Mobile Application Development Process for Diabetes Patients in Primary Care Unit, Bangkok, Thailand: A Case Study of EASYDM Mobile Application

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ABSTRACT

The aim of this study was development the mobile application that collaborated the Primary Care unit service with uncontrolled diabetes on improving medication adherence in Primary Care Unit. EASYDM development process included 4 steps following: Step 1: Problem base development, Step 2: Figure out about the application Step 3: Application developing Step 4: Test & Receive Feedback. Questionnaire were given to 584 diabetes, 8 Primary Care unit staff in Samai, Bangkok, Thailand. The result SPSS 13.0 was used for statistical analyses. All of diabetes mobile device type were android and less than 30% of diabetes patients have application download experience. 2.9% of diabetes patient participants have no application in their mobile phone. Line application were the most popular mobile application among diabetes patient 97.1% And 71.2% use mobile application every day. The most recommendation must be less complex 43.7%. The first goal of the application for both diabetes patient group (58.0%) and Primary Care unit staff group (87.5%). Most diabetes patients need to update their medication adherence status via medication adherence appraisal specification function on mobile application (99.3%) when Primary Care unit staff 1group range reminder buzz for medication taking time, health index information and laboratory result information at the first functional specification of the application (100%). However, in conclusions, the findings also highlight some challenges for the further study about as if this ideal application could be developed to meet the core needs of diabetes.

INTRODUCTION

The technology has significantly transformed traditional services to modern means of services including in health care services (Fongtanakit, Somjai, Prasitdumrong, & Jermsittiparsert, 2019; Saengchai, Pattanapongthorn, & Jermsittiparsert, 2019; Usak, Kubiatko, Shabbir, Dudnik, Jermsittiparsert, & Rajabion, 2019). This development becomes an integral part of solution to today's health care. Mobile phones, software and hardware are connectively used in providing effective and efficient health services. Through this technology, those owing smartphones can be encouraged or advised to follow information in support of good health and behavior. Mobile phones play important role in daily activities where mobile health becomes very fundamental interaction between health providers and clients. Various applications for hypertension, weight reduction, stroke management and diabetes are in the field of medical care. Supportive property of technology in today world including in the field of health care is enormous. Particularly in adherence to medication, monitoring

technology is proposed and they are based on different functions with the sole aim to improve adherence (Chen, Mao, Liu, & applications, 2014) Several studies including individual study and systematic reviews and meta-analysis have shown that technology-based interventions are favorably effective in outcomes such as reducing HbA1c level. Interventions include text messaging (Ramachandran et al., 2013), applications (Bonoto et al., 2017; Covolo, Rubinelli, Ceretti, & Gelatti, 2015) Randomized controlled trials that evaluated mobile phone intervention(Liang et al., 2011) Diabetes become a major cause of mortality and morbidity in Thailand as seen in the world with the demographic transitions which leads to the need to timely tackle this issue. A study of 8-years cohort (2005-2013) in Thailand revealed that cumulative incidence for type 2 diabetes by age standardization is 222 for men and 96 for women per 10,000 (Papier et al., 2016)To treat diabetes and delay related complications from diabetes, maintaining blood sugar level is paramount. Due to complex nature of disease, diabetes requires multidisciplinary management approach to achieve optimal control. One of the corner stone of controlling diabetes is taking drugs correctly and regularly prescribed on the condition of patient's diabetic

status. And failure to adhere to prescribed drugs may result in uncontrolled diabetes. Among factors of non-adherence reported among diabetes patients are mainly forgetfulness (Nair et al., 2011) Mobile application provides many benefits for health care service, perhaps supporting patient to follow their prescriptions. Application need and requirement should be established to ensure the proper mobile application for both medical staffs and diabetes patients in Primary Care unit in Thailand as the portable and sophisticated tools for improving medication adherence.

Purpose of This Study

Today, various kinds of mobile application for diabetes patients are presently available, diabetes patient personal use or only health care provider use, but none of those is the application which cooperated the Primary Care unit service with diabetes patients on mobile application for improving medication adherence. The underlying reason for ideal application is to investigate on requirement for the application to meet the fundamental of both health care staffs and diabetes patients in Primary Care unit throughout the 1st and 2nd step of mobile application developing process; 1) Problem base development and 2) Figure out about the application (the other step are 3) Application developing and 4) Test & Receive Feedback). In this study, we aimed to acquire and analyze requirement of health care provider and diabetes patients for the mobile application that cooperated the Primary Care unit service with diabetes patients on improving medication adherence in Primary Care unit in Sai Mai district, Bangkok Thailand which will become the foundation for the functional design and development of EASYDM application.

METHODS
Questionnaire Design

Two semi-structured survey questionnaires on EASYDM require was designed ([1] application user accessibility survey questionnaire for diabetes patients in two Primary Care unit in Sai Mai district, Bangkok, Thailand and [2] application user requirement survey questionnaire for diabetes patients and Primary Care unit staffs who work with diabetes patients of Primary Care unit in Sai Mai district, Bangkok, Thailand) and use as the basis of our survey.

[1] Application user accessibility survey questionnaire design on literature review and Primary Care unit staffs, researcher and mobile application developer brainstorming on factor affected health mobile application accessibility and operation, then design the survey questionnaire to collect the data from diabetes patients in primary health care. The survey questionnaire included two dimensions (ability for application accessibility and application operation experience of diabetes patients), five items and diabetes patients' characteristic (gender, age, and education), 3 items.

[2] Application user requirement survey questionnaire design on literature review about health mobile application requirement of both diabetes patients and Primary Care unit staff then design the survey questionnaire to collect the data from diabetes patients and Primary Care unit staffs who work with diabetes patients. The survey questionnaire includes application usage's goals, primary purpose of the application, application functional specification and suggestion for application brief content.

Sample and Procedure

The survey was carried out in June 2019. A sample of 584 respondents was randomly occasional selected from two Primary Care unit in Sai Mai district, Bangkok Thailand. We adopted the following inclusion criteria for diabetes patient respondents: 1) Primary Care unit patients who were diagnosed type 2 diabetics and follow up treatment at Primary Care unit at least one year; aged 30-65 years; consented to participate in the study; and having smart phones and 2) Primary Care unit staffs who work in the Primary Care unit at least one year and have at least one year experienced on working in diabetes care area. We chose two Primary Care unit that provided diabetes clinic service, had a similar number of diabetes patients per year, and had internet system that suite to work cooperated with mobile application. Research assistants were trained on two survey questionnaires and sample selection technique then randomly selected respondents who met the inclusion criteria and provided the questionnaires one by one with standard information. After a questionnaire was completed, the research assistant reviewed it to ensure that no errors were made. [1], [2] was done to diabetes patients who visit 2 primary health cares during a period of months and [2] was done to Primary Care unit staff who met the staffs' inclusion criteria in two primary health cares.

Survey Deployment
Diabetes patient

Three trained research assistants who were Primary Care unit staffs of each Primary Care unit drawn diabetes patients on their follow up appointment in every diabetes clinic during June 1-30 in 2019. Trained research assistants occasionally sampling to approached diabetes patients and recruited the patients who met inclusion criteria. Then, individual explanation about the research to each candidate and ask to participate in the research. If diabetes patients were willing to participate, provide information sheet and consent form to the participants to sign in. At the beginning of the survey, trained research assistants explain about [1] and [2] questionnaire and provide the questionnaire to participants. These 2 questionnaires should take around 30 minutes to complete

Primary Care unit staffs

There were eight Primary Care unit staffs of two target Primary Care unit met staff inclusion criteria. We explained about the research to those staffs since organization monthly meeting on June 3, 2019 and propose them to participate. All those staffs were willing to participate, then we explained about [2] questionnaire and provide information sheet and consent form to the participants to sign in. This [2] questionnaires should take around 15 minutes to complete

Developmental of EASYDM

Research on evidence-based practices consistently show the positive effects of using mobile application on diabetes control (Drincic, Prahalad, Greenwood, Klonoff, & Clinics, 2016). EASYDM, mobile application purposing to enhance medication adherence for diabetes patient in primary health care, will be developed to benefit patients with diabetes and easier to implement primary health care. Studies on mobile applications, usage, and effectiveness are in growth in this digital age. Multiple functionalities in applications can be used for various

purposes. Not only information provision for specific targeted population but monitoring and reminding functions are available in modern technology (Kitsiou, Pare, Jaana, & Gerber, 2017). Although there were different kinds of health mobile application for diabetes patients personal use and for diabetes health care provider use for the purposes of diabetes management, online medical consulting or daily health and but there was no application that cooperated the Primary Care unit service with diabetes patients on mobile application. In Thailand, Primary Care unit standard program for electronic medical record is Hospital OS. This program is in a stage of rapid growth and specifically used by health care providers but not for using by the patients.

The number of smartphone users in Thailand rise from approximately 14.4 million in 2013 to 22.48 in 2016. In 2017, the number of smartphone users is estimated reach to 24.14 million and 2.3 billion users of smartphone users worldwide.(Puriwat & Tripopsakul, 2017) Smartphone use to be very expensive device in last decade but not for today, simply and easily accessible smartphone could be bought at convenience store and cost only 200 bath in Thailand. Almost all Primary Care unit clients own a mobile phone, and even more are connected online. As with any industry, healthcare has needed to transform its communication processes to connect with people wherever they are. Information and communication technology link healthcare professionals together, as well as healthcare professionals with patients. These powerful instruments are all currently being used to share information but also under investigated on health care in many dimensions: diagnostics, management, counseling, education, and support.

Application developing process

Preliminary study of the application EASYDM will be conducted so as to validate contents, features, language, functionality, satisfaction on the application before the trial comment and even preferred times to receive reminding alert (Rattanayotin & Vanijja, 2018).Then, the application will be modified depending on the inputs during the preliminary study to align with the objectives of the study and the need of the population in the area taking equal emphasis on technical feasibility in consideration. With the emergence of Thailand 4.0, the rise of technology, innovation and smart business in Thailand, development and implement a specific mobile application for improving diabetes would be challenge in health care system. EASYDM refer to the application that develop by the researcher, focused on strengthening Primary Care unit diabetes medication adherence for supporting diabetes management. The application were mobile computing, medical electronic assistance, and communications technologies that can enhance diabetes medication adherence. The survey was established to understand and analyze about need and accessibility of diabetes patients and Primary Care unit medical staff affordability for diabetes assistance mobile application. Data were collected by different survey forms on different target groups and the application was designed based on the processed data and analyzed results. From brief requirements of the application, there would be application monitoring screening Primary Care unit computer network that could check and count Participants mobile application access time and frequency.

EASYDM was developed through theses all process, in the other word was how to tailor mobile application

Step 1: Problem base development

Diabetes management include 3 major components, dietary control combined with exercise, insulin treatment in necessary case and oral hypoglycemic therapy. In primary health care, we routine educated all diabetes patients every necessary information and implement health behavior modification intervention. To ensure appropriate management, the basic knowledge and skills should be acquired by the patient and his family and the health care team should work closely with the patient to achieve this objective and to promote self-care. The person with diabetes should also be involved in setting therapeutic targets for weight, blood pressure and blood sugar control.

Although Primary Care unit continues working on diabetes management, medication therapy should also be considered at this stage in the presence of marked as uncontrolled diabetes. The treatment scheme can probably be appropriately applied in most cases. There is a high rate of non-adherence to medication regimens, particularly in patients with chronic conditions and medication adherence were one of may be improved through a combination of patient educational and behavioral interventions. Practical health mobile application could help to improve diabetes medication adherence but what should the mobile application be?

The essence idea for successfulness of specific mobile application depend on its practical use and effectiveness. Therefore, the crucial mark of developing mobile health application is to understand what issues are experienced by Primary Care unit medical staffs and diabetes patient then the application could solve the problem. The requirement survey questionnaires were developed on literature review and brainstorming of researcher-Primary Care understaffs-mobile application developer. Requirement specification was important process for specifying the customer needs and list product requirement and the requirements vary in each case. (Ibriwesh, Ho, Chai, Tan, & Engineering, 2017; Laitinen, 2014) Identifying the customer needs is a necessary part in developing specific mobile application. Brain storming is one technique to solve the problem, by generating new idea between individual or within a group in order to achieve desirable answer and also use for designing survey questionnaires gathering information on the development of mobile application for diabetes patients in primary health care.First, the researcher set out a clear definition on the objective of requirement analysis of mobile application developing for diabetes patients in primary health care, determining a time limit to 8 Primary Care unit staffs and 1 mobile application developer when they are thinking and putting forward the topic of survey questionnaires, with the help of a researcher using a set of criteria checklist for evaluating the needed topic for application user accessibility survey questionnaire and application user requirement survey questionnaire. During the brainstorming session many ideas were taken down as possible and noted, not to limit any ideas from any members, encouraging contribution and participation. The note was classified into mobile application accessibility questions (diabetes patients) and diabetes patients' mobile application requirement question (diabetes patients and Primary Care unit staffs) and contribute to the survey questionnaires as following.

Step 2: Figure out about the application.

The application development contributes towards what were found and understand from surveying of mobile application need. High rate of non-adherence to diabetes medication regimens step I Problem base development in medication none adherence survey. Diabetes medication adherence were one of may be improved through a combination of patient educational and behavioural interventions that Primary Care unit routine done through Diabetes Medication Assistance Service and Health Behaviours Modification Program. Practical health mobile application could help to improve diabetes medication adherence but what should the mobile application be.

The core idea for successfulness of the application depend on its practical use and effectiveness. Therefore, the crucial mark of developing mobile health application is to understand what issues are experienced by Primary Care unit medical staffs and diabetes patient then the application could solve the problem. Before developing any mobile application, A research survey was conducted to gain valuable inputs regarding various emergent practices during the mobile application development process.

The results of the survey were utilized as a starting point to identify specific requirements in the area of mobile application developer for new and revolutionary practices. Design surveying could be great to assist the application developer preparing the design style and navigation for application user, both diabetes patients and Primary Care unit staffs who with diabetes patients. Then the application developer, the Primary Care unit staff and researchers meeting concluded about application requirement as following; Prefers larger font and simple navigation, Thai language. (53.8% of participants are female; age between 40-49 years. The biggest education group (37%) were high school/ vocational school)

Step 3: Application developing

Before developing any mobile application, A research survey was conducted to gain valuable inputs regarding various emergent practices during the mobile application development process.

The results of the survey were utilized as a starting point to identify specific requirements in the area of mobile application developer for new and revolutionary practices

EASYDM should be designed and developed as scalable and adjustable. First draft of the application preface within 1 months after focus group discussion (Primary Care unit staffs who work with diabetes patients, the researcher and mobile application developer) and building prototype with the most viable functionality within 3 months first launch.

Table 1 Respondents' characteristics of mobile application (n=584)

Mobile application users' characteristic	User (%)
Gender	
Male	48.1
Female	51.9
Age	
≤40	30.1
41-55	46.4
56-65	23.5
Education	
Elementary and below	9.4
Middle school	42.5
High school	35.6
Collage or above	12.5

Table 2 : Respondents' accessibility of mobile application (n-548)

Mobile application users' accessibility	User (%)	
Device type		
IOS	0	
Android	100	
Application download experience		
Yes	29.5	
No	70.5	
Current application use on device		
No application	2.9	
Line	97.1	
Facebook	50.5	
Messenger	45.2	
Instagram	3.6	
Other	0	
Application using frequency		
Every day	71.2	
3-5 day/week	17.3	
2-3 day/week	9.8	
1 day/week	1.7	
Recommendation for the application		
Two-way communication channel	1st	0.7
	2nd	31.5
	3rd	67.8
Less complexity	1st	43.7
	2nd	54.6
	3rd	1.5
	4th	0.2
Thai language	1st	54.5
	2nd	41.1
	3rd	4.5
Larger font	1st	1.9
	2nd	4.3
	3rd	61.3
	4th	32.5
Other		
No charge	9.3	
Real time application assistant	0.03	
Care giver application use training	0.02	

Table 3: Application requirement survey questionnaire: diabetes patients (n=548)

Mobile application diabetes patients' requirement	User (%)	
Goals on diabetes mobile application		
Glycemic controlled	1st	40.6
	2nd	58.0
	3rd	1.4
Improve medication adherence	1st	40.4
	2nd	17.6
	3rd	40.9
	4th	1.0
Improve diabetes management	1st	15.1
	2nd	0.5
	3rd	43.7
	4th	7.4
	5th	33.4
Medication adherence tracking	1st	3.9
	2nd	22.8
	3rd	6.7
	4th	43.3
	5th	23.3
Diabetes data sharing and support	2nd	1.0
	3rd	7.4
	4th	48.3
	5th	43.3
Functional Specification		
Reminder buzz	88.4	
Health index (BMI/Bp/other chronic illness)	67.8	
Patient-PHC communication channel-Smart coaching	84.2	
Adherence appraisal (graph/table/daily notification)	99.3	
Lab information (DTX/FBS/HbA1c/LDL)	68.8	
Suggestion for application brief content		
Application data privacy	0.02	
Professional suggestion on communication channel	0.02	
24 hrs application hotline	0.02	
Patients group support via line	0.02	
Laboratory result should be easy to understand with proper suggestion to solve the problem	0.03	
Less mobile data storage, less mobile power consumption to operate	0.02	

Table 4: Application requirement survey questionnaire: Primary Care unit staffs

Mobile application Primary Care unit staffs' requirement	User (%)	
Goals on diabetes mobile application		
Glycemic controlled	1st	87.5
	2nd	12.5
Improve medication adherence	1st	12.5
	2nd	87.5
Improve diabetes management	3rd	75.0
	4th	25.0
Medication adherence tracking	3rd	6.7
	4th	43.3
	5th	23.3
Diabetes data sharing and support	4th	48.3
	5th	43.3
Functional Specification		
Reminder buzz	100	
Health index (BMI/Bp/other chronic illness)	100	
Patient-PHC communication channel-Smart coaching	50	
Adherence appraisal (graph/table/daily notification)	37.5	
Lab information (DTX/FBS/HbA1c/LDL)	100	
Suggestion for application brief content		
Application activities of each user should can be tracked by Primary Care unit staffs	12.5	
Concern about privacy disturbance by reminder buzzer. Therefore, the notification should can be changed into vibration mode	12.5	
The application should be least complex, user could operate the application themselves No need to input any data and they do only click.	25	
There should be application administration page in application server	25	
Application security should be managed trough password both on application's user and application administrators' computer	12.5	
Some application's contents should be changeable. Example: if the reminder function designed to show picture of the curtain medication, that picture must changeable through application administrator's computer.	12.5	
Application content should be short and easy to understand to every user	50	
The notification should be changeable to user lifestyle and occasionally close for a while.	12.5	

Table 5: Characteristics of EASY DM

Characteristics	Detail
Hardware	
Mobile	Diabetes patient mobile
Operation system	Android
Application Size	small
Application power consumption	Less
Data input	Less
Primary Care unit computer	
Operation system - Could patch and operate application in administration part of application	
Software	

Application interaction
     - Less than 30% of DM have application download experience and 2.9% of target users have no application in their mobile phone
     - Line application were the most popular mobile application among DM patient(97.1%)
     - 71.2% use mobile application everyday	

Application development
      Diabetes patient mobile
       -The application must be developed in Thai and must be less complexity, 54.5% of diabetes patient group set Thai language application at the first range and 43.7% set less complexity set
       - To make diabetes patients glycemic control is the first range goal of the application for both diabetes patient group and Primary Care unit staff group
       - Inviting care giver for application training session will be considered
       - Application will be free for download
       - Medication adherence appraisal is ranged at the first functional specification of the application in diabetes patient group (99.3%). In Primary Care unit staff group, reminder buzz for medication taking time, health index information and laboratory result information is ranged at the first functional specification of the application (100%)
       - Privacy disturbance from reminder buzz will be considered
      Primary Care unit computer
       - Application administration in application server computer will track and communicate with application user
       - Data fully input trough administration part of application
       - Some application's contents should changeable trough administration part of application	

Application security -Password setting will be used for application security management through both on diabetes patients mobile and administrators' computer	
Communication	
- EASYDM should be tri-parties mobile application for improve diabetes patient medication adherence then there will be 2-way communication channel for diabetes patient and Primary Care unit staff to support EASYDM usage -Because almost all diabetes patient frequency used application were line application, therefore communication channel will appearance alike they used to use	

Step 4: Test & Receive Feedback

The researcher ideal about the application were the application should be two-way communication application and be smart application that do not only remind about medication but also provide the patient some advises. After the first draft launch, we will do pilot implement the application in 30 diabetes patients in the other PHC in similar cortex. Then collected the application's problem from user complain and the suggestions within 1 month. From the collected list, adjust the application again before play store launch

Step 5: Security & Privacy is a Core Component

As the privacy policy to get access to user data, it is expected that the participants should be able to freely check out the policy before downloading EASYDM application. Most importantly, EASYDM dealing with personal patient information have to meet standard ethical guidelines.

RESULTS

In this survey research, we used SPSS23.0 to explore and analyze the data, which was included two questionnaires. Gathering from survey result, we adopted(Flora, Wang, & Chande, 2014) key characteristic of mobile application that classified into 3 categories: characteristics related to Hardware, Software (application interaction, application development, and application security) and Communication.

LIMITATIONS AND RECOMMENDATIONS

Another recommendation was gamification like "once daily easy quizzes" or other game formats allow users to keep up with medical terms more easily. As the privacy policy to get access to user data, it is expected that the participants should be able to freely check out the policy before downloading EASYDM application . Most importantly, EASYDM dealing with personal patient information have to meet standard ethical guidelines

Security & Personal information Security login by ID & password setting .

CONCLUSION

The information from the survey is incorporated to EASYDM application development, which will then be evaluated to examine its effectiveness in diabetes control of diabetic patients at Primary Care Units in Thailand. Brief picture EASYDM would be like smart medication reminder, reminder system notifications medication to avoid missing medication, more advanced setting services, and the ability to supply data on the phone and work offline for management of complex for Uncontrolled Diabetes medical conditions attending Primary Care Unit that not only remind but could be track their medication adherence behavior with these following function (1) Reminder buzzle for reminding diabetes patients' medication taking times. (Frequency of notifications are depended on diabetes patient's medication prescription and this notification buzzle also able to close occasionally and could be turned to notify in vibration mode too. When the notification had been closed more than 24 hours, it could restart the notification mode itself automatically) (2) Recent health index (BMI/ Bp/other chronic illness) (3)Patient-Primary Care unit communication channel (4) Smart coaching (5)Adherence appraisal (graph/table/daily notification) (6) Laboratory information (7)Application manage and monitoring screen at Primary Care unit server computer (could monitor every application user and Primary Care unit pharmacist could also tracking the patient medication adherence daily, we will do pilot implement the application in 30 diabetes patients in the other Primary care unit. Then collected the application's problem from user's complains and suggestions. From the collected list, adjust the application again before play store launch.
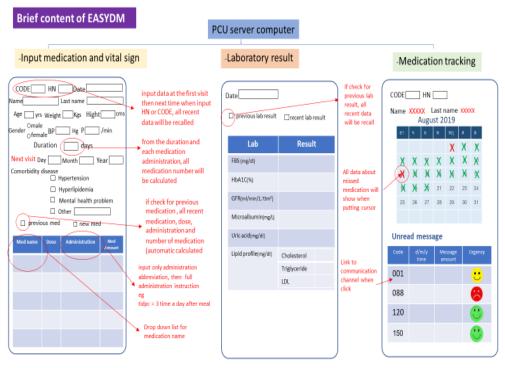
Ethic consideration

This study had been reviewed by Thai Clinical Trials Registry (TCTR) Committee. It deemed satisfactory for all items of Trial Registration Data Set required by World Health OrganizationTCTR identification number is TCTR20190509002 .

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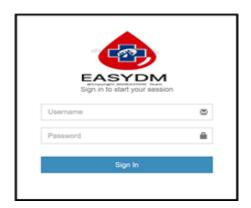6. Fongtanakit, R., Somjai, S., Prasitdumrong, A., & Jermsittiparsert, K. (2019). The Role of Innovation in the Healthcare Supply Chain of Thailand. International Journal of Supply Chain Management, 8(6), 317-324.
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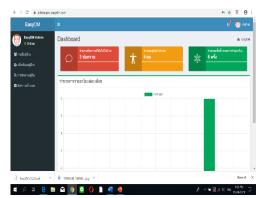Figure 1: Application developer develop EASYDM (1st Mobile application prototype)

Figure 2 : Layout of application on progress