Advancement level of mobile applications intended for type 1 diabetes therapy supporting

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ABSTRACT

Diabetes mellitus is a group of metabolic diseases characterized by hyperglycaemia due to defective secretion and/or action of insulin. Chronic hyperglycaemia is associated with damage, dysfunction, and failure of various organs, in particular eyes, kidneys, nerves, heart, and blood vessels. It is estimated that the number of patients with type 1 diabetes accounts for about 10% of all diabetics, even more children and young adults i.e. under 30 constitute between 85 – 90 % of morbidities. The fundamental part of type 1 diabetes therapy is providing patient with an external insulin therapy. The objective of this research was to

formulate requirements concerning mobile applications for diabetes 1 therapy as well as an overview and a classification of such applications currently available. This paper includes a set of 20 requirements for mobile applications intended for type 1 diabetes patients. Some of them are beyond the possibilities of the modern-day IT industry. Nowadays there is no applications that meets all of the criteria. However, the tendency to fulfill all of them can be noticed.

Key words: type 1 diabetes mellitus, therapy of type 1 diabetes, mobile applications

INTRODUCTION

According to the definition formulated by the Polish Diabetic Association "diabetes mellitus is a group of metabolic diseases characterized by hyperglycaemia due to defective secretion and/or action of insulin. Chronic hyperglycaemia is associated with damage, dysfunction, and failure of various organs, in particular eyes, kidneys, nerves, heart, and blood vessels" [1]. The definition emphases that diabetes mellitus is not a single disease but a group of them with a common characteristic that is hyperglycaemia. The definition explains also two main causes regarding the increase in serum glucose [2].

The fundamental part of type 1 diabetes therapy is supplying a patient's body externally with an analog insulin analog [3]. There are plenty of insulin analogs available on the market that are able to imitate human insulin secretion with increasing precision [4]. The aim of the insulin therapy is to maintain life, preventing complications of diabetes and providing patient with a good quality live. The success is possible only by mimicking healthy pancreas action with proper injections of insulin analogs [5].

Nowadays there is a possibility to conduct a therapy of diabetes mellitus using computer programs that are available as mobile applications intended for smartphones. Due to this it is feasible to use such programs almost at any time and any place. At present computer programs at the service of diabetes constitute a leading group of modern tele-medicine. The diabetes epidemic is visibly reflected in a big number of applications intended for diabetics. These programs offer different functionality most important of which are helping with blood glucose level self-control, reporting of carbohydrate intake, physical activity, body weight, blood pressure, logging drugs taken orally and injected insulin, calculating of insulin doses and so on. In 2013, approximately 390 applications for iOS platform and 380 for Android operating system were available for diabetic patients [7].

OBJECTIVE

The objective of this research has been to formulate a list of requirements concerning mobile applications regarding diabetes 1 therapy as well as an overview and classification of such applications that are available on the market.

MATERIALS AND METHODS

The research has been narrowed down to mobile applications for Android operating system only. However, most of the presented applications are also available for iOS operating system. All of the information has been sourced from the web pages of the developers. The criteria for including an application for the analysis have been: (1) the application is available at play.google.com, (2) the application is useful in diabetes treatment, (3) the application or at least its basic version is available free of charge. Fourteen applications with highest download rate from about 250 available have been included in the analysis.

The applications have been divided into 3 groups: a) simple ones developed by individual programmers, b) applications created for specific medical equipment, c) advanced commercial products. The three groups of software are being developed in different circumstances what influences their potential and speed of growth. Due to the large offer of the software in question, only a few in each group have been selected for presentation in order to depict modern trends in the areas. Descriptions of the applications focus mainly on the implementation of the postulated therapeutic functions. Additional functionality, such as units' conversions, location or quality of an interface, has not been taken into account. The authors of the article did not test all of the functions of the presented applications and cannot state if the applications always work correctly.

RESULTS

The scale of expectation for mobile applications

Referring to a mobile application supporting the therapy of type 1 diabetes we mean a computer program that is an extension of the medical equipment that patient has already acquired and been using. Whereby, the equipment may be successfully utilized without the application. Such application only supports creating and managing a database of the therapy, making decisions and planning events. The patient is still responsible for conducting his or her therapy. The Table 1 lists and describes requirements for such applications. These requirements have been ranked from the simplest to the most advanced ones. This list is the

authors' original proposal developed based on their own experience in the treatment of type 1 diabetes. All these requirements are derived from the therapeutic point of view (Tab. 1).

Table 1. Expectations for mobile applications supporting the therapy of type 1 diabetes.

	Function name	Description of the function
1.	Database	Archiving all the events important for the therapy such as: glucose levels, eaten meals, physical and mental efforts, past sickness. This function facilitates studding history of the therapy. All the records stored here is referred farther as data.
2.	Data presentation	Delivering the data in a readable form of tables, charts etc.
3.	Data analysis	Statistical processing of the data: indicating trends, searching for periodicity, localizing problems etc.
4.	Data acquisition	Automatic collecting of the data.
5.	Data backup	Archiving the data in an external storage in case of loss of a mobile device.
6.	Remote information	Sending real time data to another person, e.g. a parent. This function let the person monitor the patient's condition and take an action by other methods, e.g. telephone call.
7.	Meal assistant	Composing a meal and designing a bolus.
8.	Equipment assistant	Controlling reserves of medical equipment and drugs. Controlling state of the equipment.
9.	Effort assistant	Preparing for physical or mental effort.
10.	Sickness assistant	Aid in short-term sickness time.
11.	Extreme situation assistant	Aid in extreme situation such as an accident or trapping.
12.	Knowledge base about the disease	Medical information about type 1 diabetes with the answers how to deal with typical problems.
13.	Knowledge base about the patient	Knowledge base about the type 1 diabetes returned personally to the patient.

		This function helps to solve individual problems.
14.	Community participation	Shearing therapeutic data on the Internet for consultation or as research data.
15.	Short-term forecasting	Prediction of glucose level up to 3 days based on a computer metabolic model. Proposing changes to the settings of therapy parameters.
16.	Long-term forecasting	Anticipating the prospects of disease development up to a year based on the history of the therapy.
17.	Alerts	Predicting of sudden or recurring emergency situations and effective notification of them.
18.	Psychological support	Recognition and taking action in a situation of lowering mental condition of the patient.
19.	Control of medical equipment	Automatic controlling of medical equipment including changing the therapeutic settings.
20.	Android interface	The application mimics a being with a personality. The contact with application uses phone calls, short message service, multimedia messaging service. The application can interact with other persons in order to make appointments or ask for help.

Review of mobile applications supporting the therapy of diabetes 1

Simple applications

Simple applications meet expectations numbered 1 and 2. Two Polish programs are included among them: *Cukrzyca* [6] (Fig. 1a) developed by Szymon Klimaszewski and *Betes – Dziennik Cukrzycy* [7] created by Mateusz Drzazga. To this group we can also assignedalso Canadian program *Diabetes Journal* [8] (Fig. 1b) by company Suderman Solutions, Russian *Diabetes Diary* [9] by mEL Studio, Austrialian *Diabetes Monitor* [10] written by Huan Nquyen. It is easy to find plenty of corresponding applications on the Internet all over the world.

One of the most interesting application in this group is Australian *Diabetic Calculator* [11] (Fig. 1c), which except the requirements 1 and 2 implements also function no 7 i.e. the meal assistance. This program has been written by an individual programmer for his own use.

Fig. 1. Selected screenshots of the applications under discussion: a) *Cukrzyca* [6], b) *Diabetes Journal* [8], c) *Diabetic Calculator* [11]

There are also simple educational mobile programs for smartphones that meet the expectation 12 i.e. knowledge base. The examples here can be: *Diabetes : How to Control Diabetes, Diabetes Diet* [12] by the company Vdicts and *Diabetes and Symptoms* [13] by Appz Inventors. Browsing this group of applications, it can be notice that the expectation no 7 is covered by plenty of small applications. The following can be distinquished: Polish program *Indeks Glikemiczny* [14] by Mobiem company and *Diabetic Diet Recipes: Control Diabetes & Sugar* by Edutainment Ventures from USA [15].

Applications created for specific medical equipment

Mobile applications developed as a supplementation to a specific medical equipment constitute a separate group. This group of applications is interesting because they are integrated with the medical hardware perfectly. By extension, the functionality no 19 is achieved very well if used with dedicated equipment. It is the sale of the equipment what finances development of such software. On the other hand, the programmers are in close contact with patients. It helps to improve the applications based on quick feedback.

A good example here is *mylife™App* [16] (Fig. 2) developed for a German insulin pump mylifeYpsoPump manufactured by *Ypsomed* [17]. When using this application, it is easy to

keep records of all therapeutic documentation. Data is collected automatically from the insulin pump via a Bluetooth connection. The data can be presented in the legible form of tables and charts. Basic statistical calculations are performed. The data of individuals patient is gathered in the company computational cloud so it is secured in the case of a patient's equipment crush and can be easily shared with others. The application let the user check current and previous settings of their insulin pump. This functionality enables to study effectiveness of the therapy. The application meets the expectations from no 1 to no 7, as well as no 13 and no 19. However, the full potential of this applications comes only with the dedicated insulin pump.
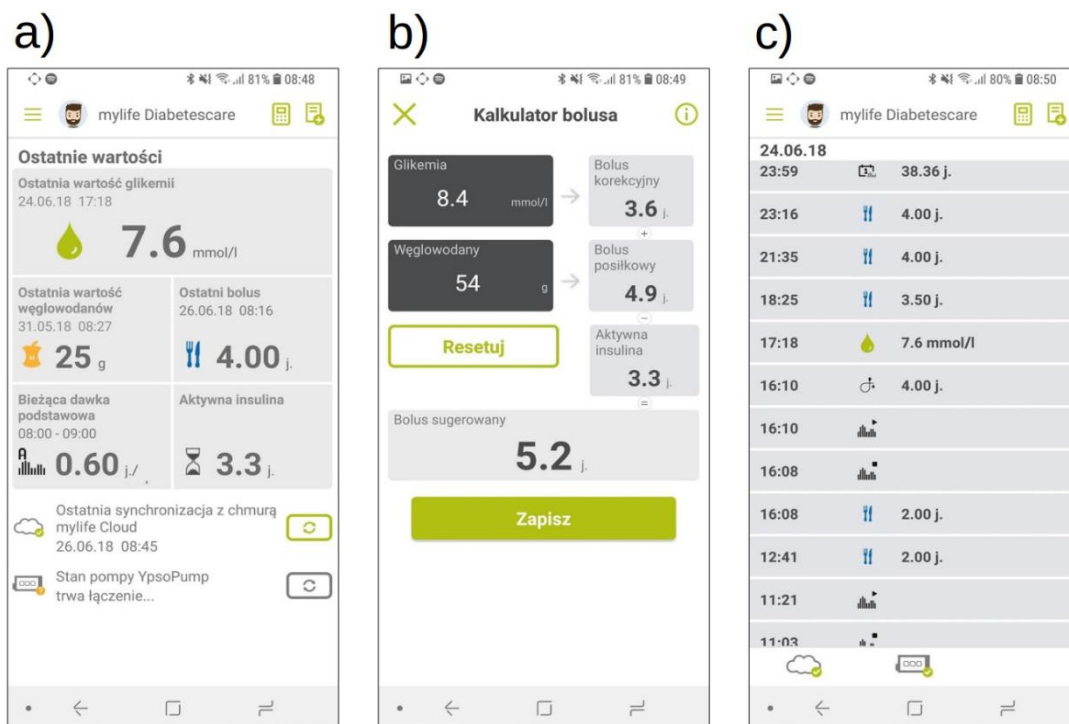

Fig. 2. Screenshots of *mylife™App* [16]: a) last activity quick list, b) bolus calculator, c) history of therapy events.

Advanced commercial products

When using the name advanced commercial products, we have in mind multipurpose software systems manufactured by professional enterprises in a scheduled engineering process. Such applications are able to connect to most of popular insulin pumps and glucose meters and offers sophisticated algorithms.

Nowadays the best know application in this group is an Austrian program *mySugr* [18] (Fig. 3). The project has been started in 2012. It has got many language versions and is used all over the world. It is a commercial product which basic version is free of charge,althoughtheir professional full version requires payment. The application implements the requirements from

no 1 to no 5 in a very good way. It means that the application automatizes keeping a diabetes diary. It offers easy and quick presentation module of therapeutic data including statistical calculations. User data is stored in the company's database and thus protected against loss. A meal assistant (requirement no 7) is available in the form of carbohydrate and insulin calculator. It is possible to note events related to the therapy such as efforts, sickness, emotional states, which mean partial implementation of expectations 9, 10 and 11. The application predicts the level of HbA1c glycated hemoglobin based on observation of blood sugar levels. Therefore, it is a fragmentary implementation of point 16. Using the application gives the opportunity to participate in a wide community of people involved in the subject of diabetes so the functionality 14 is fulfilled as well.
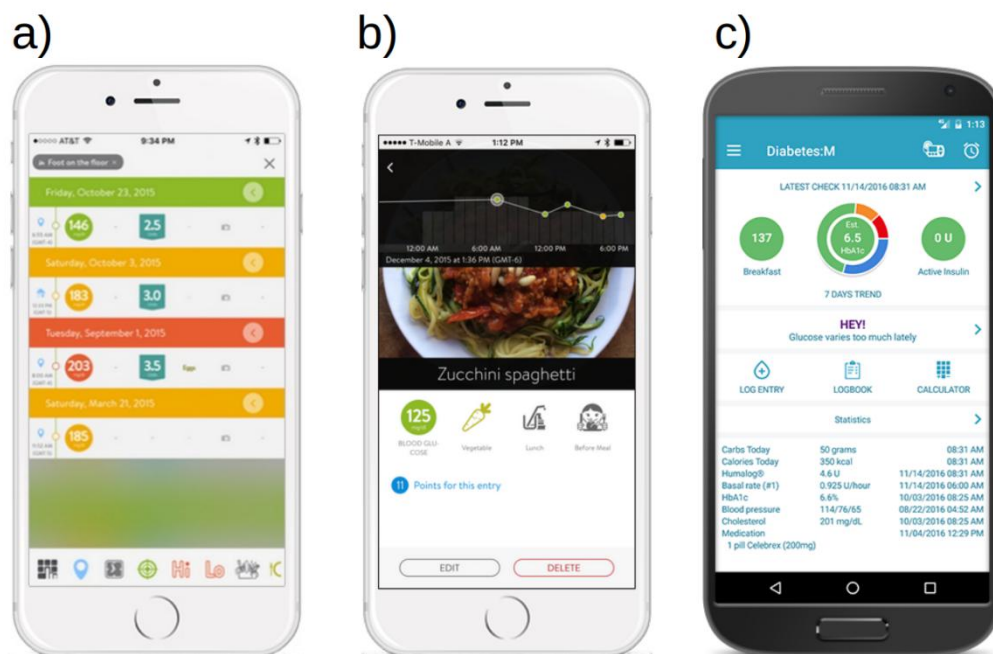

Fig. 3. Screenshots of advanced application for diabetes therapy: a) and b) *mySugr* [20], c) *Diabetes: M* [21]

The second example of a high-class application intended for supporting a diabetes patient is *Diabetes: M* [19] (Fig. 3c). It has been developed by Bulgarian company Sirma Group. The application has been in offer from 2013. As a professional application it realizes entirely requirements from no1 to no 5. The app includes a meal assistant (7), allowing to compose a meal and a plan with a correct insulin bolus. It is possible to send personal therapeutic data for medical consultation, which fulfils functionality no14. The application included a module for analysis the data that has been gathered. It can suggest the cause of the problems that have

appeared. Future events are predicted by an artificial intelligence module. Consequently *Diabetes: M* fulfils partially expectations no 15 and no 16.

CONCLUSIONS

Keeping a diary and ability of interpreting collected data is an essential part of type 1 diabetes therapy. Nowadays a person suffering from this disease can do this job using an application run on a smartphone. There is a broad offer of such applications. In this paper the applications have been divided in three groups according to their genesis. All of the presented applications can be used free of charge. Small amateur programs are distributed absolutely free. Other include advertisements, which is the only cause of using them for free. Advanced applications are available for free in their basic versions which are still useful from the therapeutic point of view. However, full versions that include additional functions require payment.

This paper has included a set of 20 requirements for mobile applications intended for type 1 diabetes patients. All the expectations are based on the therapeutic point of view and some of them are beyond the possibilities of the modern-day IT industry. Nowadays there is no applications that meets all of criteria. However, the tendency to fulfill all of them can be noticed. It has not been the authors' intention to rank the applications. In this paper they are only enumerated applications when taking into consideration supporting patients. It may turn out that an application with higher functionality is too difficult and the exposure to it may discourage a patient to using any applications. Such situation would have an adverse effect because even the simplest computer program used consequently could benefit the therapy.

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