Integrating Persuasive Technology to Telemedical Applications for Type 2 Diabetes

Sakib Jalil[1], Rita Orji[2]

[1]Discipline of Information Technology, College of Business, Law & Governance, James Cook University, Australia
sakib.jalil@my.jcu.edu.au
[2]Accessible Computing Technology Lab, McGill University, Canada
rita.orji@mail.mcgill.ca

Abstract. *Type 2 Diabetes* (T2D) patients need constant monitoring of food, exercise and insulin level. Telemedical systems aid the patients in monitoring and sending their regular blood glucose to nurses and in receiving suggestions on food, exercise and insulin dosage, especially on food choices. This paper presents a qualitative inquiry aimed at investigating the possibility of integrating *Persuasive Technology* (PT) into existing telemedical system for T2D to promote desirable dietary and physical activity among T2D patients and how T2D patients perceive the role of such PTs in comparison to a human persuader. The findings show that T2D patients prefered to receive dietary recommendation and suggestions or restrictions from a PT. The T2D patients prefer to be told what they can or cannot eat by a PT than hearing it from a human. Thus, PTs hold significant promise of complementing existing telemedical applications to achieve desirable health outcome for T2D. However, since the motivational needs of T2D patients may differ from those of non-diabetic individuals [12], there is a need to understand them and tailor the PT to reflect the needs and beliefs of the T2D patients

Keywords: health, type 2 diabetes, telemedicine, clinical trial, model-driven persuasive technology, tailoring.

1 Introduction

Type 2 Diabetes (T2D) is one of the most dangerous chronic diseases [1] where the body essentially develops immunity to insulin; eventually this causes blood glucose levels to alter to abnormal levels and generates complications in health of a person. T2D has no permanent cure yet, but is managed through three parameters: food, exercise and insulin. Insulin is controlled by medical professionals and requires medical knowledge about dosage. However, food and exercise are parameters that can be directly controlled by T2D patients. Hence, regular management of blood glucose levels through medical intervention and lifestyle adaptations, such as a changed diet and

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increased physical exercise, has been shown to reduce complications in T2D patients [2].

The use of technology-intervened treatments, such as *Telemedicine* to monitor patients from home is on the increase with chronic diseases such as T2D. Telemedicine is the use of Information and Communication Technologies (ICT) to provide clinical treatments over distances [2]. For a telemedicine treatment of T2D, patients generally send regular blood glucose data to nurses or health care providers via one of the following devices such as phone, tablet, computer, web-based system, video-conference, phone calls, Short Message Services (SMS), etc. [3]. A nurse or healthcare provider is involved in T2D telemedicine treatments continuously while the technology-intervention remains as a means of transferring data (e.g., blood glucose, blood pressure) and facilitates the communication between patients and nurses. When a patient's blood glucose is too high, the nurse generally alerts the patient to suggest foods to be avoided, how much insulin to be taken and exercise that could be done. Sometimes patients' family members remind the patients about food and exercise too. How much the patients like to hear about food and exercise advice from their nurses or family members remains a topical question.

On the other hand, a significant advantage that Persuasive Technologies (PT) possesses over regular technologies is the ability to persuade users without having a human persuader's involvement and/or interaction with the users [4]. Thus, PT can offer greater anonymity for a human persuader. In case of T2D management, PT has great promises to help to manage two of the three parameters (food and exercise) of T2D management. However, since the motivational needs of T2D patients may differ from those of non-diabetic individuals [12], there is a need to tailor the PT to reflect the needs and beliefs of the T2D patients. This paper presents results from investigating T2D patients' perception of the role of a PT versus the role of a human persuader in T2D management. All our participants are T2D patients who use an in-home monitoring telemedicine device and officially enrolled in a clinical trial.

2 Background

Food and exercise are the two parameters that are very crucial for T2D management and patients can directly control them. T2D patients' motivational needs differ from non-diabetic individuals in several ways. For T2D patients, healthy eating and regular exercise is a requirement as they are necessary for T2D management unlike non-diabetic patients who may adopt healthy eating and regular exercise for health promotion and disease prevention purposes. T2D patients are required to eat healthy nutritious meals by choosing foods that help stabilize blood glucose and need to control their portion of food. Excessive blood glucose causes hyperglycemia that may result into stroke, heart failure, nerve and eye disease. Extremely low blood glucose causes hypoglycemia that may result into sweating, dizziness, fainting, etc. Therefore, T2D patients' motivational needs are very different to non-diabetic individuals, whose motivational needs could be weight loss and general health promotion and improve-

ment. T2D patients' motivational needs for food control arise to avoid fatal health conditions. In terms of exercise T2D patients are required to stay fit and burn excessive blood glucose due to insulin intolerance, while for non-diabetic individuals the motivation for exercise could be to reach certain fitness goals.

PTs, which are designed to promote desirable behavior, have been shown to be effective at motivating behavior in various domains including healthy eating and physical activities [16,17]. Research has also shown that PTs can be used to increase engagement, adoption, and adherence to certain task including medication adherence [5], oral hygiene [6], and physical activity [7]. Similarly, strategies to design effective PT to motivate healthy behavior among individuals have been thoroughly researched [8], where tailoring through personalization and culturally-relevant design guidelines [9] proved significant.

With respect to T2D specific PT design, an experiment consisting of daily persuasive text message and a weekly tailored newsletter was shown to be effective for T2D patients on two participants [10]. The daily text messages sent to the subject were fresh and were limited in number. Although the persuasive text message support systems have shown promise as means of motivating adherence to insulin therapy in adolescent diabetics [11], it is not clear that text messages could be used to motivate increased physical activity and healthy eating for T2D patients. More specifically, as a research community we do not have a good understanding of how PT can be incorporated into technology-enabled therapy for T2D patients to motivate desirable physical activity and healthy eating behavior. Persuasive interaction design may be especially fundamental to achieving high motivation in the context of individuals with T2D. However, since their motivational needs may differ from those of non-diabetic individuals [12], there is a need to tailor the PT to reflect the needs and beliefs of the T2D patients.

3 Method

We conducted a qualitative study to understand T2D patient's perception and attitude towards PT in comparison to a human persuader. This study was conducted in parallel with a research project called Clinical User-experience Evaluation (CUE) of T2D patients. The CUE project studied T2D patients' uses and interactions of an in-home diabetes-monitoring device in a telemedicine clinical trial in Townsville region of Australia [13]. The telemedicine clinical trial was conducted by Townsville-Mackay Medicare Locals (TMML) while the CUE project was an independent study. The CUE project and the original clinical trial used a non-persuasive in-home monitoring device.

In the telemedicine clinical trial, T2D patients were using an in-home monitoring device to send blood glucose data to nurses and receive medical advice through phone. The in-home monitoring device these patients used consisted of a tablet with

11-inch screen, a glucometer and a sphygmomanometer, which would upload the patients' blood glucose and blood pressure automatically to an online system. The patients received phone calls from nurses about food, exercise and insulin doses. Some patients received consultation via phone 2 times a week while other patients received consultation via phone once every 2 weeks, depending on the severity of their diabetic conditions. In addition, patients' family members were also involved in their diabetes management.

This study involved six T2D patients (Table 1) of the CUE project. Participation to this study was voluntary. All patients are computer literate Caucasians and were given pseudonyms for privacy reasons.

Table 1. Patient Information

Patient pseudonyms	Sex	Age	Diagnosed with T2D (years)
Zach	M	70	10+
Vince	M	66	10+
Bill	M	64	20
Heidi	F	60	25
Serena	F	55	2
Pete	M	53	1

The entire fieldwork was done one-on-one. Each patient was visited individually in his/her own home. The study presented a scenario to each patient in non-technical language. The scenario described a persuasive technology integrated into their existing telemedicine system for T2D that would provide a patient with a choice of foods he can eat that day and suggested portion, based on his recent blood glucose reading from the telemedicine system. The system would also list foods the patients should avoid and could send reminders to keep them motivated. The current device would provide patients with types of physical exercise that he could perform based on his recent blood glucose. It will remind him to exercise and will encourage and inspire him throughout the day.

Next, each patient was asked to explain his/her thoughts about such an application and to compare it to a human persuader. The questions asked - "*If PT features (as described in the scenario) were to recommend and encourage you about food and exercise instead of a human, how would you feel?"* followed by *"How helpful would the PT features for food and exercise be for you?*" The patients often referred to the nurses or some family member as their human persuaders. The answers were audio-recorded and transcribed. Note that we were not allowed to show the patients any interfaces due to ethical restrictions.

This study assumes that for the insulin dosage, the patients will still receive instructions from the nurses in their telemedicine in-home monitoring device. The per-

suasive features to motivate about food and exercise would be integrated into the existing system while the nurses would control insulin dosage.

4 Findings and Discussion

The patients provided interesting feedback concerning the idea of integrating a persuasive application to existing telemedical systems to help motivate them to meet their healthy dietary and physical activities requirement inline with each T2D patients needs and capabilities.

4.1 PT for Healthy and Appropriate Dietary Intake among T2D Patients

Most of the T2D patients found the use of the PT for motivating health dietary intake and recommending appropriate diet in line with their individual T2D need, very interesting and showed enthusiasm. Bill, a 64-year old male said he would not like to hear from his wife or other people about the food that he can or cannot take, especially the fact that he cannot take some of the foods he like. He mentioned "battered fish" being one of his favorite foods, which he has to consume sparingly due to his diabetes. Yet, he does consume "battered fish" and he stated he would prefer to hear what he can eat or cannot eat, or the results of eating "battered fish" from a PT. *"I prefer an app telling me than a human. You know I like eating fish, battered fish. My blood sugar will just go through the roof if I had battered fish."*

Similarly, Serena is a 55-year old female and lives with her university going son. Serena specifically mentioned that she would prefer PT to provide her with food guidelines. According to her, hearing food advice from nurses does not feel very good. She said that people can tell her what not to eat, but she still can eats it. At this point Serena was seen to respond with emotion to say that she can eat what she wants even if a human says she cannot. "*An app. Someone tells me I can't; I can* (signs of strong assertion in her voice). *So an app far better*."

Zach a 74-year old male showed similar preferences for a PT. Zach said he would not like to go through series of conversations to convince his wife about his food choices. He does not want to justify and be answerable to his wife about what he eats. "*The gizmo*-referring to PT (Zach broke into laughter). *You don't like your wife to nag you and she doesn't like you to nag. The gizmo can nag as much as it can*"

Other patients Vince, Heidi and Pete also expressed similar interests in having a PT to advice about their food choices as opposed to a human persuader or informer. Pete provided a positive argument for PT. Pete mentioned that just by looking at his blood glucose readings every morning and evening, he started to be conscious of his food intake. He has lost 13 kg of bodyweight in 5 months from this practice. So Pete think that a PT targeted at healthy eating would benefit him more in comparison to the

simple non-persuasive telemedicine technology. This finding suggests that T2D patients may trust and adhere to feedbacks provided by PT than that from human. This is contrary to Orji et al [14] who found that some people might not be open to receiving feedback and praise from a system. This highlights the need to tailor PT to individual's inclinations and suggests indeed that T2D patients may be different.

One patient, Bill additionally pointed out the importance of triggers in the PT. Surprisingly, none of the patients had any experience about PT before the study and was not given any information about PT design while the study was conducted. Yet, Bill described PTs as having a trigger that would help in prompting behavior. In Bill's words: "*if you have that app, you need that app to have jumped out at you. You know sort of like make a sound or something …*" This supports the concept of triggers in the theory of PT [4].

Serena, in addition, mentioned that besides being on the clinical trial of the in-home monitoring telemedicine technology, she was using her iPad to look for applications that could help her with making better food choices. She said she received food advice from the nurses in the clinical trial, but wanted to see all the details of the food choices, the nutrition, and the calories because the nurses only guided about food. She wanted concrete food choices to stay healthy with T2D. Serena and her son had done extensive search of applications on App Store of Apple Inc. After having tried many current applications, she suggested that the PT could include information for T2D patients such as, GI (glycemic index), nutritional value as opposed to just asking for body weight, an important need for T2D patients.

4.2 PT for Promoting Physical Activity among T2D Patients

Even though the patients were asked about a PT for food and exercise, very few patients spoke about PT for exercise specifically. There could be two possible reasons for this. First, it was hard for them to perceive how a PT can motivate them to exercise since this study was scenario based and therefore requires the patients to imagine the applications without the use of any interfaces or mock-ups. Second, the patients perhaps were not involved in physical activity for diabetes management. They may not believe that physical activity is a significant contributor to the overall health of T2D patients. They probably placed more emphasis on food because they believe that food have a direct relationship with T2D.

Pete a 53-year old male said he could not see the PT helping with physical activity as it could for healthy eating choices. "*But not so much about the exercise because I know what to do about the exercise and what I have gotta do.*"

In conclusion, these preliminary findings show that PT can be an effective tool for T2D self-management by promoting healthy eating and physical activity among patients. Patients have positive beliefs and perception about PT in general. However, for

PT to be really effective, they need to be tailored to capture the unique needs, motivations, and capabilities of the T2D patients.

4.3 Discussion and future of telemedicine devices for T2D management

Telemedicine technologies are currently designed ad-hoc. The particular in-home monitoring device used in the clinical trial, where the CUE project was conducted, was simply a digital version of the regular T2D management, in the traditional way. The traditional way of T2D management consists of patients recording their blood glucose data and diet in a hand written diary and then meeting nurses or doctors every 90 days. With the in-home monitoring device, the patients' data are regularly sent to the nurses and feedback on health is received more frequently. However, PT can significantly benefit telemedicine in-home monitoring devices. T2D patients require constant motivation to make adequate food choices and avoid high GI food. T2D patients are also recommended to do certain amount of physical activity to remain healthy.

Opportunely, recent Model-driven Persuasive Technology (MPT) research [8] has demonstrated with large-scale studies how to effectively use persuasion strategies to motivate healthy eating choice. MPT research [9,14] showed that tailoring PTs with the right categories of users showed positive outcomes in the users for healthy food choice. Telemedicine in general, and especially telemedicine devices for T2D can incorporate the MPT to tailor PT for T2D patients based on their needs, motivations, and individual characteristics. Our findings from the interviews of T2D patients in the CUE project in this paper showed that patients perceive the importance of PT to motivate them to adopt a healthy eating behavior. The findings also showed that the patients prefer a PT in comparison to a human persuader.

T2D patients have higher carbohydrate cravings such as sweetened foods [15]. T2D does not have a permanent cure. Patients have to manage it on a daily basis with the right food choice and exercise. Telemedicine for T2D and MPT researchers can work hand-in-hand together to create technologies that help the patients on a daily basis instead of simply collecting and sending blood glucose data to nurses from patients. Incorporating tailored persuasive strategies in the existing device used in the clinical trial promises to create a positive and compelling persuasive experience that will promote desirable changes among T2D patients.

This study has several limitations. It is a side study of the CUE-project and thus it did not have a strong focus on the design and development of a PT. This study simply explores the promises of PT in telemedical systems for T2D. This study is a first step towards exploring if regular T2D patients in a clinical trial using a non-persuasive telemedicine in-home monitoring device can perceive the benefits of a PT. Again, the dual aspect of the system – having nurses administer the insulin dosage and having PT help with food and exercise may affect the patients. We hope to investigate that as part of our future work.

5 Conclusion

Diabetes is an epidemic worldwide and telemedical in-home monitoring systems facilitate T2D management by replacing hospital visits. However, T2D telemedical systems are failing to harness the full potential of the devices. By integrating Persuasive Technology (PT) features to existing telemedical systems, they will benefit T2D patients who struggle hard to control their daily food intake.

This paper presents insights from a qualitative inquiry of T2D patients with respect to the possibility of integrating PTs to existing telemedical systems as opposed to a non-PT solution. All patients were T2D diagnosed patients and were enrolled in a telemedicine clinical trial. The patients use a simple, non-persuasive in-home monitoring device to send blood glucose data over to the nurses and receive feedback. Our findings reveal that patients perceive the whole idea of integrating PT to telemedical applications to help them meet their dietary and physical activity need as positive. In fact, they would prefer to receive dietary recommendations and suggestions from a PT, as opposed to a human persuader such as a nurse or family member. This results show that PTs hold great potential for T2D patients and in the area of telemedical systems. PT techniques can easily be integrated into to existing telemedical in-home monitoring devices (such as the one in this study) to increase their effectiveness.

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