

Development and Primary Evaluation of a Smartphone Application for Blood Glucose Control in Hospitalized Patients

Abstract

Background: Diabetes is one of the major causes of morbidity and mortality. Diabetes and hyperglycemia are leading causes for cardiovascular diseases, chronic infections, and other serious problems. The use of smartphone is dramatically increasing, and as such, it is sensible to use an application for management of hospitalized patients with diabetes or hyperglycemia. We designed a software for physicians by use of which they educate to take appropriate decisions in management of patients with diabetes and evaluated the quality of the application using a questionnaire. **Materials and Methods:** Application is designed in a cascade framework to help in management of patients with diabetes and hyperglycemia. The treatment protocols presented in the program were extracted from diabetes management guidelines and valid review articles. Furthermore, we developed a questionnaire to assess the quality of the program. Physicians ($n = 36$) used this program for 1 week after which they completed the questionnaire. **Results:** The physicians described the application to be useful and understandable. **Conclusion:** A high percentage of physicians and health providers are aware of the problems when it comes to hospitalized patients with diabetes and our application was designed to resolve the associated difficulties.

Keywords: Diabetes, education, hyperglycemia, mobile application, software

Introduction

Diabetes mellitus (DM) is one of the major causes of morbidity and mortality in the world.^[1,2] In 2016, 422 million adults were estimated to suffer from diabetes worldwide.^[3] Hyperglycemia with or without previous DM may complicate the medical condition and outcome of every hospitalized patient.^[4-8] It is well known that good glycemic control is mandatory for improvement of the outcome of any patient admitted to the hospital.^[4,5,9] The situation is somehow complicated because the reason for admission comprises a wide range of conditions with different patient's characteristics and needs. For example, the patients who are planned for an operation, those who are on high-dose glucocorticoids, total parenteral nutrition, or at intensive care settings, each have different treatment goals and various management tools.^[5,10] On the other hand, management of hyperglycemia in patients who are affected by acute or chronic complications of DM (e.g., ketoacidosis, cardiovascular disease, neuropathy, nephropathy,

and retinopathy) is more difficult and challenging.^[11-16] Therefore, each person of medical team who should make a decision regarding appropriate management plan for hospitalized patients with hyperglycemia, needs distinctive knowledge, attitude, and skills.

Today, the use of smartphone has become vital part of our daily lives. Approximately, over 20 million Iranian use smartphone and also estimated that 2.53 billion people use smartphone worldwide.^[17-19] Over 100,000 health applications (app) are available on iTunes and Google Play.^[20] A lot of apps have been designed for diabetes monitoring and also patients' education, but there is no app for controlling blood glucose in hospitalized patients with diabetes which intended to be used by physicians.

To enhance the quality of care provided for patients with diabetes and hyperglycemia, we designed and developed an application for physicians by use of which they become able to take appropriate decisions in management of aforementioned patients.

This is an open access journal, and articles are distributed under the terms of the Creative Commons Attribution-NonCommercial-ShareAlike 4.0 License, which allows others to remix, tweak, and build upon the work non-commercially, as long as appropriate credit is given and the new creations are licensed under the identical terms.

For reprints contact: reprints@medknow.com

How to cite this article: Salehidoost R, Mirtallae E, Siavash M. Development and primary evaluation of a smartphone application for blood glucose control in hospitalized patients. *Adv Biomed Res* 2019;8:45.

Received: September, 2018. **Accepted:** January, 2019.

Rezvan Salehidoost, Elaheh Mirtallae¹, Mansour Siavash

From the Isfahan Endocrine and Metabolism Research Center, Isfahan University of Medical Sciences, ¹Department of Internal Medicine, School of Medicine, Isfahan University of Medical Sciences, Isfahan, Iran

Address for correspondence:

Dr. Mansour Siavash, Isfahan Endocrine and Metabolism Research Center, Sedigheh Tahereh Medical Research Complex, Khorram Street, Isfahan, Iran. E-mail: siavash@med.mui.ac.ir

Access this article online

Website: www.advbiores.net

DOI: 10.4103/abr.abr_188_18

Quick Response Code:



The application attempts to examine all of the different conditions of the patients admitted (preoperation, critical illness, gavage feeding, and others). In addition, we assessed the quality of the application using a questionnaire which was filled by physicians.

Materials and Methods

Search strategy

There are no approved methods to search for apps on the App Stores, but there were approximately 1000 apps with the word “diabetes” in the iTunes and the Google play. Of these, about 50% were designed with the intention of giving basic information about diabetes and the role of nutrition, about 30% was related to health tracking, and only about 10% of the applications were designed to aid health providers which merely gave information on physiological and pharmaceutical aspects of diabetes. Previous apps have been almost designed for helping clinicians to manage blood glucose in outpatient setting. These applications usually were useful only for data gathering. No application is available for step-by-step control of blood glucose in hospitalized patients with diabetes and hyperglycemia.

Application design

The application was evaluated at Isfahan University of Medical Sciences. Due to the higher prevalence of android and iPhone operating system (IOS) use in the world, and especially in Iran, the program was built on the Android and IOS platform. Great attempts were made for the application to be designed with a user-friendly interface for assisting physicians who make use of it. Applications designed in a cascade framework to help in management of blood glucose of patients with diabetes.

To design this software, first, different databases such as

PubMed, Scopus, and Google Scholar were searched. The following keywords were used to search: diabetes, hyperglycemia, inpatient management, hospitalized patients. After collecting articles, an expert team investigated the articles and therapeutic algorithms were prepared from the selected articles. Algorithms were changed to software by Tariana Software Company that was expert in this field. Schematic view of algorithms is presented in Figure 1 (only initial steps are shown). The scheme summarizes the primary steps of the program to help in understanding the system by which the application works. The application operates by asking the required questions in each step and providing the necessary data needed for therapeutic procedures to the physician. The capacity of this program is 9.3 MB and can be performed by android systems with the version of 4 and more. The required random access memory is the minimum one.

Application assessment

To assess the application, a questionnaire containing 10 questions about the quality of the program was developed. Physicians ($n = 36$) used this program for 1 week after which they completed the questionnaire. The results are shown in Table 1. During this time, the designing team received suggestions and reports of problems regarding the application from users.

Results

To evaluate the quality of the application, it was used by 36 physicians for 1 week. They completed a questionnaire consisting of 10 questions that assessed the different performative aspects of the application. During the 1-week testing period, experts were able to report their problems and give suggestions about the app. The results are given in Table 1. As shown in Table 1, 72.1% of the physicians

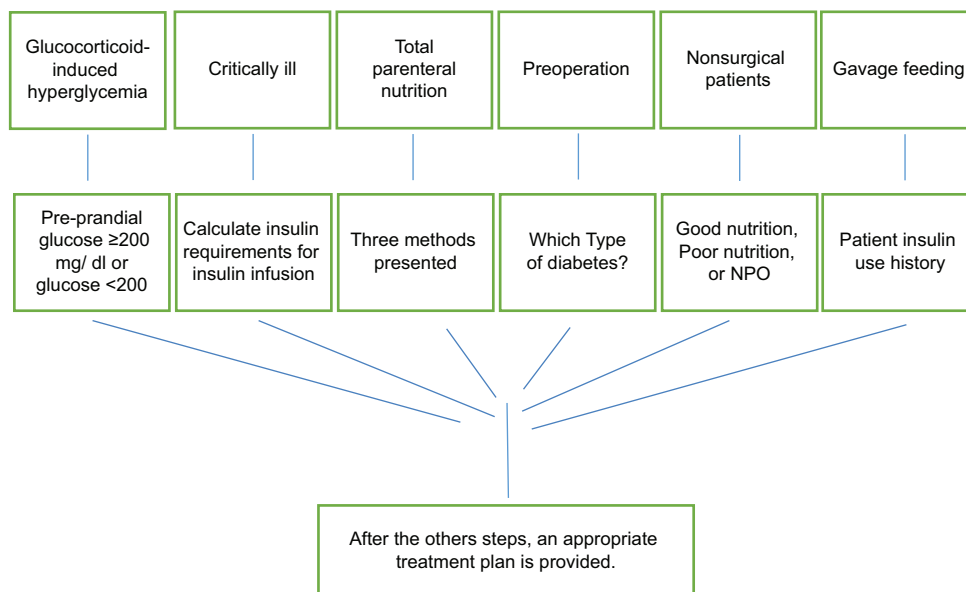


Figure 1: Flow diagram illustrating schematic view of application steps (only initial steps are shown)



Figure 2: Some screenshots of different parts of the app

described the application to be user-friendly (high and very high). Moreover, 69.3% reported the application to be very necessary for health providers, especially physicians [Figure 2]. More than 77% of physicians described that the design of application is appropriate, 88% mentioned that the texts are understandable and legible, and 80.4% described the different steps of application are well sequenced. Based on the appraisal, the application has helped physicians in course of treatment process. Using the software was easy for the vast majority of physicians. More information is provided in the Table 1.

Discussion

We designed a program by use of which physician can manage the hospitalized patients who also suffer from diabetes or hyperglycemia. Management of patients with diabetes and hyperglycemic is very important, as failure to do so can lead to serious complications, namely, postsurgical problems, vascular problems, and chronic infectious diseases.^[4,5,8] Moreover, with increasing the prevalence of diabetes and hyperglycemia, a higher percentage of hospitalized patients admitted for various reasons such as trauma have diabetes and hyperglycemia.^[21] Therefore, an application that can provide the necessary information quickly to the physician and other health-care providers is required, as this will bring about a decreased rate of medical errors. A large number of applications aimed at patients with diabetes are now available in app stores.^[22] One of the previous studies, conducted by Arnhold *et al.* in 2014, reviewed mobile applications pointed at diabetes.^[22] They concluded that despite the large number of applications for diabetes, few of them are beneficial and most of them have little functionality.^[22] This app has some advantages and limitations. It is a user-friendly software; it helps the physicians to make correct decisions

Table 1: Physicians’ response to questionnaire intended for evaluating the application (n=36)

Aspects	Questions	Satisfaction				
		Very low (%)	Low (%)	Moderate (%)	High (%)	Very high (%)
Simplicity	1. The application is user-friendly	0	0	10 (27.7)	20 (55.5)	6 (16.6)
	2. Application has performed successfully in each use	0	0	20 (55.5)	13 (36)	3 (8.3)
	3. It was easy to learn how to operate the program	0	0	6 (16.6)	17 (47.2)	13 (36)
Comprehensibility	4. The texts are understandable and legible	0	1 (2.7)	3 (8.3)	17 (47.2)	15 (41.6)
	5. Different steps are well sequenced	0	0	7 (19.4)	19 (52.7)	10 (27.7)
User interface	6. prominent tasks and duties are highlighted	0	0	7 (19.4)	17 (47.2)	12 (33.3)
	7. The graphical design of the application is appropriate	0	2 (5.5)	6 (16.6)	17 (47.2)	11 (30.5)
Usefulness	8. The application facilitates the treatment process	0	0	6 (16.6)	20 (55.5)	10 (27.7)
	9. Physicians need this app	0	0	11 (30.5)	11 (30.5)	14 (38.8)
	10. The application works to my expectations	0	2 (5.5)	11 (30.5)	14 (38.8)	9 (25)
Total		0	5	87	165	103

step by step and its design is convenient. Different groups can use this app (e.g., physicians, nurses, and medical students). The application has also some limitations such as Persian language of the software. The applied units of blood glucose are mg/dl, and the software does not have the capability to change mmol/L to the mg/dl or vice versa.

Moreover, there is almost no application for step-by-step managing of patients for physicians. In view of these circumstances, our application can resolve these issues. Furthermore, according to the results of the questionnaire, the vast majority of physicians considered that the application is useful and understandable.

Conclusion

Using the application to control blood glucose in hospitalized patients with diabetes and hyperglycemia can be very rewarding. In addition, a high percentage of physicians and health providers are aware of this void and our program was designed to resolve the associated difficulties. Due to the cascading framework of this program, not only is it easy to master, but also a very slight error rate exists too.

Financial support and sponsorship

This study was financially supported by Isfahan University of Medical Sciences, Isfahan, Iran.

Conflicts of interest

There are no conflicts of interest.

References

- Economic consequences of diabetes mellitus in the U.S. in 1997. American Diabetes Association. *Diabetes Care* 1998;21:296-309.
- Narayan KM, Gregg EW, Fagot-Campagna A, Engelgau MM, Vinicor F. Diabetes – A common, growing, serious, costly, and potentially preventable public health problem. *Diabetes Res Clin Pract* 2000;50 Suppl 2:S77-84.
- World Health Organization. Global Report on Diabetes. Geneva: World Health Organization; 2016.
- Capes SE, Hunt D, Malmberg K, Gerstein HC. Stress hyperglycaemia and increased risk of death after myocardial infarction in patients with and without diabetes: A systematic overview. *Lancet* 2000;355:773-8.
- Capes SE, Hunt D, Malmberg K, Pathak P, Gerstein HC. Stress hyperglycemia and prognosis of stroke in nondiabetic and diabetic patients: A systematic overview. *Stroke* 2001;32:2426-32.
- Umpierrez GE, Isaacs SD, Bazargan N, You X, Thaler LM, Kitabchi AE, *et al.* Hyperglycemia: An independent marker of in-hospital mortality in patients with undiagnosed diabetes. *J Clin Endocrinol Metab* 2002;87:978-82.
- Wahab NN, Cowden EA, Pearce NJ, Gardner MJ, Merry H, Cox JL, *et al.* Is blood glucose an independent predictor of mortality in acute myocardial infarction in the thrombolytic era? *J Am Coll Cardiol* 2002;40:1748-54.
- Yendamuri S, Fulda GJ, Tinkoff GH. Admission hyperglycemia as a prognostic indicator in trauma. *J Trauma* 2003;55:33-8.
- McAlister FA, Majumdar SR, Blitz S, Rowe BH, Romney J, Marrie TJ, *et al.* The relation between hyperglycemia and outcomes in 2,471 patients admitted to the hospital with community-acquired pneumonia. *Diabetes Care* 2005;28:810-5.
- Duggan EW, Carlson K, Umpierrez GE. Perioperative hyperglycemia management: An update. *Anesthesiology* 2017;126:547-60.
- Kalladka M, Greenberg BL, Padmashree SM, Venkateshaiah NT, Yalsangi S, Raghunandan BN, *et al.* Screening for coronary heart disease and diabetes risk in a dental setting. *Int J Public Health* 2014;59:485-92.
- Lloyd-Jones DM, Larson MG, Beiser A, Levy D. Lifetime risk of developing coronary heart disease. *Lancet* 1999;353:89-92.
- Onat A, Dönmez I, Karadeniz Y, Cakır H, Kaya A. Type-2 diabetes and coronary heart disease: Common physiopathology, viewed from autoimmunity. *Expert Rev Cardiovasc Ther* 2014;12:667-79.
- Rao Kondapally Seshasai S, Kaptoge S, Thompson A, Di Angelantonio E, Gao P, Sarwar N, *et al.* Diabetes mellitus, fasting glucose, and risk of cause-specific death. *N Engl J Med* 2011;364:829-41.
- Vasan RS, Beiser A, Seshadri S, Larson MG, Kannel WB, D'Agostino RB, *et al.* Residual lifetime risk for developing hypertension in middle-aged women and men: The Framingham Heart Study. *JAMA* 2002;287:1003-10.
- Wong ND, Patao C, Malik S, Iloeje U. Preventable coronary heart disease events from control of cardiovascular risk factors in US adults with diabetes (projections from utilizing the UKPDS risk engine). *Am J Cardiol* 2014;113:1356-61.
- Young Adults and Teens Lead Growth Among Smartphone Owners Nielsen: newswire; 2012. Available from: <http://www.nielsen.com/us/en/insights/news/2012/young-adults-and-teens-lead-growth-among-smartphone-owners.html>. [Last accessed on 2018 Feb 15].
- Agency Tn. Over 20 Million Iranians use Smart Phones; 10 June, 2015. Available from: <https://www.en.trend.az/iran/society/2404528.html>. [Last accessed on 2018 Mar 17].
- Teens LA. Smartphones and Texting. Pew Internet and American Life Project; January, 2013. Available from: <http://www.pewinternet.org/2012/03/19/teens-smartphones-texting/>. [Last accessed on 2018 May 21].
- Carroll JK, Moorhead A, Bond R, LeBlanc WG, Petrella RJ, Fiscella K, *et al.* Who uses mobile phone health apps and does use matter? A secondary data analytics approach. *J Med Internet Res* 2017;19:e125.
- Mokdad AH, Ford ES, Bowman BA, Dietz WH, Vinicor F, Bales VS, *et al.* Prevalence of obesity, diabetes, and obesity-related health risk factors, 2001. *JAMA* 2003;289:76-9.
- Arnhold M, Quade M, 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. *J Med Internet Res* 2014;16:e104.

© 2019. This work is published under

<https://creativecommons.org/licenses/by-nc-sa/4.0/>(the “License”).

Notwithstanding the ProQuest Terms and Conditions, you may use this content
in accordance with the terms of the License.