Design of Mobile Healthcare Reminder for Chronic Diabetes

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***Abstract*—Mobile technology has been increasingly used in healthcare services. However, little has been done in handling patients of chronic disease. Accordingly, this study aims to design a mobile reminder system that cares for patients' self-management of their chronic diabetes. To achieve the main aim, the following sub objectives have been formulated; (i) to identify the requirements for the mobile healthcare reminder suitable for chronic diabetes, (ii) to develop and construct the prototype of the system, (iii) to evaluate the prototype in terms of perceived usefulness, perceived ease of use, and satisfaction. The prototype has been evaluated using an adapted questionnaire, involving 30 patients in Baghdad Hospital. The results reveal that the prototype is perceived useful and easy to use by the participants. Also, they are highly satisfied with the prototype. The outcome of this study would help mobile healthcare applications developers to design future mobile reminder system particularly for patients who are suffering from chronic disease.**

***Index Terms*—Mobile Healthcare; Perceived Usefulness; Perceived Ease of Use; Satisfaction.**

I. INTRODUCTION

Mobile health (M-health) has been popularized since the last decade by research communities as well as the manufacturing sector [1]. Recent advancement in mobile technology has enabled mobile devices to perform functions previously not possible with handheld devices [2]. In addition, the advancement in the utilization of android and smartphones has accelerated the betterment of technologies in the communication industry. It presents some current challenges in terms of accuracy and reliability of mobile applications. In fact, Arnhold *et al.* [3] found that mobile applications are increasingly used in managing various tasks in daily life. As an example, in healthcare industry, m-health applications are used to support the management of illnesses, and in promoting health awareness and well-being [4]-[6]. Among common diseases, diabetes is considered as a one of the most widely spread [7]. On top of that, it is a chronic disease that requires a lifelong care [8].

With the emergence of various mobile technology platforms and the need to make diabetes logs more accessible, several forms of diabetes self-management applications have been developed [9]. These applications range from a straight conversion of conventional paper logs into an electronic form to unique designs that strive to achieve positive health behaviour changes in patients [10]. In addition to mobile communication and related features, which acquire more reputation because of their intelligence, mobile services can play a vital role in addressing the essential demands of prevention, the initial identification, and efficient self-management of diabetes. Therefore, many previous studies recommend that mobile reminder applications should support patients' self-management by facilitating their education, behaviour change, and adherence to recommended care practices [11-13]. Besides that, Belzer *et al.* [14] and Hanauer *et al.* [15] also studied the requirements related to diabetes management. In short, it is recommended that the healthcare industry should take the advantage of modern communication technologies, such as smartphone and tablet that offer remarkable access to data with the intention of helping the masses for managing their health. This really could positively impact the management of healthcare.

II. PROBLEM STATEMENT

According to International Diabetes Federation, 371 million people between the age of 20 and 79 suffered from diabetes worldwide in 2013. The number is estimated to increase to 552 million people by 2030 [16]. 77 per cent of people with diabetes live in low- and middle-income countries, including Iraq. Figure 1 shows a comparison between the diabetic sufferers in Iraq, Yemen and Syria.

In a recent study conducted by International Diabetes Federation [16], among three unstable Arab countries (see Figure 1), Iraq records the highest diabetes prevalence. Interestingly, Arnhold et al. [3] found that diabetes prevalence increases with age. Thus, the young, youth, and elderly are the largest target groups that could benefit from the mobile diabetes application. On the other hand, based on a systematic review carried out by Arnhold et al. [3], works on m-health applications focusing on reminder function are lacking. Based on the needs, such initiative requires an urgent attention.

The widespread availability of mobile phones enables such reminder application to support electronic disease management, which opens up the potential of a new approach in enhancing the self-management of diabetes. Unfortunately, studies that develop applications focusing on chronic diabetes are still in the infancy, even though the healthy living factor and wellness are deeply-attended to by the research community working on mobile applications. It should be urgently worked-on, because m-health reminder is a very

beneficial apparatus, particularly if medical officers or patients are stretched for time [17], [18]. Consequently, this study aims to develop a mobile healthcare reminder that allows patients with chronic diabetes to self-care of their condition, through their interaction with physicians (medical officers). Besides being independent, quick monitoring of the disease, the process also reduces the operational cost.

III. PREVIOUS STUDY

Several studies have been conducted to enhance the self-management of chronic diabetes, with different healthcare conditions ranging from public awareness to more real-time monitoring. Having compared those studies, the results are depicted in Table 1.

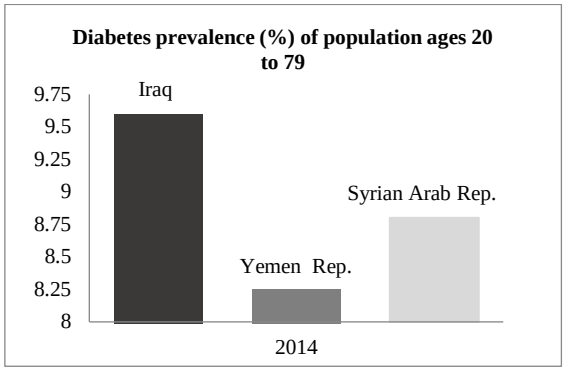

Figure 1: Ranking of diabetic people in Iraq compare with other countries

Table 1
Results of comparative analysis

System name	Author name	Appointment scheduling	Food management	SMS	Diabetes recommendations	Chatting
Intelligent diabetes system	Alotaibi *et al.* [19]	√	×	√	×	×
Diabetes management system	Jung and Hinze [20]	×	×	√	×	×
Glucose Buddy	Kirwan *et al.* [21]	×	√	×	√	×
Children vaccination reminder system	Almohamed [22]	×	×	√	×	×
Self-management mobile app for diabetes	Nguyen *et al* [23]	×	√	×	√	×
Renewing health application	Ribu *et al.* [24]	√	×	√	√	×
SapoMed	Silva *et al.* [25]	√	×	√	×	×
Diabetes manager	Alhazbi *et al.* [26]	×	√	√	×	×
Mobile Healthcare Reminder	Proposed study	√	√	√	√	√

With reference to Table 1, this study deduces that not all features are appropriate for a mobile healthcare reminder. Hence, an appropriate system for self-managing chronic disease should include appointment scheduling, food management, SMS, diabetes recommendations, and online chatting features.

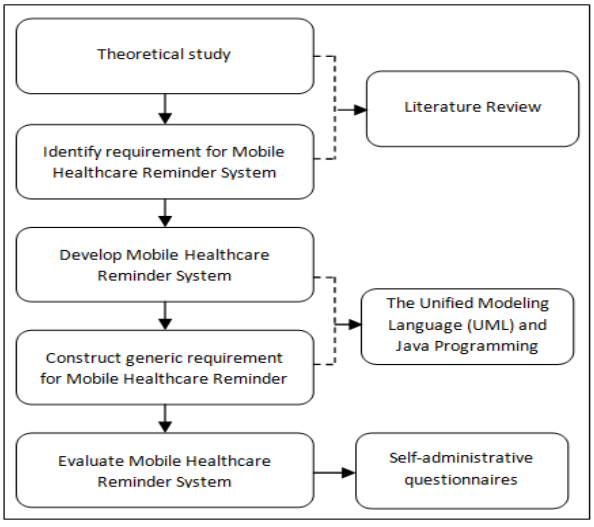

Figure 2: Research procedure

IV. RESEARCH METHODOLOGY

A methodology is the strategy or architectural design by which the researcher maps out an approach to problem-finding or problem-solving [27]. In general, this study achieves its objectives through a process that consists of five main phases as seen in Figure 2.

Figure 2 shows that the process begins with understanding the existing system through a theoretical study. It is followed by identifying the requirements of the system. Both phases are part of the literature study. Then it is followed by constructing the generic requirement for mobile healthcare reminder in the form of Unified Modelling Language (UML) and Java programming. Then, the system is evaluated through a set of questionnaires.

V. SYSTEM IMPLEMENTATION AND SNAPSHOTS

The prototype has been successfully and completely developed comprising of all the requirements defined by the functional requirements. Java android and JavaScript were used for coding and the database was developed using SQL. The interface has been developed using Photoshop. In general, the admin (medical officer) is able to manage the medicines and the food for the patients (Figure 3). Besides that, the admin could also determine the appropriate activities for the patients.

Figure 3: Interface for the admin

When the patients have successfully logged into the system, they are able to view a list of options available in the system. They could choose to view their profile and update password, view their medication or others as shown in Figure 4.

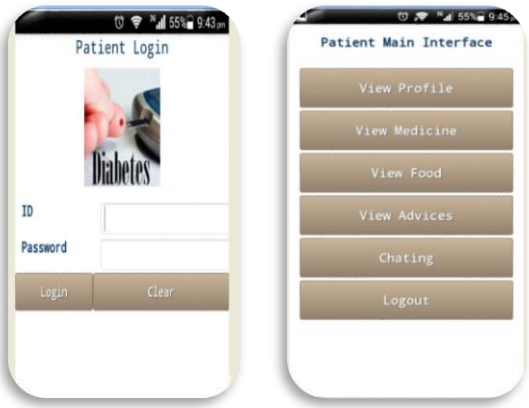

Figure 4: Interface for the patient

VI. FINDINGS

This section discusses the evaluation of the developed prototype. The evaluation was performed after the prototype has been developed to determine the level of usefulness, ease of use, and satisfaction of the system. The evaluation was carried out using a set of questionnaires, which was distributed to 30 patients in Baghdad Hospital. The questionnaires were adapted from Abdalla [28], based on the Technology Acceptance Model. The items in the questionnaires are measured using Likert scale from 1 to 5, in which 1 is for strongly disagree and 5 for strongly agree. Each respondent was given a brief description on the functionality of the prototype. In addition, the respondents were allowed to use the prototype, and finally they were given a set of questionnaires to obtain their perception. The result reveals a Cronbach Alpha greater than 0.8. The results of the evaluation on Perceived Usefulness are shown in Table 2.

Based on the results, the prototype helped the respondents to quickly attain tasks (M = 3.37 and SD = 0.718). It also helped them to manage the task (M = 3.53 and SD = 0.571) at the right time (M = 3.60 and SD = 0.724). Finally, the prototype supported them to achieve their needs (M = 3.73 and SD = 0.521).

Table 2
Perceived Usefulness

Questions	Mean	SD
The system is easy to be learnt	3.73	0.640
The interaction with the system is easy and understandable	3.73	0.740
I find the system is flexible	3.77	0.568
Overall, I find the system is easy to use	4.00	0.455

The results of the evaluation on Perceived Ease of Use are shown in Table 3. The respondents agree that the prototype was easy to learn (M = 3.73 and SD = 0.640). Besides that, the interaction with the prototype was easy and understandable (M = 3.73 and SD = 0.740) and flexible (M = 3.77 and SD = 0.568). Finally, the respondents agreed that the system was easy to use (M = 4.00 and SD = 0.455).

Table 3
Perceived Ease of Use

Questions	Mean	SD
The system will help me to quickly attain the task	3.37	0.718
The system will help me to manage the task	3.53	0.571
The system will help me to manage the task at the right time	3.60	0.724
I achieved my needs	3.73	0.521

The results of the evaluation on Satisfaction are shown in Table 4. The respondents felt comfortable while using the system (M = 3.70 and SD = 0.596) and they enjoyed using it (M = 3.97 and SD = 0.718). Finally, the respondents were satisfied with the system (M = 3.93 and SD = 0.521).

Table 4
Satisfaction

Questions	Mean	SD
I felt comfortable while using the system	3.70	0.596
I enjoyed while using the system	3.97	0.718
Overall, I am satisfy with using the system	3.93	0.521

VII. CONCLUSION

This paper describes the development of a mobile healthcare reminder for patients' self-management of their chronic diabetes and patients' evaluation of the system. This study started with identifying the requirements for a mobile healthcare reminder. Having gathered the requirements through a comparative analysis, a prototype system has been developed. Then, it was evaluated among a sample of 30 diabetic patients in terms of perceived usefulness, perceived ease of use, and satisfaction. The results of the evaluation indicated that the developed prototype system is useful and easy to use. The respondents were also satisfied with it.

The results of the evaluation indicated that the diabetic patients expect some form of mobile system that can assist them in self-managing their problems related to diabetes. The introduction of such a system can facilitate medical practitioners and diabetic patients in terms of reducing the number of appointments since communication can be done online. This helps to reduce the time, effort, and cost. The results of this study correspond with the findings of the previous works in other countries by Boules *et al.* [29],

Kumar *et al.* [30], and Leonard [31]. Accordingly, this study adds new findings to the existing knowledge [28], [32], [33].

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REFERENCES

[1] Heerden, A. V., Tomlinson, M., and Swartz, L. "Point of care in your pocket: a research agenda for the field of m-health". *Bulletin of the World Health Organization*. Vol. 90(5), pp. 393-394, 2012.

[2] Gagnon, M.P., Ngangue, P., Payne-Gagnon J. and Desmartis, M. "Health Adoption by Healthcare Professionals: A Systematic Review". *Journal of the American Medical Informatics Association*. 2015.

[3] Arnhold, M. Quade, M and Kirch, W. "Mobile applications for diabetics: a systematic review and expert-based usability evaluation considering the special requirements of diabetes patients age 50 years or older". *Journal of medical Internet research*. 4. 2014

[4] Mirza, F. and Norris T. "Opportunities and barriers for mobile health in New Zealand". *Studies in health technology and informatics*. Vol .129(1), 2007

[5] Eng, D. S. and Lee, J. M. "The promise and peril of mobile health applications for diabetes and endocrinology". *Pediatric diabetes*. Vol. 14(4), 2013.

[6] Martinez, B. Perez, I. Torre-Diez, L. and Lopez-Coronado, M. "Mobile health applications for the most prevalent conditions by the World Health Organization: review and analysis". *Journal of medical Internet research*. Vol. 15(6), 2013.

[7] Zaki, A. "Isolation of Incensole and Molecular Docking on Human Aldose Reductase," *Enliven: Bio Anal Techniques*. Vol. 1(1), 2014.

[8] Malam, P. P., Kantharia, N. D. , Zala, A. C., Amin, A. J., Deoghare S. B., and Gajera, C. N. " *Role of glipizide therapy on oxidative stress parameters in the patient with Type-II diabetes mellitus"*. 2014.

[9] Min, L. *Design and Evaluation of a Mobile Health Application for Adult Patients with Type 1 Diabetes Mellitus*. 2013.

[10] Cafazzo, J. A., Casselman M., Hamming, N., Katzman, D. K., and Palmert, M. R. "Design of an mHealth app for the self-management of adolescent type 1 diabetes: a pilot study". *Journal of medical Internet research*. Vol. 14(3), 2012.

[11] Cole-Lewis, H. and Kershaw, T. "Text messaging as a tool for behavior change in disease prevention and management". *Epidemiologic reviews*. 2010.

[12] Nilsen, W., Kumar, S., Shar, A., Varoquiers, C., Wiley, T., Riley, W. T., Pavel, M. and Atienza, A. A. "Advancing the science of mHealth". *Journal of health communication*. Vol. 17(1), 2012.

[13] Sarasohn-Kahn, J. "How smartphones are changing health care for consumers and providers". *California HealthCare Foundation. 2010.*

[14] Belzer, M. E., Naar-King, S., Olson, J., Sarr, M., Thornton, S., Kahana, S. Y., Gaur, A. H., and Clark, L. F. "The use of cell phone support for non-adherent HIV-infected youth and young adults: an initial randomized and controlled intervention trial". *AIDS and Behavior*. Vol. 18(4), 2014.

[15] Hanauer, D. A., Wentzell, K., Laffel, N., and Laffel, L. M. "Computerized Automated Reminder Diabetes System (CARDS): e-mail and SMS cell phone text messaging reminders to support diabetes management". *Diabetes technology & therapeutic*. Vol. 11(2), pp. 99-106. 2009.

[16] Gan, D. *International Diabetes Federation: Diabetes Atlas. 2003.*

[17] Benferdia, Y. and Zakaria, N. H. "*A Systematic Literature Review of Content-Based Mobile Health"*. 2014.

[18] Island, D. H., Arsand, E. and Skarderud, F. "Improving diabetes care for young people with type 1 diabetes through visual learning on mobile phones: mixed-methods study," *Journal of medical Internet research*. Vol. 14(4). 2012.

[19] Alotaibi, Maryam M, Istepanian, Robert SH, Sungoor, Ala, and Philip, N. "An intelligent mobile diabetes management and educational system for Saudi Arabia: System architecture". *Paper presented at the IEEE-EMBS International Conference on Biomedical and Health Informatics (BHI*), 2014.

[20] Jung, Doris, and Hinze, Annika. "A mobile alerting system for the support of patients with chronic conditions". *First European Conference on Mobile Government (EURO mGOV)*. Brighton, UK. 2005.

[21] Kirwan, Morwenna, Vandelanotte, Corneel, Fenning, Andrew, and Duncan, Mitch J. "Diabetes self-management smartphone application for adults with type 1 diabetes: randomized controlled trial". *Journal of medical Internet research*. Vol. 15(11). 2013.

[22] Almohamed, Asam Hamed Abbas. "*Children Vaccination Reminder System via SMS Alert"*. Universiti Utara Malaysia. 2012.

[23] Nguyen, Hoang D, Jiang, Xinyi, and Poo, Danny Chiang Choon. "Designing a Social Mobile Platform for Diabetes Self-management: A Theory-Driven Perspective". *Social Computing and Social Media*. pp. 67-77. 2015.

[24] Ribu, Lis, Holmen, Heidi, Torbjørnsen, Astrid, Wahl, Astrid Klopstad, Grøttland, Astrid, Småstuen, Milada Cvancarova, Årsand, and Eirik. "Low-intensity self-management intervention for persons with type 2 diabetes using a mobile phone-based diabetes diary, with and without health counseling and motivational interviewing: protocol for a randomized controlled trial". *JMIR research protocols*. Vol. 2(2). 2013.

[25] Silva, Bruno M, Lopes, Ivo M, Marques, Mickael B, Rodrigues, Joel JPC, and Proenca, Mario L. "A mobile health application for outpatients medication management". *IEEE International Conference on Communications (ICC)*, 2013.

[26] Alhazbi, Saleh, Alkhateeb, Moh', Abdi, Abdulla, Janahi, Ahmed, & Daradkeh, Ghazi. "Mobile application for diabetes control in Qatar". *International Conference on Computing Technology and Information Management (ICCM)*, 2012.

[27] Hung, K. Lee, C., and Choy, S. O. "Ubiquitous Health Monitoring: Integration of Wearable Sensors, Novel Sensing Techniques, and Body Sensor Networks. *Mobile Health.* pp. 319-342. 2015.

[28] Abdalla, I. "Evaluating effectiveness of e-blackboard system using TAM framework: A structural analysis approach". *AACE Journal*. Vol. 15(3), pp. 279-287, 2007.

[29] Boulos, M. N., S. Wheeler, S., Tavares, C. and Jones, R. "How smartphones are changing the face of mobile and participatory healthcare: an overview, with example". *Ecaalyx. Biomedical engineering online*. Vol. 10(2), pp. 24, 2011.

[30] Kumar, S., Nilsen, W., Pavel M., and Srivastava, M. "Mobile health: revolutionizing healthcare through trans disciplinary research". *Computer.* pp. 28-35, 2013.

[31] Leonard, T. L. *Improving the failure-to-attend occurrences in an inner-city family medical practice: Utilizing short message system text messaging as a patient reminder system. 2015.*

[32] Lester, W. T., Zai, A. H., Chueh, H. C. and Grant, R. W. "Diabetes information technology: designing informatics systems to catalyze change in clinical care". *Journal of diabetes science and technology*. *Vol*. 2(2): pp. 275-283, 2008.

[33] Olalere, T. *Methodology in accounting research: A critique of taxonomy. 2011.*