# Gluco Coach—A Self-Management Application for Type 2 Diabetes Mellitus

User testing to understand comfort levels and sustained patient engagement

Way Kiat Bong
Department of Computer Science
OsloMet – Oslo Metropolitan University
Oslo, Norway
e-mail: wayki@oslomet.no

Kuthethur Sneha Jagannath Das, Felix Janszen
Inpaqt Technology Solutions B.V.
16, Marconistraat
Rotterdam, The Netherlands
e-mail: sneha.das@inpaqt.com, felix.janszen@inpaqt.com

***Abstract*—The increase in the number of patients with type 2 diabetes mellitus is a global concern. Using information and communications technologies, particularly mobile applications, to empower patients with remote self-management has shown promising results. However, there is still a lack of evidence regarding an app content's contribution to making sustained impacts on the users' lifestyle behaviors and hence health. To make a positive health change through such a self-management app, the users are expected to be engaged in using the app. This engagement has to be sustained for a long period of time to reflect on both lifestyle behavioral and health changes. In our project, we developed Gluco Coach, a type 2 diabetes mellitus self-management app focusing on supporting type 2 diabetes mellitus patients to achieve and sustain healthy lifestyle behaviors. This paper presents work on understanding type 2 diabetes mellitus patients' comfort levels and interest in using Gluco Coach. User testing were conducted, and the findings showed potential in Gluco Coach and resulted in a list of lessons learned concerning design that aims to provide high usability and functionality, positive user experience, and thus sustained patient engagement.**

***Keywords: type 2 diabetes mellitus; self-management; self-monitoring; patient-centered design.***

## I. INTRODUCTION

The prevalence of chronic conditions is increasing globally, and it affects the quality of life of many individuals; type 2 diabetes mellitus (T2DM) is one of these chronic conditions [1][2]. The presence of T2DM is associated with various other comorbidities, such as obesity, cardiovascular issues, and renal issues [2]. It is estimated that by 2040, the number of people with T2DM will increase to 642 million globally [3]. The blood glucose level (BGL) of a T2DM patient rises due to insulin resistance or the ineffective use of insulin. Hence, in T2DM care, the goal is to maintain the BGL within the target range. The crux of T2DM care is remote self-management of lifestyle behaviors from the patient's side [4].

Growth in information and communications technologies (ICT) has led to the development of mobile health (mHealth) solutions, which predominantly consist of smartphone applications (apps) and wearables. Studies have shown the benefits of mHealth in chronic disease management [5][6]. Through mHealth, virtual coaching can be implemented in aiding the self-management of lifestyle behaviors. Many apps focusing on T2DM care are commercially available on the Apple App Store and the Google Play Store. These apps have the features of blood sugar tracking, reminders for meals, tracking calories burned, and T2DM care information. These are some essential features required for optimal T2DM self-management.

A popular definition of user engagement focuses on the aspect of the users' experiences with a technology [7]. Studies have shown that positive user engagement is a prerequisite for achieving positive health effectiveness [8][9]. However, while these apps are initially engaging for users, the aspect of sustained user engagement has not been thoroughly addressed [8][9]. Bringing about a positive health behavior change through an mHealth intervention requires users to engage with the interventions. This engagement needs to be sustained for a long period to reflect on the patients' behavioral and lifestyle changes. In addition, there is insufficient thorough information available about app content such as lifestyle behaviors along with evidence concerning their efficacy [10]. Studies have also emphasized the point that these apps still lack the clinical focus that a T2DM app requires [10][11]. Some examples of these apps are My Sugr Diabetes Logbook, Diabetes Pal, Diabetes Connect, Sugr Sense, and Health2Sync [10].

To address these knowledge gaps, in our project, we developed Gluco Coach, a T2DM self-management app focusing on supporting T2DM patients to achieve healthy lifestyle behaviors. The app is targeted to be science- and evidence-based concerning the aim of sustaining the patients' user engagements through personalization, which is lacking in current T2DM apps [10]. The personalization factor will be implemented using artificial intelligence (AI), which forms the crux of Gluco Coach. The evidence-based approach will lead the way to proving the clinical efficacy of the app. This position paper describes user testing conducted among T2DM patients to understand their comfort levels and interest in using Gluco Coach. These user testing were conducted as one of the first steps to understand patient engagement in relation to using a self-management app. In our earlier study, the CeHReS roadmap methodology was used throughout the development of Gluco Coach 1.0, where expert stakeholder sessions, think-aloud sessions, and a questionnaire study with T2DM patients were implemented to understand user engagement [12].

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## II. GLUCO COACH

Gluco Coach is currently under development as a science- and evidence-based intervention. Aspects of T2DM physiology, along with behavior science, have been integrated into the app design to bring about the core feature of self-management. Pursuit of regular physical activity, a healthy diet, and adherence to prescribed medicines or insulin are integral to optimal T2DM care and can be understood as healthy lifestyle behaviors for the patients [11][13]. These features, along with T2DM care awareness messages, are the core functions of the app.

In addition, features such as personalized goal setting, self-monitoring, providing feedback, reminders, cues, and suggestions were incorporated into the app as virtual health coaching. The aim was to have users achieve healthy behavior changes. To implement this virtual health coaching, various behavioral science theories, such as goal-setting theory, the health belief model, the information-motivation behavior skills model, and protection motivation theory, were incorporated in the app design [14][15][16][17]. These theories were chosen as they involve personalized goal setting, adapted to the user [14], and provide information about T2DM care and the user's individual progress to motivate them to pursue healthy behaviors [15][16][17].

Figure 1 illustrates the main functionalities of Gluco Coach. Users can set personalized goals in terms of step count and diet in terms of calorie consumption and provide feedback on goal achievements in the form of visuals such as pie charts. The component of goal setting comes from goal-setting theory, while the components of self-monitoring and feedback come from the health belief model, the information-motivation behavior skills model, and protection motivation theory. The component of providing general T2DM care information also arises from these theories.

## III. METHODOLOGY

In this study, user testing with four T2DM patients (P1–P4) were conducted. They were recruited by convenience sampling because they were easily accessible. Their demographic information is summarized in Table 1. First, they were briefed about the project. Second, they were asked to provide their consent prior to participating in the user testing. The user testing consisted of providing their demographic background, performing a series of testing tasks, and answering a System Usability Scale (SUS) questionnaire. To avoid participants feeling exhausted, the testing tasks had to be prioritized, which were as follows:

1) Sign up (using a username and one-time code).
2) Enter physiological information, i.e., weight, height, blood pressure, BGL, and presence of other comorbidities. The information was based on what the participants knew previously, e.g., from their last health check, last self-measurement at home, etc.
3) Type in a medicine name and time for intake (dosage was not required).
4) Change the medication time for intake reminders.
5) Delete the medicine.
6) Inspect the navigation function.
7) Inspect the home page.
8) Insert the goal for the step count.
9) Log diet.
10) Investigate the T2DM care function.

TABLE I. DEMOGRAPHIC INFORMATION OF ALL PARTICIPANTS

| | **Age (years)** | **Gender** | **Self-rated ICT skills (1 is *very bad* and 10 is *very good*)** | **Highest education obtained** |
|---|---|---|---|---|
| P1 | 56 | Male | 2 | High school |
| P2 | 34 | Male | 9 | Master's |
| P3 | 58 | Female | 4.5 | High school |
| P4 | 43 | Male | 8 | Bachelor's |

When the participants were performing the tasks, they were observed and their actions were clarified, if required. They were also asked for their opinions on the main functions after completing the testing tasks. Each user testing lasted around one hour.

## IV. RESULTS

The participants could complete most of the testing tasks without much guidance. The two tasks that needed the most help were tasks 2 and 9. The reason P1 and P3 struggled with task 2 was because they did not understand some terms, such as "mmol/L" (millimoles per liter), a unit of BGL (see leftmost panel of Figure 1) and "Hemoglobin A1c" (Hb1Ac), a test for diabetes giving average (avg) BGL over the past two to three months. For task 9, the issues were due to finding a matching food name and amount. The function could only now offer to insert and search for a set of meals

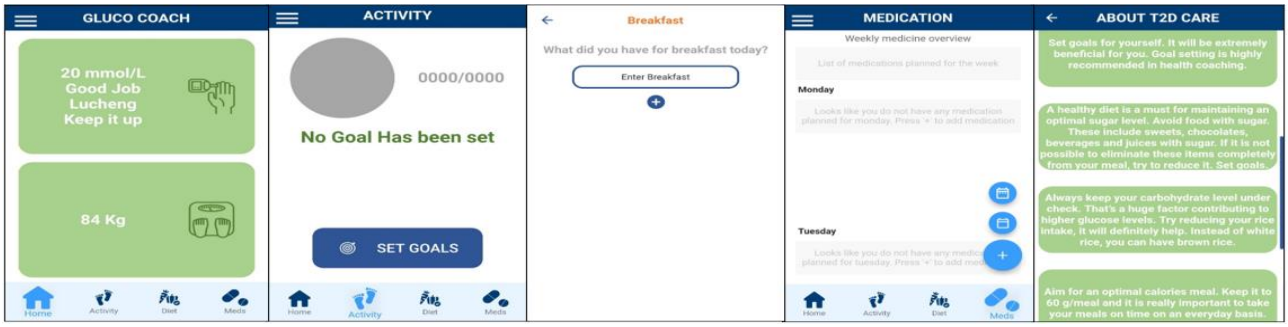


Figure 1. Gluco Coach. From left to right: home page, goal for step count, log diets, log medication intake, and T2DM care with awareness messages

with predefined amounts of food.

The participants managed to use the medication taking functions. They liked that the time for taking the medication could be set for each medicine and all participants appreciated the reminder function. They wanted it to be like an alarm, which could repeat to remind them to take the medicines, or the reminder could stay on the screen until the users acknowledged that they had taken the medicines. Only P4 perceived the logging diet function as useful to her. P1 and P3 expressed that they were not particularly interested in logging their diet. Instead, they preferred suggestions or to be instructed on what they should eat less or more of. They wanted to be guided to make better choices, rather than purely just logging the diet. Concerning the T2DM care function, all participants agreed that the information was useful. However, there was too much text; hence, it appeared boring and was not very attractive to them. They suggested having small tips provided to them one at a time, and the tips should be made based on their data.

TABLE II. SUMMARY OF AVG SCORE FOR SUS SURVEY

| **SUS statements (to rate from 1 to 5; 1 = *strongly disagree*, 2 = *disagree*, 3 = *neutral*, 4 = *agree*, 5 = *strongly agree*)** | **Avg** |
|---|---|
| 1. I think that I would like to use this system frequently. | 2.25 |
| 2. I found the system unnecessarily complex. | 3.25 |
| 3. I thought the system was easy to use. | 2.25 |
| 4. I think that I would need the support of a technical person to be able to use this system. | 3 |
| 5. I found the various functions in this system were well integrated. | 3.25 |
| 6. I thought there was too much inconsistency in this system. | 3.75 |
| 7. I would imagine that most people would learn to use this system very quickly. | 2.5 |
| 8. I found the system very cumbersome to use. | 2.5 |
| 9. I felt very confident using the system. | 3.5 |
| 10. I needed to learn a lot of things before I could get going with this system. | 2 |

Lastly, SUS results are presented in Table 2. Based on the avg scores, the participants perceived Gluco Coach as slightly complicated (statements 2, 3, and 8) due to inconsistency (statement 6). After clarifying with them, it was found that they wanted a more consistent and similar design for inserting meals and medicines. Both the placement and color of the buttons for adding meals and medicines were different (see Figure 1). The appearance of headings for some pages was not consistent, either. For example, the adding breakfast page in Figure 1 has a different heading from the other pages. Despite these issues, they agreed that the functionalities in Gluco Coach were well integrated (statement 5), which was aligned with their feedback when performing testing tasks. The participants saw potential in Gluco Coach as a self-management app for T2DM patients. Their SUS results indicate that they themselves have confidence in using it (statements 9 and 10).

## V. DISCUSSION

User testing with four participants for the first working prototype of Gluco Coach was conducted as one of the first steps in examining its design concerning usability, functionality, and user engagement. The findings indicate that Gluco Coach as a self-management T2DM app has the potential to sustain user engagement. However, some issues have to be addressed accordingly. Previous studies have indicated the importance of having features of reminders, personalized suggestions, feedback, and self-monitoring, which form a part of health coaching [18][19]. The diet function in Gluco Coach consists of a regular diary entry theme for logging food. From the user feedback, the feature of food suggestion would be much appreciated in addition to a more user-friendly way of logging diets. A personalized food suggestion that is relevant to the user can contribute to enhancing user engagement. Commercialized apps such as MyNetDiary [20] and HealthifyMe [21] have the feature of personalized food suggestions. These features can be implemented based on the person's BGL variation in a day, preferences, and allergies [11][22].

The feature of T2DM care information with awareness messages was appreciated, although the participants would prefer to have less text. To achieve this, coaching and awareness messages should be more personalized, like the above-mentioned personalized food suggestions, with tips to increase physical activities, for example. Personalization needs to be a pervasive feature of the app, as it supports user engagement [9]. These features can be implemented through AI with developing a context-aware feature, which can be utilized and implemented in the further development of Gluco Coach, since it will help in developing a more personalized and interactive user interface [23].

In task 2, it was observed that terms such as "mmol/L" and "Hb1Ac" were not easily understood by some participants. To alleviate such concerns, these terms can be explained to the users as a part of T2DM care and education in an interactive format. More visual and interactive forms of representation can be explored, such as the use of avatars to impart a more intuitive and fun way of raising awareness [24]. Lastly, the medication system of the app was well received by the participants. The idea of reminders was appreciated, and the participants suggested optimizing the reminders further in a more solid form. For instance, they should persistently appear on the screen until the users have taken the medicine and logged their medication taking.

Through user testing, a list of lessons learned have been compiled concerning design that will sustain user engagement among Gluco Coach users. They are summarized as follows, and they will be used to guide the further development of Gluco Coach in addition to suggestions from other relevant work [11][13][24]:

1) Offer personalized messages in the form of small tips that cover the three main areas of lifestyle, i.e., physical activity, diet, and medication adherence.
2) Provide necessary guidance or interactive education regarding T2DM.
3) Have a consistent design across pages in the app.
4) Make reminders more solid, e.g., persistent alarms and strong visuals on the app screen.
5) Suggest what to eat, besides logging the meals.

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6) Offer a more user-friendly way to log diets, e.g., taking photos.

This study's major limitation is the small number of participants, and hence lacking diversity in the demographic backgrounds. Therefore, they do not represent the entire user group of T2DM patients. However, findings from the testing of four users can almost be sufficient to identify usability issues at this stage, as suggested by Nielsen [25].

## VI. CONCLUSION AND FUTURE WORK

This paper demonstrates the ongoing work of developing a self-management app, Gluco Coach, for T2DM patients. The app is targeted to be science- and evidence-based regarding the sustainability of patients' user engagement. User testing with four TD2M patients were conducted concerning their comfort level and interest in using the app. The findings indicate the potential of Gluco Coach despite some usability and functionality issues. Design recommendations were gathered as a list of lessons learned.

This study is one of the first steps toward understanding patient engagement. When conducting these user testing, the focus was on designs that provide good user experience and therefore sustained user engagement. Hence, our future work will include improving Gluco Coach based on the feedback from participants and lessons learned, and conducting user testing and a longitudinal study with more T2DM patients with diverse backgrounds to probe their user engagement.

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