An Integrated Model for Cognitive Behavioural Therapy for Mobile Diabetes Self-Management System

T.M. Alanzi , R.S.H. Istepanian, and N. Philip

Abstract—**There is increasing clinical evidence that behavioural change theories can help diabetic patients with their diabetic management in providing better education and a healthy lifestyle. In recent years, Cognitive Behavioural Therapy (CBT) has been increasingly used as a key psychological method for studies of behavioural changes for diabetes patients. However, to date, there is no extensive study that addresses the challenges and opportunities on applying CBT models within the mobile diabetes management cycle of care. In this paper, we present a review of the current status of CBT in diabetes management and propose a model for the implementation of CBT Therapy into a mobile diabetes management system by using smart mobile phone technologies.**

I. INTRODUCTION

The global prevalence of diabetes is alarming, as approximately 366 million individuals are living with this long-term condition [1]. Diabetes mellitus is categorized into two main types: Type 1 and Type 2. Type 1 occurs when the cells in the pancreas are damaged. Globally, Type 1 diabetes affects nearly 10% of all people with diabetes, as it hits young people under 25 years old. Type 1 diabetes is also called Insulin Dependent Diabetes (IDD). Type 2 occurs when the cells in the pancreas are not working effectively. Type 2 diabetes is known as noninsulin dependent diabetes (NIDD). There are many different causes and risk factors behind both types of diabetes, including environmental factors, behavioural change factors, family history, high blood pressure, unhealthy awareness of diabetes, alcohol intake, smoking, sedentary lifestyle, and obesity [2].

From the psychological perspective, behavioural change theories were used to help people in gaining insight into their health-related issues, influenced by their behavioural aspects. The theories presented methods to modify or change individuals' behaviour to lead to a healthier lifestyle [3]. In general, several behavioural theories have been successfully applied for different healthcare methods and patients' behavioural change issues. These include Health Belief Model (HBM), The Protection Motivation Theory (PMT), Theory of Reasoned Action (TRA), Theory of Planned Behaviour (TPB), Information - Motivation – Strategy Model (IMS), Social Cognitive Theory (SCT), and Cognitive Behavioural Therapy (CBT) [3]. From the diabetes perspective, CBT has been the most common and successfully used theory within this chronic disease domain. More recently, several systematic review and literature studies indicated that the effectiveness of this approach is improved in T1D and T2D management [4][5].

In parallel, Mobile Healthcare has been increasingly used in different chronic disease management application practically for diabetes care. Mobile health (m-health) is "an evolving paradigm that brings together the evolution of emerging wireless communications and network technologies with the concept of 'connected healthcare' anytime and anywhere" [6]. The concept was first defined as "mobile computing, medical sensor and communication technologies for health care" [7]. This process includes the collection of clinical health data, sharing related healthcare information to medical practitioners, patients, and researchers with the use of mobile devices.

Since then, the concept of 'm-health' was associated with several healthcare domains, particularly for mobile diabetes management systems [7, 8, 9]. In recent years, there have been an increasing number of studies on the effectiveness of mobile diabetes management systems [10, 11]. A recent meta-analysis study on use of mobile diabetes management indicated the effectiveness of these technologies for both T1D and T2D management with improved HbA1c levels practically for T2D patients [12].

Fig. 1: Typical Mobile Diabetes Management System

Fig. 1 shows a typical mobile diabetes management system that uses smart phone technologies with short-range (mostly Bluetooth) connectivity for the patient's glucose and other medical sensors. This information is linked via Internet

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connectivity with a remote web portal for usage by clinicians and specialist diabetic nurses.

In recent years, and as mobile apps are being increasingly used by diabetic patients, there is increasing demand to integrate CBT modules with these apps and systems. The Integration of CBT techniques with mobile health management systems will provide the best tools for behavioural changes and education, which are lacking in the current systems. These tools can empower the patients with better education, motivation, and an improved compliance rate for their daily activities and medical advice. This process can result in increased motivation, self-control, and self-efficacy in controlling the diabetes and hence, in avoiding complications.

To date, there is no study that addresses the integrated approach of CBT module with a typical mobile diabetes self-management system. The objective of the paper is of twofold; first, the paper presents a review of the current status of CBT within the diabetes management. Second, the paper proposes an implementation approach for integrating and implementing a CBT therapy module to typical mobile diabetes management systems by using smart mobile phone technologies. The paper is structured as follows: In section II, we present an overview about Cognitive Behavioural Therapy (CBT) for Diabetes Management, and in Section III, we present the proposed module. Section IV concludes the paper with future and ongoing work in this area.

II. COGNITIVE BEHAVIOURAL THERAPY (CBT) FOR DIABETES MANAGEMENT

In general, CBT is a psychotherapeutic approach that addresses different psychological problems, such as maladaptive behaviours, psychological disorders, stress, health conditions, etc. Talking about and changing your behaviour can change how you think (cognitive) and what you do (behaviour). Computerized CBT (CCBT) is one of the most popular examples used these days. CCBT is a software program for individuals to manage their problems by changing the ways they think and behave [13]. There are different models and approaches of CBT that are used for different health conditions. However, thoughts, feelings, and actions/behaviour are the main factors considered in CBT, and these factors are interconnected, as shown in Fig.2.
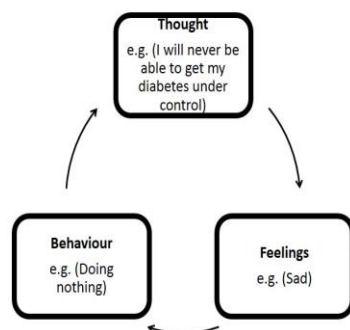

Fig. 2: General CBT Architecture [13]

In addition, CBT has major strengths, as it can be used as an effective tool for health behavioural change. This therapy can be completed in a short period of time, compared to other methods and also can be implemented easily on smart phones. Therefore, CBT has more flexibility for having different structural formats that can be easily integrated to smart mobile phone-based self-management systems.

From the diabetes perspective, different studies have on the use of CBT been reported to improve glycaemic control. A recent systematic review and meta-analysis study reviewed 25 studies on this topic [4]. This study aimed to assess the effectiveness of psychological therapies, such as CBT, in improving glycaemic control in adults with Type 2 diabetes. The key outcome of this study was that 12 trials significantly improvement in HbA1c (0.76%). Another study reviewed 29 studies aimed to assess the effectiveness of psychological therapies in improving glycaemic control in patients with Type 1 diabetes [5]. This study found that psychological therapy was associated with a significant improvement in glycaemic control, with a 0.5% reduction in glycated haemoglobin (HbA1c). Thus, these studies reveal that there is a considerable impact in linking CBT with diabetes management.

From the health apps perspective, there are a number of CBT smart apps that are commercially available [14]. For example, 'Thought diary pro' is one such mobile application that uses CBT in resolving a wide range of emotional and behavioural problems [15]. This application is designed to help people record and change the thoughts that cause emotional and psychological distress. It allows the identification of thinking errors (cognitive distortions), and the modification of our unhelpful thoughts into more productive ways of thinking. 'My thoughts' is another such similar application that is designed to control thoughts [16]. It is a fun little program to keep the user's mind focused on his or her true potential. Every time a user starts it up, the user is greeted with a positive, life-changing affirmation, which helps in having positive thoughts.

There are other applications that use the same concept of CBT but in different formats. 'MoodPanda' is one such application that is used for tracking a patient's mood [17]. The benefit of this process is that once the patients start to track their daily moods, this places a seed in their minds, and they can start to think positively, which will make them happier and help them get rid of thoughts that will make them unhappy. 'Cognitive Diary CBT Self-help' is another example that helps challenge irrational thinking, which causes many psychological and emotional problems [18]. The application provides a simple way of conducting this process by reviewing the history of the user's recorded events.

However, from this review, we can see that to date, no study or application has been developed that integrates CBT methods with mobile diabetes management systems in one smart phone-based mobile platform. Hence, the need for such a system is timely to provide the combined benefits of

both the intelligent CBT tools and the mobile diabetes self-management.

III. INTEGRATED MOBILE DIABETES CBT MANAGEMENT MODULE

The proposed integration of Mobile Diabetes-Cognitive Behavioural Therapy (MD-CBT) module is shown in Fig 3. This module consists of a patient's mobile CBT component. This module will assist the patient in providing his/her CBT data remotely via the smartphone. It will also display the patient's CBT (thought, feeling, and action) in graphical presentation, such as in formats of tables or charts, linked with a web-portal CBT specialist component; this will assist the therapist in sending feedback and observing the state of the patient's behavioural changes remotely. This module will aid in CBT intervention by applying a specific classification algorithm to decide whether or not to trigger an intervention via SMS message, instructing the patient to submit his or her CBT data.

The MD-CBT cycle starts from the event in which high blood glucose levels of the patients are recorded or observed from the diabetes management system. In such an event, and based on the classification algorithm, detailed in the next section, the system will automatically send an SMS to the patient, requesting the submission of his or her CBT data. The patient will then submit the CBT data, which comprises thought, mood, and action. The patient is required to select the appropriate options, which define the thought, mood, and action at the point of time when the list is displayed on their mobile screens and when accessing the MD-CBT module application. These actions are discussed in detail in the following section, which completes the MD-CBT cycle.
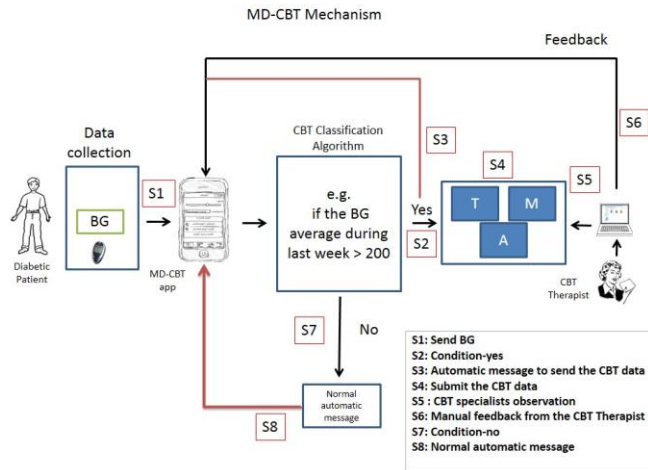

Fig. 3: MD-CBT Functions Cycle

A. Classification Algorithm

The classification algorithm used in this module is the software that triggers the MD-CBT therapy module and the automated message, if the specified criterion is met. The criterion is the reading of the blood glucose level. For example, the average BG level of a patient for one week can be set at 200 mg/dL, which could be a criterion for a patient.

In case the patient's average BG level during a week crosses 200 mg/dL, then an automated text message will be sent to the patient, requesting the submission of the CBT data. Then, the patient will access the MD-CBT module to load the behavioural data and submit the data by selecting the most suitable option from the list given for each specific component, including thought, mood, and action. The data is then analysed by the CBT therapist, who sends feedback to the patient accordingly. The criterion for the CBT algorithm is set by the CBT therapist, based on the each patient's type of diabetes and health condition.

B. Thought

Thoughts are basically the ideas or opinions that are derived from thinking. They can be categorized as positive and negative thoughts. Some of the most popular negative and positive thoughts from the review [19] and consultation with CBT specialist are developed, which include:

TABLE 1 MOST POPULAR NEGATIVE AND POSITIVE THOUGHTS

Most popular negative thoughts	Most popular positive thoughts
I am confused	I can do it better
I am afraid	I will learn to love and be happy
I am scared	Life is interesting
I have no patience	I really feel good
I am stupid	I am a good person
I am not capable of loving	I really handled this situation well
My hopes have vanished	I like people
I will never be able to change	I will find strength to solve any difficulty
I have no enthusiasm for anything	I am honest
Everything is my fault	I am very responsible
I am inferior to others	I am important to my family
Life isn't worth it	I am lucky
I am not as good as others	I am intelligent

The patients can choose their thoughts from the table and move on to the next step, where they can define their mood.

C. Mood

Mood is the temporary state of mind or a feeling that is presented in a person at a certain point of time. The mood can be different in different time periods. However, the mood can be categorized into different sets of feelings and can be numbered in order to analyse the changes in the mood of a person [20]. This process can be reflected on a mood scale. The patients can select their mood, as shown in Table 2, and move on to the next step, where they can define their action.

TABLE 2 MOOD SCALE

Mood scale	Scale weight
The best	9
Much better	8
Better	7
Better than regular	6
Regular	5
Worse than regular	4
Worse	3
Much worse	2
The worst	1

D. Action

Action is the process of doing something, and it defines the patients' behaviour. Therefore, an action list is developed for this purpose [19], and the patients can choose the actions they have performed. The list is shown in the following table.

TABLE 3 MOST POPULAR ACTIONS

Most popular actions
Wear clothes I like
Watch or participate in sports
Help groups I respect (NGO/ local community)
Buy things
Talk to my friends
Read books, magazines, and newspapers
Drive a car
Do my job
Sing
Watch nature
Give gifts
Take pictures

After completing the action part, the patients can submit their selection data remotely. This data will be reviewed by the CBT therapist who will send the suggestions and feedback to the patients, as required.

IV. CONCLUSION AND FUTURE WORK

The need for an integrated functional module, combining CBT therapies with mobile diabetes management is both timely and important due to a sharp increase of current smart apps for diabetes management and patients, and the need to add the functional modules, from the behavioural change perspective, to these systems and apps. In this paper, we proposed a functional model that integrates CBT with a typical mobile diabetes management system. We presented a state-of-art review of the work to date in these areas and then proposed an integrated system. The system is currently being developed, and a feasibility pilot clinical trial study is currently being conducted to study the impact of this new approach for diabetic patients.

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