Original Article

Developing "Aryan:" Diabetes Self-care Mobile Application

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Abstract

Background: Diabetes as a chronic and progressive disease leads to multiple complications. Therefore, it is important to control and treat it. More effective control of this condition and the provision of therapeutic approaches require awareness and active participation of patients in self-care. In this regard, a smartphone that is accessible to most people at anytime and anywhere and is easily applicable can be useful in self-care diabetes, with the ability to install various applications. This study aimed to develop a diabetes self-care mobile application as a suitable solution for self-managing diabetes for Iranians. **Methods:** We conducted a mixed methods study in three Phases: (1) comparative study of existing mobile applications; (2) developed its object-oriented conceptual model; and (3) developed the initial version of "Aryan" that was approved for production. **Results:** This application was designed for the appropriate diabetes self-care, with following functionalities: The user ID and his/her personal page setting; generating self-care reports such as blood glucose, nutrition, physiological indicators, physical activities, and patient history reports; care setting; providing patient training materials; nutrition control; insulin and other medications control; blood glucose and key tests control; and other paraclinical tests. **Conclusions:** "Aryan" has been designed in compliance with Iranian experts' opinions. It is expected "Aryan" plays an effective role in self-care of patients with diabetes.

Keywords: *Diabetes mellitus, mobile applications, self-care*

Introduction

Diabetes, as a common metabolic disorder, will be affected on more than 6 million Iranians by 2030. It causes complications, reduces life quality, decreases life expectancy, and increases mortality, and its treatment imposes a great deal on society.[1-4] People with diabetes can control their condition and increase their life quality through self-care.[5] It requires increasing patient responsibility and training from the health-care staff about medication, exercise, and diet for self-monitoring, psychological adjustment, and clear understanding of the disease.[6-10]

Today, Information and Communication Technology development has prepared mobile technology presence in health field, and it is possible to provide a variety of health services using it at anytime and anywhere.[11,12] Mobile can reduce costs and increase access to health services by improving health-care process productivity.[13] Therefore, we conducted this study to develop diabetes self-care mobile application ("Aryan") to increase diabetics' participation in their own care process as well as playing self-care role in controlling blood glucose, managing physical activity and nutrition.

Methods

This is a mixed method study which be conducted in three phases from 2014 to 2017 as followings:

Phase 1: Comparative study of some existing mobile applications and providing a comparative model for Iran: In the first step of this phase, we searched for diabetes self-care mobile applications and their related articles to identify features of the applications. In this step, we analyzed content of 38 mobile applications (Diabetes journal, e-SMBG, Sugar log, Live better life with diabetes, Sugar tracker, Blood Sugar log, Diabetes diary, Diabetes insulin calculator, Diabetes log book, Sugar sense, Diabetes log, Scrivvy blood, Get to HbA1C goal, Diabetes tracker, diaguard, My diabetic log, 2 in 1 diamon, Glucose tracker, diabelog, Gluco star, Diabetes checker, Diabetes coach [free], My diabetes dairy, Dia tracker, My Sugar diary, Diabetes companion, Diabetes studio, Mobiab diet, laborom, Life span

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measure, diabeto, I gluco, Diabetes pa, My glyc, Life span Diabetes Management Index [DMI], glooko, Dia vitas, Dia pilot) because of the easy installation and availability. We extracted all their features and attributes and recorded on the "data extracted form" and classified them as application functions and elements of each function in input, process, and output.

In the second step, the common extracted features were selected for a comparative model of "Aryan." To assess the validity of the comparative features and attributes, a research-made questionnaire was developed on the basis of the selected entities (with 204 questions). The reliability (Cronbach's Alpha = 0.992) and content validity of the questionnaire was confirmed. Then, the questionnaire was distributed through Delphi technique. Seventeen experts of health information technology filled technical questions, and forty-two metabolism and endocrine specialists filled clinical questions and then, obtained results were analyzed.

In the third step of this phase, the comparative modal of "Aryan" was prepared with study participants.

Phase 2: Developing its object-oriented model: In the first step of this phase, to design of the conceptual model of the initial version of Aryan, the experts panel decided to choose common features of comparative model (with the minimum agreement of 90%). Thus, in this step, 60 features were selected.

In the second step, the conceptual modal of "Aryan" application was designed through drawing unified modeling language diagrams, which include three kinds of diagrams as followings: Class diagram, Package diagram, and Activity diagram.

Phase 3: Developing "Aryan" application: In this Phase, using Android Studio software, we developed the initial version of physical model for diabetes self-care mobile application according to the findings of comparative and conceptual model. The developed application can be installed on Android operating system version 4–7.

Results

By content analysis on 38 different models, 204 features were extracted in three parts of input, processing, and output. Some of them had commonly been used in different mobile applications, but there were some features that had been used unique in some models and received special data from the user. After completing the questionnaire during one round of Delphi technique, the agreement was done on the required features of the initial version design of "Aryan" that include: the user ID and his/her personal page setting; generating self-care reports such as blood glucose, nutrition, physiological indicators, physical activities, and patient history reports; care setting; providing patient training materials; nutrition control; insulin and other medications control; blood glucose and key tests control; and other paraclinical tests.

How to perform tasks in "Aryan" application are as follows.

Input

Inputs are directly entered by a user; including demographic, medical, blood glucose, insulin and drug, physiologic, diet, and test results data. "Aryan" inputs designed based on the studied applications inputs.

Process (the application functions)

Patient data processed through the formulas such as: calculating body mass index (BMI), insulin dose, calorie intake, daily calorie intake, daily calorie distribution, mean blood glucose, BMI, carbohydrate intake, standard deviation of blood glucose and its variance, conversion of blood glucose unit (mg/Deciliter to millimole per liter), and conversion of glycosylated hemoglobin unit (percentage to millimole/mole).

Output

Includes the results of data analysis and reports include:

- Diagrams: Blood glucose, insulin dose, carbohydrate intake, and BMI
- Means: Blood glucose, carbohydrates, blood pressure, weight, physical activity steps
- Some calculation reports: Changes in weight and BMI, blood glucose standard deviation and its variance, the last, maximum and minimum amount of blood glucose, the last and maximum blood pressure
- Histories: Accumulative reporting all user-entered items within a specific time frame
- Reminders: Reminding blood glucose test, medication administration, and insulin injection at the appointed time
- Calculation results: BMI, required insulin dose, energy, and carbohydrate of intake meal, daily calorie intake, distribution of daily calories per meal [Figure 1].

Discussion

Diabetes self-care requires patient participation in controlling the disease using appropriate methods. In Iran, much effort has been devoted to determining the extent of the use of diabetes mobile applications in self-care and little mobile applications has been developed in this area that offers more textual or short message training to diabetics.

In Iran, in comparison with other countries, less studies have been done on diabetes self-care mobile applications. However, the interest and eagerness of health-care providers and diabetics in self-care for diabetes and the use of mobile technology for it is remarkable. Therefore, Aryan functions make it possible to control nourishment, physical activity, medication (especially insulin), and blood glucose.

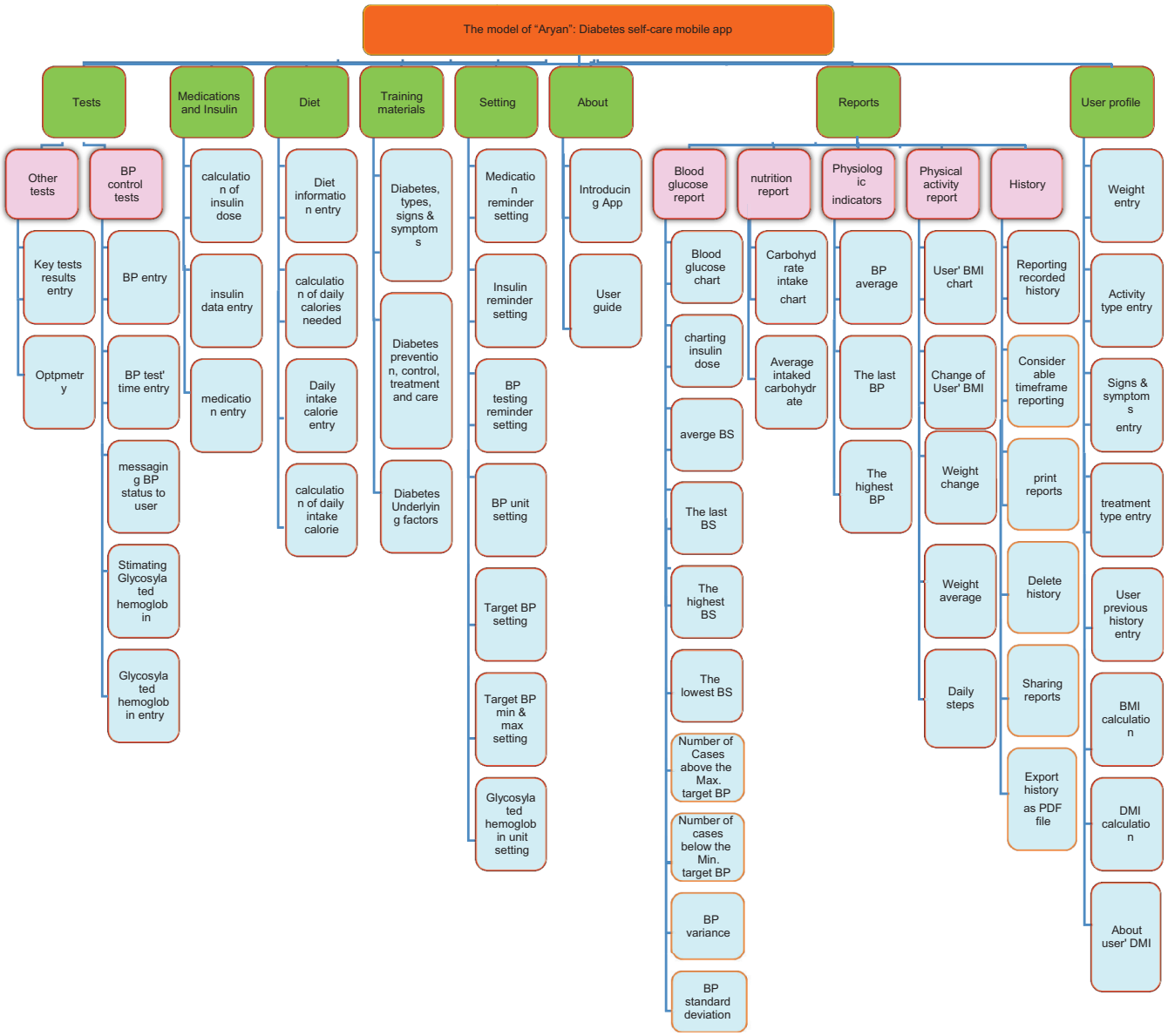

Figure 1: The model of "Aryan" (Diabetes self-care mobile application)

It promotes the patient' direct participation in the care and improves self-care, through sharing test results and analytical reports at regular intervals among the treatment team as well as the ability to set up a variety of essential reminders such as blood glucose measurement, medication administration, and insulin injection.

More desire to exercise leads to good fitness level and a better sensitivity to insulin. Thus, during exercise, blood glucose levels decrease.[14] By "Aryan," user controls his/her physical activity and improves his/her blood glucose levels through recording weight and its changes, BMI and its changes, and average daily walking steps. Studies show of weight loss, reduction of BMI, physical activity, and aerobic exercise has a direct impact on improving blood glucose level, glycosylated hemoglobin level, decreasing insulin resistance, and preventing complications of diabetes.[14,15]

Energy intake and metabolism control, especially carbohydrates, affects the glucose level in diabetic patients.[16,17] By Aryan, user chooses the type and amount of his/her food and controls the absorption of calories and carbohydrates, through calculating the amount and average calorie intake foods and registering them, calculating the daily calorie requirement (based on gender, age, height, weight, and activity), and the average carbohydrate intake. Gökşen *et al*.and Dussaillant *et al*. findings also showed that nutritional control, adherence to appropriate dietary patterns, and knowledge of nutritional behavior modification have a positive effect on improving diabetics' blood glucose and their quality of life.[18,19]

One of the cornerstones of diabetes, management is insulin administration management as a blood glucose lowering agent.[20] By "Aryan," user can use standard rules to

calculate the injectable insulin dose (based on weight, target blood glucose, current blood glucose, and carbohydrate intake) and contribute to maintaining his/her optimal blood glucose level. "Aryan" determines the type of diabetes treatment (by medication, insulin, and both), records insulin data, calculates the dose of insulin, and records current medications, in addition to sharing medication and insulin data with the care team. Cani *et al*. and Capoccia *et al*. findings confirmed the effect of compliance with the rules of insulin administration, the control and balance of consumption, and the timing and dose of medication and insulin on the control of diabetes.[21,22]

The patient history effects on the pathobiology of diabetes and its care planning.[23] User can record in "Aryan" his/her history and share it with the care team to determine how to relate history to diabetes and to adopt an appropriate care plan through health providers. There is a relationship between some of the underlying diseases in diabetes and emphasized the need for control of underlying diseases simultaneously with the control of diabetes.[23]

Training and enhancing the knowledge, attitude, and skill of diabetics is very effective in controlling and managing the disease. Strawbridge *et al*. found that diabetes self-management training leads to lower health service utilization, costs, and the burden of diabetes on both individuals and the health care system.[24] "Aryan" provides training materials about diabetes, its signs and symptoms, control, care, treatment, and the underlying causes. By increasing his/her awareness of the disease, the user can further motivate the adherence to care, and more willingness to search for training content. Various studies have also shown the effect of providing training materials on better control of metabolism and nutrition, diabetic feet care, blood glucose, BMI, and self-care behaviors.[25-27]

Patient and clinical team awareness about diabetes signs and symptoms (as a prognosis and side effects of diabetes) affects diabetes care planning. According to Kishore *et al*., people training about diabetes care is necessary to prevent a huge financial and health burden of diabetes complications.[28] "Aryan," while providing training materials on signs and symptoms, has the ability to determine and share it for the user to help the clinical team to diagnose the type and complications of diabetes, which increases the severity and sensitivity of the patient's perception of diabetes signs, symptoms and complications, and improves self-care levels of diabetes.

Regular reporting in the form of graphs and printable text and sharing it for the clinical team will help the patient and clinical team to adapt data and track the progression and improvement of diabetes.[29,30] "Aryan" provides graphs for the user's BMI, carbohydrate intake, blood glucose and insulin dose and plays an effective role in controlling nutrition, physical activity, blood glucose, and insulin injection, through reporting patient histories.

Controlling the physiological indicators is critical for controlling blood glucose and reducing diabetes side effects such as cardiovascular outcomes.[31] "Aryan" controls blood pressure changes and prevents uncontrolled blood pressure complications by calculating the average blood pressure of the user, and his/her last and highest blood pressure. Findings of Mbanya *et al*. and Kamoi revealed that proper control and the use of a consistent blood pressure monitoring, the determination of the target blood pressure level and its timely measurement, are effective and useful in controlling the diabetes complications of large and small blood vessels (including ocular complications) studies have emphasized the need to review blood pressure training programs.[32,33]

Mobile health interventions improves medication adherence of Type 2 diabetics and can trigger timely action.[34] "Aryan" allows the user to set reminders for medication administration and insulin injection (based on a specified amount and the desired or recommended time), and reduce forgetfulness effects, medication administration or insulin injections mistakes, and medication interactions as well as checking blood glucose regularly. As it is revealed in Celik *et al*. and Heatley *et al*. findings, mobile reminder, as an effective method, improves insulin self-administration and controls metabolism.[35,36]

Target blood glucose determination leads to make the diabetics aware of the desired blood glucose level. In "Aryan" the range of target blood glucose is calculated according to diabetes type and the user age. In addition, based on this range, following the user entering blood glucose, a message is displayed to him/her containing blood glucose status. According to Jiang, maintaining target blood glucose can improves cardiac dysfunction. It also improves the quality of diabetics' life effectively.[37]

Regular self-monitoring of blood glucose (SMBG) is a factor in improving glycemic control, glycosylated hemoglobin and the management of insulin-treated Type 2 diabetes.[37-39] With "Aryan," diabetics can control their blood glucose level in the desired range, by registering blood glucose and its average, its last, maximum and minimum amount, variance and standard deviation, and then by sharing reports and charts. In "Aryan" also the amount of glycosylated hemoglobin is estimated based on the amount of blood glucose. The findings of Thevarajah indicated that glycosylated hemoglobin should be measured using standard and accurate methods to determine diabetics' blood glucose level and timely prevention of diabetes complications.[40]

Due to the negative impact of diabetes on retina small vessels, diabetic vision examination is essential to avoid diabetic eye disease and its timely treatment.[41,42] In "Aryan," visual examination has been prepared to measure the user visibility, so that diabetics can participate in eye examinations and prevent the occurrence of ocular

complications and blindness, by sending digital images or visual examination result. By taking a visual examination, using an affordable method and by sending digital images or the result of a remote visual examination can avoid the prevalence of ocular complications and blindness.[43]

Based on the patient's compliance or noncompliance with regular glycosylated hemoglobin and blood glucose measurements, medication administration program, BMI control, nutritional control, physical activity, blood cholesterol measurement, visual examination and foot care, "Aryan" calculates DMI and provides recommendations for preventing diabetes. This indicator is also included in the DMI mobile application, developed by Life Span's professionals in India.[44]

Regarding the growing trend of diabetes and the importance of its preventing, controlling and treating, and developing diabetes-related mobile applications around the world, diabetics can participate in their own care process, through the development native model of the application, according to the metabolism and endocrine professionals as well as health information technology specialists, so that diabetics can play their self-care role in the process of controlling their blood glucose, by timely measuring it and insulin dose while controlling their physical activity and nutrition. Therefore, introducing such application to diabetics and diabetes research and control centers in Iran through national media, as well as its utilization reviewing, can be helpful in diabetes controlling.

Conclusions

"Aryan" has been designed in compliance with Iranian experts' opinions. It is expected "Aryan" plays an effective role in self-care of patients with diabetes.

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Conflict of interest

There is no conflict of interest.

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