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Development of Hypertension Management Mobile Application based on Clinical Practice Guidelines

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Abstract. This study aims to develop and evaluate a mobile application for hypertension management based on Clinical Practice Guidelines. The application was developed according to Web-Roadmap methodology. In planning phase, we defined the tasks and product of each phase, selected clinical practice guidelines and extracted intervention items for hypertension management. In analysis phase, we analysed intervention items and made data dictionary, rules, use-case diagram, hypertension management ontology and tailored recommendations for the application. In design phase, we developed an entity-relations diagram, algorithm, and user interface and coded them in the implementation phase. In evaluation phase, first, the knowledge-base was evaluated for its accuracy by experts and they proposed three more detailed recommendations, which were added to the application. Second, mobile heuristics were evaluated. The evaluators pointed out 33 usability-related problems on mobile heuristics items. Out of these, three problems were solved by reflecting evaluators' comments.

Keywords Telemedicine, Health planning guidelines, Hypertension, Self care

Introduction

Hypertension is a disease that leads to myocardial infarction, cerebral infarction, and heart failure [1]. The two most important aspects of hypertension care are lifestyle improvements and drug treatment. Thus, it is important for hypertension patients to foster self-management skills for lifestyle improvement and drug treatment. Use of mobile healthcare is becoming increasingly popular in self-management of chronic diseases such as hypertension. In order to develop a mobile application that will help patients manage their lifestyle and medication, it is important to use clinical evidences available. Although there are many clinical practice guidelines (CPGs) for hypertension management, applying them to daily management is not an easy task. A CPG-based mobile application can be used to help hypertension patients manage their disease. This study aims to develop a mobile application for hypertension management based on CPGs and to have the experts evaluate the accuracy of knowledge-base and mobile heuristics.

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1. Methods

Hypertension management application (HMA) was developed using the Web-Roadmap methodology of information science [6] as a reference to define data, process and interface domains of each phase(Figure 1).

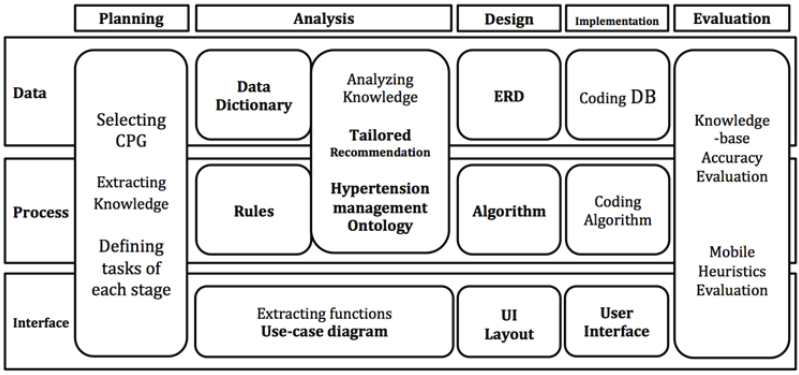

Figure 1. Development phases of hypertension management application

1.1 Planning

Tasks and products of data, process, and interface domains of each phase were defined. CPGs to serve as evidence for HMA were selected and knowledge was extracted.

1.2 Analysis

Data were extracted from the CPGs and data dictionaries were developed. Rules to serve as judgment criteria were identified. Hypertension management ontology and tailored recommendations were developed. Functional requirements were extracted and presented as a use-case diagram.

1.3 Design

The data structure was described in an entity-relation diagram. Algorithms were developed. User interfaces were designed to realize functional requirements.

1.4 Implementation

Designs of database, algorithms, and user interfaces were realized through coding.

1.5 Evaluation

Accuracy of knowledge-base was evaluated by three evaluators using seven scenarios. The degree of consistency was compared between the recommendations produced by the application and those made by evaluators as proposed by Martins et al.[3].

Mobile heuristics were evaluated using mobile heuristics principles proposed by Bertini et al.[4] translated into Korean [5]. Five evaluators were asked to try the application, asked to provide freeform comments about the usability and rate the severity of each usability problem with a scale from 0 to 4.

2. Results

2.1 Planning

Three well-known CPG search websites (National Guideline Clearinghouse, the Guidelines International Network, and National Institute for Health and Clinical Excellence) were searched. Four keywords, ‘hypertension management’, ‘hypertension’, ‘hypertension treatment’, and ‘high blood pressure’ were used. Five CPGs [1, 6-9] were selected after consulting with a group of nurse experts.

Taking into consideration of nursing and self-management, eight intervention categories with detailed items were extracted. Target systolic blood pressure for hypertension patients depending on age and underlying diseases were extracted.

2.2 Analysis

Forty-one data items were extracted and data dictionaries of these data were developed by specifying type, values and unit. The data was categorized into two groups, input data and calculated data.

Eight rules – i.e. "IF male AND weight≥60kg THEN Alcohol restriction target≤2 glasses/day and 14 glasses/week" and "ELSE Alcohol restriction target≤1 glasses/day and 9 glasses/week" – were extracted for each intervention items according to the subject's demographic data were extracted. Twenty rules for providing tailored recommendations based on pre-set target and input data were extracted.

An ontology for hypertension management (Figure 2) was developed based on previous study[10] by linking hypertension concepts with nursing process. The ontology has three levels. Concepts of the analytical level are linked to the nursing process categories level. Nursing process categories are linked to data, judgment and action concepts, which compose the hypertension management concept.

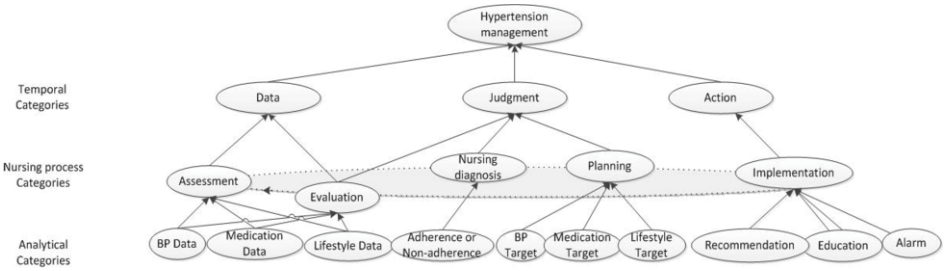

Figure 2. Hypertension management ontology

In total, 17 tailored recommendations were developed: one maintenance and one modification recommendation for each of seven intervention items and three recommendations for three stress levels. Each tailored recommendation has three parts; the first informing the target of the intervention item, the second notifying the evaluation result and the third providing the recommendation itself. The tailored recommendations were reviewed by an expert group.

Nine application features (Join, Register, Input data, View data, Send data, Set alarm, Alarm, Recommend and Education) were extracted and they were presented in a use-case diagram. In the use-case diagram, there are three actors -- the system database, knowledge database and user -- outside of the system. In the system, there are nine use cases, which are connected to actors according to their interactions.

2.3 Design

The data structure was described in an entity-relation diagram. Separate tables were arranged by data domain and knowledge domain. Data tables were further divided according to the change cycle of data values.

Eight algorithms were developed by linking twenty-eight rules evaluating user's status in each intervention item and seventeen tailored recommendations. For example, Figure 3 is the algorithm for waist circumference evaluation. When a user enters his or her waist circumference, depending on the user's sex and target waist circumference (T7 or T8), the evaluation result (E19 or E20) and recommendation (R19 or R20) will be presented to the user. A female user with waist circumference 92cm will receive a

recommendation composed of T8, E20 and R20; 'Your target waist circumference is 88cm (T8). Your waist circumference is 92cm, 4cm over the target (E20). For a hypertension patient, maintaining proper waist circumference is necessary to lower blood pressure. Reduce your waist circumference to 88cm (R20).'

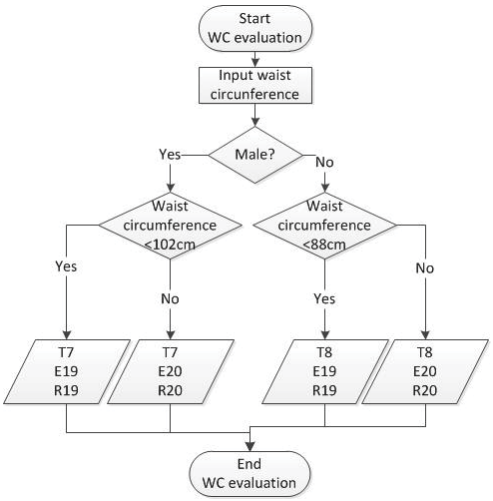

Figure 3. Algorithm for waist circumference evaluation

All in all, 34 screens were designed around the main menu with extracted functional requirements.

2.4 Implementation

The HMA was developed using Android SDK Platform 4.4.2 Java Development Kit (JDK) and Eclipse. The database management program was developed using MYSQL.

The HMA was implemented with five basic menus: 'My records' shows the most recent blood pressure and medication records in a graph. 'Blood pressure management' can be used to check target blood pressure, input blood pressure, receive tailored recommendations, and review blood pressure records. 'Medication Management' can be used for the users to browse medication information, input medication schedule for reminders, record medication taken, and review medication adherence weekly or monthly. With 'Lifestyle Management', tailored recommendations will be presented based on the user's answers to questions regarding the seven lifestyle management items. With 'Settings,' basic functions such as information management, alarm settings, password settings, and data sending via e-mail can be used.

2.5. Evaluation

There was no inconsistency in broader recommendations between the experts and the application. However, the evaluators proposed three more detailed recommendations. First, they recommended adding the option to input the daily amount of alcohol intake in addition to the existing weekly amount of intake. Second, they requested more specific comments on sodium intake. Third, they recommended adding 'get advice from healthcare professional' to stress management. The evaluators' recommendations were added to the application.

Evaluators pointed out 33 usability problems. Out of the 33, three problems with severity score 4 and seven problems raised by more than two evaluators were revised by reflecting evaluators' comments.

3. Discussion

In the HMA developed in this study, hypertension diagnosis and drug therapy were not included because they are beyond the scope of nursing. Instead, domains where self-management skills of the patients are important – i.e. control blood pressure, life style management, and medication adherence – were focused.

In order to develop an evidence-based application, knowledge extracted from CPG needs to be converted to a computer-interpretable form. The process of making the computer-interpretable CPG requires cooperation between clinical experts and system analysts [11]. Advances in modeling tool and system development methodology for CPG-based mobile application, would make the aforementioned process more efficient.

In mobile heuristics evaluation, diverse experts' opinions were sought from the evaluators with different backgrounds such as nursing and medical informatics, as well as computer programming. Each evaluator made a various number of comments on different heuristics items. Since the capability of the evaluator acts as an important variable in mobile heuristics evaluation [12], it is useful to have diverse experts from different domains in identifying the application's usability problems.

Further study measuring long-term patient outcome such as medication adherence, lifestyle improvement and blood pressure changes are needed.

Acknowledgement

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References

[1] James PA, Oparil S, Carter BL, Cushman WC, Dennison-Himmelfarb C, Handler J, et al. *2014 Evidence-Based Guideline for the Management of High Blood Pressure in Adults*. JAMA. American Medical Association; 2014 Feb 5;311(5):507–20.

[2] Jung B-K, Kim D-S, Song J-H, Hwang C-S. *Development and Application of Analysis & Design Methodology for Web-based System.* Journal of Korean Institute of Information Scientists and Engineers. 2002;:1550166.

[3] Martins SB, Lai S, Tu S, Shankar R. *Offline testing of the ATHENA Hypertension decision support system knowledge base to improve the accuracy of recommendations*. AMIA Annual Symposium Proceedings. Vol. 2006. American Medical Informatics Association, 2006.

[4] Bertini E, Gabrielli S, Kimani S. *Appropriating and assessing heuristics for mobile computing*. the working conference. New York, New York, USA: ACM; 2006.

[5] Jeon E. *Development Smartphone Application for Clinical Guideline Based Obesity Management*. [Seoul]; 2013. pp. 1–144.

[6] The Korean Society of Hypertension. *Hypertension guideline of The Korean Society of Hypertension*. 2013.

[7] Krause T. *The clinical management of primary hypertension in adults*. 2011 Aug 17;:1–328.

[8] Mancia G, Fagard R, Narkiewicz K. *2013 ESH/ESC Guidelines for the management of arterial hypertension.* The Task Force for the management of arterial hypertension of the European Society of Hypertension(ESH) and of the European Society of Cardiology(ESC) 2013. doi:10.1093/eurheartj.

[9] Bolton C. *Nursing management of hypertension. Nursing best practice guideline: Shaping the future nursing.* 2005.

[10] Kim HY, Park H-A, Min YH, Jeon E. *Development of an Obesity Management Ontology Based on the Nursing Process for the Mobile-Device Domain.* Journal of Medical Internet Research JMIR Publications Inc; 2013 Jun 1;15(6):e130. PMID: 23811542

[11] Tu, SW, Campbell JR, Glasgow J, Nyman MA, McClure R, McClay J, Abarbanel, RM. *The SAGE Guideline Model: achievements and overview*. Journal of the American Medical Informatics Association 14.5 (2007): 589-598.

[12] Park JH, Han SH, Park JH, Park WK, Kim HK, Hong SW. *Comparison of Usability Evaluation Methods for Mobile Application*. Journal of the Ergonomics Society of Korea. 2012 May 16;:154–157.