In the analysis stage, the requirements of the app for chronic Hepatitis B patients were analyzed, other apps were examined, and a review was conducted of evidence-based literature, to determine the organization of the content of the app.

Need assessments were carried out on 187 chronic Hepatitis B patients to determine app usage and content demand. The sources of information related to chronic Hepatitis B were as follows: Internet (41.3%), medical team (23.8%), TV (15.6%), and smartphone (6.2%). The reasons for not obtaining information using a smartphone were 'useful apps are not available' (75.9%). On the question of intent to use the app once it is developed, participants responded 'will actively use it' (59.9%) and 'will use when needed' (33.2%). The functions needed when the app is developed include 'disease-related knowledge delivery' (27.1%), 'medication calendar' (16.8%), 'references to information' (15.5%), and 'record test results' (14.6%) [11].

In addition, to search for existing apps related to chronic Hepatitis B, a search was conducted in Google Play Store and Apple App Store with the keywords "Hepatitis B", "Hepatitis", and "HBV". A total of 12 apps (in English) related to Hepatitis B were found. The contents of 11 apps included disease information and four apps included additional functions such as calendar or game, Hepatitis risk calculator, monitor, question and answer, and chatting [11].

Domestic and foreign research articles were searched for content organization of the app. These included databases such as the Ovid-MEDLINE (1966 ~ August 2014) and Ovid EMBASE (1950 ~ August 2014), Cochrane CENTRAL, KoreaMed, KMbase (Korea Medical database), KISS (http://kiss.kstudy.com), KISTI (http://society.kisti.re.kr), RISS, PubMed, and the Korean Association for the Study of the

Liver (http://www.kasl.org/). The detailed areas of disease-related knowledge of chronic Hepatitis B, in both domestic and foreign literature [1, 3], were classified into nine areas, which included anatomical structure and function of the liver, overview and causes, pathophysiology, symptoms, infection route, diagnosis, treatment, daily living and dietary habits, and vaccination.

2.2. Design

Functional Design

Detailed items to be organized to accomplish improvements in self-care performance, which was the ultimate goal of the app, were organized into regular checkup, medication, diet, drinking, exercise, weight, and view results, focusing on lifestyle habits and eating habits as confirmed through the review of literature.

System Interface Design

The system interface to implement the app was as follows. Once the app is downloaded using the user's smartphone and signup is complete, the phone is registered on the company server. In addition, the signup ID is saved in the chronic Hepatitis B app server.

Database Design

Android was the development Operating System (OS) of the app. Therefore, MYSQL, an open-source relational database management system using SQL (Structured Query Language) and included in Android, was used in designing the database. The relationship between the functional units table within the database was represented by an entity-relationship (ER) diagram.

2.3. Development

System Development Environment

For the app development, Android SDK 4.4.2, an Android development platform, JDK (Java development kit) 1.7.0, a Java development tool, and Eclipse, an open-source interactive development environment (IDE), were used.

Database Development

A registration interface that links input data and the SQL database with a calendar class was designed and developed. In addition, a module that outputs 3D graphs and tables, and was designed by analyzing the database collected from personal smartphones, was developed.

After the database was created, many tables were created within the database. Through such processing, 15 databases and 20 tables within the app were generated (*e.g.*, Figure 1. Database for Self-Care System of Smartphone App).

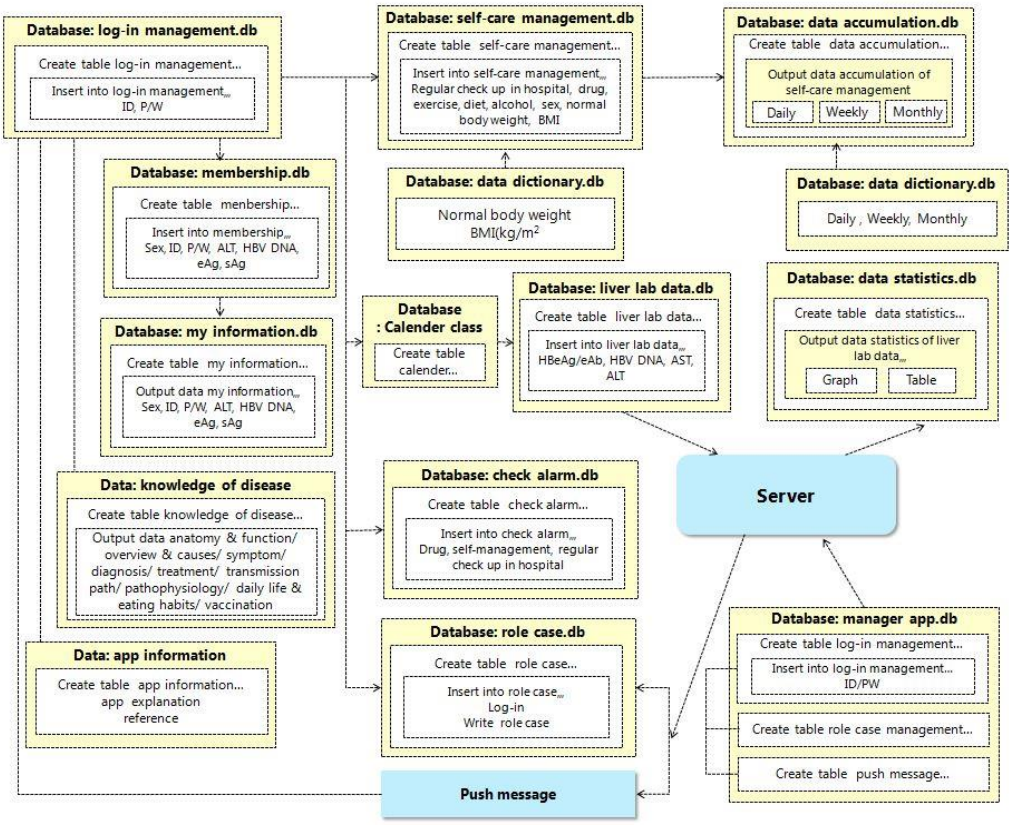


Figure 1. Database for Self-Care System of Smartphone App

User-interface Screen

The developed app was named as 'Hepatitis B self-care'. Three of the user-interface screens are shown in Figure (*e.g.*, Figure 2. Screen on Smartphone App). The main screen is organized into eight areas: self-care, disease-related knowledge, statistics, record liver numbers, my information, notices, role-case, and app information.

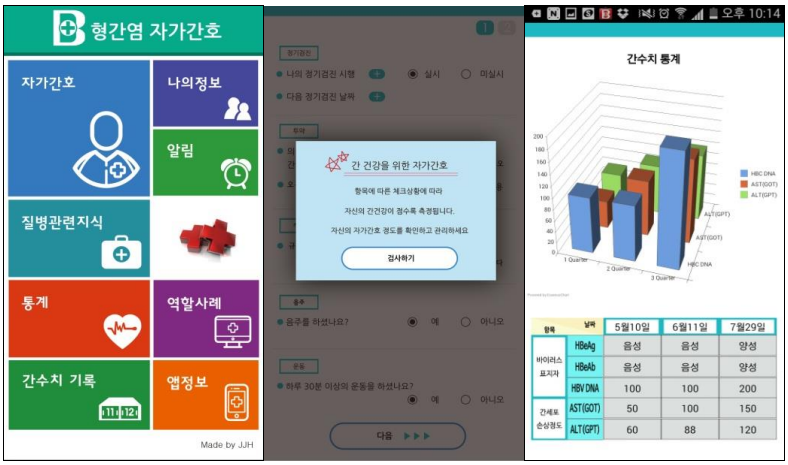
'Self-care' menu consists of a total of eight items in six areas: regular checkup, medication, diet, drinking, exercise, and body weight. When each item is measured, a pre-set scoring criterion is applied to it and the results are shown as high, middle, and low. The measured results can be saved and accumulated so that the measured self-care scores can be checked by day, week, and month.

'Disease-related knowledge' menu is divided into a total of nine areas. Theoretical explanations (with references) are provided for each area.

'Liver lab data record' menu is displayed by touching the test date. The liver lab data are recorded for HBeAg (e antigen)/ eAb (e antibody) and HBV DNA as virus markers, and AST (GOT) and ALT (GPT) as degree of hepatocellular injury. This data can be queried in the 'Statistics' area of the main screen.

In 'Notice' menu, alarms can be set up for a total of three items including medication, self-care, and regular checkup.

In the 'role-case' menu, the app can be registered and the logged-in users can post or read messages.



(a) (b) (c)

Figure 2. Screen on Smartphone App: (a) Main Screen, (b) Self-care Screen, and (c) Statistics Screen

2.4. Implementation

This was the stage of actually trying out the developed app for performing self-care of chronic Hepatitis B patients. The required operating environment ranged from a minimum of Android version 2.2 to a maximum of Android version 4.4. The developed master version was distributed to four app development specialists and five chronic Hepatitis B patients, and they were asked to try out the app for a certain period of time.

2.5. Evaluation

At the evaluation stage, the usability was evaluated after the master version of the app was used by specialists and chronic Hepatitis B patients. The results of the usability evaluation were used to modify the app to create the final version.

Evaluation by Specialists

The four specialists who participated in the evaluation had experience in app development and held masters' degrees or higher in nursing informatics, medical informatics, or computer or IT related fields. They were introduced to the app and were asked to use it. Data collection for the evaluation was carried out through a survey questionnaire, after the specialists had used the app.

For evaluation by the specialists, a heuristics evaluation tool was used. This tool was a combination of eight questions of mobile heuristics evaluation principles by Bertini *et al.* [12] (who modified the ten heuristics principles developed by Nielsen [13] for mobile devices) and Nielsen's five-point Severity Ranking Scale (SRS). The eight heuristics were as follows: (i) visibility of system status and losability/findability of the mobile device, (ii) match between system and the real world, (iii) consistency and mapping, (iv) good ergonomics and minimalist design, (v) ease of input, screen readability and glanceability, (vi) flexibility, efficacy of use, and personalization, (vii) aesthetic, privacy and social conventions, and (viii) realistic error management. The Nielsen SRS (0-4) was as follows:

0: I don't agree that this is a usability problem at all
1: Cosmetic problem only. Can be fixed only if extra time is available
2: Minor usability problem. Fixing this should be given low priority
3: Major usability problem. Important to fix, so should be given high priority
4: Usability catastrophes. Imperative to fix this before product can be released.

The results of the specialists' evaluation were utilized in improving system performance if any one of the four specialists gave a severity score of 3 or 4. The results

are shown in Table (*e.g.*, Table 1. Distribution of Frequency and Severity Scores by Heuristics). The total number of modification suggestions for each heuristic item (A) was 55. A total of 30 different kinds of modification suggestions (B) were found when duplicate suggestions were combined and classified according to the severity scale. These were selected for system modification.

Table 1. Distribution of Frequency and Severity Scores by Heuristics

H. P.	A	B	Severity ranking scale									
			0		1		2		3		4	
			n	kinds	n	kinds	n	kinds	n	kinds	n	kinds
1	6	4	-	-	3	2	2	2	1	1	-	-
2	14	6	-	-	2	1	-	-	4	2	8	3
3	3	2	-	-	1	1	2	1	-	-	-	-
4	5	2	4	1	-	-	1	1	-	-	-	-
5	10	5	-	-	1	1	-	-	2	1	7	3
6	10	6	-	-	3	2	2	1	1	1	4	2
7	3	1	-	-	-	-	-	-	-	-	3	1
8	4	3	-	-	-	-	1	1	-	-	3	2
Total	55	30	4	1	10	7	8	6	8	5	25	11

H.P. = Heuristic Principle; A = Number of comments; B = Number of kinds of comments

Evaluation by Participants

The four specialists who participated in the evaluation had experience in app development and held masters' degrees or higher in nursing informatics, medical informatics, or computer or IT related fields. They were introduced to the app and were asked to use it. Data collection for the evaluation was carried out through a survey questionnaire, after the specialists had used the app.

The instrument used for usability evaluation on chronic Hepatitis B patients was the Mobile App Rating Scale (MARS) developed by Stoyanov *et al*. [14]. The MARS is composed of 23 questions in five areas: Engagement, Functionality Aesthetics, Information, and Subjective quality. The questions are on a five-point scale except for the question number 22, which is on a 3-point scale. Five chronic Hepatitis B patients among the members of a chronic Hepatitis B patient cafe who had prior experience of using apps were allowed to use our app and then asked the survey questions. The results of evaluations are shown in Table (*e.g.*, Table 2. Mean and Standard Deviation of the MARS Results).

Table 2. Mean and Standard Deviation of the MARS Results

Sub-scale	Number	Item	Mean	SD
Engagement	1	Entertainment	2.21	0.45
	2	Interest	3.03	0.84
	3	Customization	3.42	1.14
	4	Interactivity	2.23	0.84
	5	Target group	3.81	0.45
Functionality	6	Performance	3.22	0.84
	7	Ease of use	3.81	0.45
	8	Navigation	4.65	0.55

	9	Gestural design	4.27	0.84
Aesthetics	10	Layout	3.41	0.55
	11	Graphics	3.62	0.55
	12	Visual appeal: How good does the app look?	3.05	0.71
Information	13	Accuracy of app description	3.41	0.55
	14	Goals	3.85	1.30
	15	Quality of information	4.23	0.84
	16	Quantity of information	3.66	1.14
	17	Visual information	4.01	0.00
	18	Credibility	3.49	0.89
	19	Evidence base	4.02	0.00
Subjective quality	20	Would you recommend this app?	3.80	0.84
	21	How many times do you think you would use this app?	4.41	0.89
	22	Would you pay for this app?	2.20	0.84
	23	What is your overall star rating of the app?	3.82	0.71
Total			3.51	0.47

Sub-scale	Number of Items	Actual Scores(A)		Possible Scores(B)	Percentage of A/B Scores
		Mean	SD	Mean	
Engagement	5	14.41	2.41	25	57.6
Functionality	4	15.80	2.39	20	79.0
Aesthetics	3	10.05	1.22	15	66.7
Information	7	26.42	4.67	35	75.4
Subjective quality	4	13.41	2.51	18	74.4
Total	23	80.02	10.70	115	69.6

Among the scores measured by the MARS, the parts that need to be reflected in the app modification were Entertainment and Interactivity of the Engagement sub-scale, which showed the lowest scores.

At the time of usability evaluation by the participants, they were asked to freely write suggestions or recommendations for the app, and the total number of modification suggestions through the process was 11 and nine of them were reflected in the system modification.

3. Discussion

Apps developed for people in need of medical care in South Korea are hypertension management apps [15], educational apps for patients with coronary artery disease [16], and obesity management apps [17]. In the analysis stage of these apps, the analysis stopped with the review of literature and the analysis of related apps [18]. In the present study, however, a need analysis of the people who are actually going to use our app, was also performed. Such an analysis facilitated the planning of the contents and functions needed to achieve the goal of the app. In particular, the results and various opinions

obtained from the survey of the needs of patients who will be using the developed app was very helpful in the app designing stage. It is considered to be the foundation for improving the satisfaction of the target users later and the possibility of actual utilization.

Since the evaluation items based on heuristics were not divided into fine details, however, the problem of recording the same modification suggestion based on different heuristic principles from different specialists, was discovered. Therefore, an instrument composed of more detailed evaluation items is needed when the evaluation is done by specialists.

The ultimate goal of the MARS is to evaluate the quality of an app, and the quality in the present study was determined by item number 23: 'Overall, how many stars would you give for this app?' [15]. In the present study, the star grading was 3.8, which corresponds to 76 points out of 100. Therefore, it appears that the app developed in the study was evaluated as relatively high quality in the usability evaluation by patients. It is necessary, however, to have the evaluation conducted again with more patients using the same instrument since there were only five usability evaluators.

The limitation of the present study is that the app is Android-specific; it cannot be used in all smartphone models. Accordingly, further research is needed so that the app can be used in other operating systems, especially iOS-based smartphones, so that more patients can use it.

4. Conclusion

Chronic Hepatitis B patients are required to have persistent self-care in various areas throughout their lifetimes to prevent Hepatitis B from progressing into severe liver disease. Accordingly, the present study developed a smartphone app for chronic Hepatitis B patients, based on their needs, so that they can help themselves in performing self-care.

The development of the app went through analysis, design, development, implementation, and evaluation stages, and a systematic development process was followed. System completeness was increased by identifying problems through a usability evaluation involving both specialists as well as actual patients. Therefore, it is expected to be helpful in performing self-care. Based on the results of the present study, the following suggestion is made. More research is needed to confirm the effects of smartphone apps developed in the future on the disease-related knowledge, self-efficacy, and self-care performance of chronic Hepatitis B patients.

Acknowledgments

Before the beginning of the present study, approval was obtained from the Internal Review Board (C2014188(1385)). In addition, permission was obtained from the manager of the Hepatitis B patient café regarding recruitment of Hepatitis B patients who were to be participants in the user evaluations. The participants were explained the purpose and method of the research, protection of personal information, the spontaneity of participation and withdrawal, and then were asked to sign the research participation agreement. This paper is based on the first author's (unpublished) doctoral dissertation from Chung-Ang University in Korea.

References

[1] Korean Association for the Study of the Liver, Chronic Hepatitis B treatment guidelines, **(2011)**.
[2] N. B. Ha, H. N. Trinh, T. T. Nguyen, T. Leduc, C. Bui and N. B. Ha, "Prevalence, Risk Factors, and Disease Knowledge of Chronic Hepatitis B Infection in Vietnamese Americans in California", Journal of Cancer Education, http://dx.doi.org/10.1007/s13187-013-0466-0, vol. 28, no. 2, **(2013)**, pp. 319-324.
[3] A. S. Lok and B. J. McMahon, "Chronic Hepatitis B: Update 2009", Hepatology, http://dx.doi.org/10.1002/hep.23190, vol. 50, no. 3, **(2009)**, pp. 661-662.

[4] D. King, F. Greaves, C. Exeter and A. Darzi, "Gamification: Influencing Health Behaviours with Games", Journal of the Royal Society of Medicine, http://dx.doi.org/10.1177/0141076813480996, vol. 106, no. 3, **(2013)**, pp. 76-78**.**
[5] A. S. Miller, J. A. Cafazzo and E. Seto, "A Game Plan: Gamification Design Principles in mHealth Applications for Chronic Disease Management", Health Informatics Journal., http://dx.doi.org/10.1177/1460458214537511, **(2014)**.
[6] M. R. C. Cuenca, M. A. R. Cortés, M. D. C. Cuenca and R. M. Verdugo, "A Better Regulation is Required in Viral Hepatitis Smartphone Applications", Farm Hosp. vol. 38, no. 2, **(2014)**, pp. 112-117.
[7] E. Seto, K. J. Leonard, J. A. Cafazzo, C. Masino, J. Barnsley and H. J. Ross, "Self-care and Quality of Life of Heart Failure Patients at a Multidisciplinary Heart Function Clinic", The Journal of Cardiovascular Nursing, doi:10.1097/JCN.0b013e31820612b8, vol. 26, no. 5, **(2011)**, pp. 377-385.
[8] J. H. Jeon and K. H. Kim, "Development of Mobile App for Self-Management Performance of Patients with CHB", Proceedings of the Convergent Research Society among Humanities, Sociology, Science, and Technology on Advanced Science and Technology Letters, vol. 129, **(2016)**, pp. 229-233.
[9] M. Molenda, "In Search of the Elusive ADDIE Model", Performance Improvement, http://dx.doi.org/10.1002/pfi.4930420508, vol. 42, no. 5, **(2003)**, pp. 34-37.
[10] M. Driscoll and L. Alexander, "Web-Based Training: Using Technology to Design Adult Learning Experiences with Disk", Jossey-Bass Inc., **(1998)**.
[11] J. H. Jeon, "Development and Evaluation of Smartphone Application for Self-care Performance of Patients with Chronic Hepatitis B" [dissertation], Seoul, Chung-Ang University, **(2015)**.
[12] E. Bertini, S. Gabrielli and S. Kimani, "Appropriating and Assessing Heuristics for Mobile Computing", Proceedings of the Working Conference on Advanced Visual Interfaces, http://dx.doi.org/10.1145/1133265.1133291, **(2006)**, pp. 119-126.
[13] J. Nielsen, "Finding Usability Problems Through Heuristic Evaluation", Proceedings of the SIGCHI Conference on Human Factors in Computing Systems, http://dx.doi.org/10.1145/142750.142834, **(1992)**, pp. 373-380.
[14] . R. Stoyanov, L. Hides, D. J. Kavanagh, O. Zelenko, D. Tjondronegoro and M. Mani, "Mobile App Rating Scale: A New Tool for Assessing the Quality of Health Mobile Apps", JMIR mHealth and uHealth, http://dx.doi.org/10.2196/mhealth.3422, vol. 3, no. 1, **(2015)**, pp. 27.
[15] H. N. Kang, "Development and Application of Hypertension Management Mobile System Based on Clinical Practice Guidelines", [master's thesis], Seoul, Seoul National University, **(2014)**.
[16] M. J. Cho, "Development of Smartphone Educational Application for Patients with Coronary Artery Disease" [master's thesis], Gwangju, Chosun University, **(2013)**.
[17] E. Jeon and H. Park, "Development of a Smartphone Application for Clinical-guideline-based Obesity Management", Healthcare Informatics Research, http://dx.doi.org/10.4258/hir.2015.21.1.10, vol. 21, no. 1, **(2015)**, pp. 10-20.
[18] G. M. Kwon, A. R. Kim and S. I. Kim, "The Activation Methods of Mobile Service through Usability Testing - Focus on Comparison Mobile Application YES24 and KYOBO Bookstores", Journal of Digital Design, http://dx.doi.org/10.17280/jdd.2014.14.3.039, vol. 14, no. 3, **(2014)**, pp. 391-399.

Authors

Jae Hee Jeon, Faculty of Nursing, RN, PhD.

Kyunghee Kim, Faculty of Nursing, RN, PhD.