

Identifying Sociodemographic Factors for a User Engaging Type 2 Diabetes Mellitus Mobile Self-management Application

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Abstract: Type 2 Diabetes Mellitus (T2DM) is a chronic condition affecting the elderly population across the globe. Self-management from the patient's side is a key factor for T2DM care. Growth in the information and communication technology field has paved way for the rise of digital health interventions. Digital health interventions (DHI) can support self-management behaviors in patients suffering from chronic conditions through health coaching. Patient Engagement with DHI is crucial for the intervention to be effective on the patient's health. This paper discusses user engagement and focuses explicitly on identifying the sociodemographic factors impacting user engagement with a mobile health intervention (mHealth) in T2DM patients. The factors along with their interrelations have been identified through expert reviews, feedback from T2DM patients and their family member through questionnaires and think aloud interview, and the conduction of a literature study.

1 INTRODUCTION

Type 2 Diabetes Mellitus (T2DM) is a highly prevalent chronic condition across the globe. By 2040, T2DM is estimated to be prevalent in 642 million people globally (den Braber et al., 2019). Prevalence of T2DM is a risk factor for several comorbidities and health complications such as obesity, cardiovascular diseases, renal failure, and blindness to name a few, and poses a burden on the healthcare system (Pardhan et al., 2020; Stühmann et al., 2020; Sun et al., 2019).

Immense advancements in medical technology have led to the growth of telemedicine. Telemedicine is the crux of mHealth interventions, a subset of DHI (Shan et al., 2019). Studies have shown that DHI support the management of chronic conditions in a home setting (Maresca et al., 2019). mHealth implemented through smartphone applications (app) and wearable can be personalized (Shan et al., 2019).

In T2DM management, the goal is to achieve and maintain the blood glucose level (BGL) within the optimal range (den Braber et al., 2019; Shan et al., 2019). Pursuit of sufficient and regular physical activity (PA), healthy diet, prescribed medication (insulin doses) intake, sufficient sleep, stress management and regular BGL monitoring are factors integral to optimal T2DM management (den Braber et

al., 2019; Grandner et al., 2016; Shan et al., 2019; Simon et al., 2014). These can be understood as lifestyle factors (den Braber et al., 2019; Schoeppe et al., 2016). Studies show that self-management is a cornerstone for holistic T2DM management (Izahar et al., 2017). Health coaching can support in facilitating self-management (Gupta et al., 2018).

Health coaching involves targeting and improving poor health behaviors such as lack of pursuit of PA, smoking, and eating an unhealthy meal (Gupta et al., 2018; Snaith et al., 2018). Previous studies reveal that mHealth facilitates self-management of T2DM and is effective in supporting the individual to maintain an optimal BGL (Boyle., 2017; Kebede & Pischke, 2019; Murray et al., 2016). Studies also suggest that an engaging mHealth intervention is a prerequisite for achieving the health effectiveness (Agarwal et al., 2019; Yardley et al., 2016).

Despite this significant advantage of mHealth in T2DM care, T2DM app usage in an individual's daily use scenario is not prevalent (Kebede & Pischke, 2019). Findings from literature show that lack of thorough evidence in the areas of behavior change models, less clinical focus addressed in the app development, and minimal integration of T2DM care functionalities in a single application (app) could be some possible reasons (den Braber et al., 2019; Helbostad et al., 2017; Yardley et al., 2016).

Hence, our goal in this project is to develop an engaging mHealth app that is science-based, evidence-based, and artificial intelligence (AI) driven, supporting T2DM patients to self-manage their condition in a remote setting. This paper solely focuses on addressing the question of what sociodemographic factors contribute to developing a user engaging mHealth app that would support T2DM patients in maintaining their BGL within the target range.

In the beginning of this project, during the conduction of an expert stakeholder analysis, the possibility of sociodemographic factors affecting the user engagement with the app was addressed. Hence, that was taken as one of the problem statements in the pursuit of this project. To solve this, a thorough literature study was conducted followed by interaction with T2DM patients and caregivers through questionnaires and think aloud interview.

2 BACKGROUND

Diabetes education is closely related to the self-management of T2DM as it induces self-care behaviors in the individual (Kebede & Pischke, 2019; Weston et al., 2015). Diabetes education includes equipping the patient with knowledge about T2DM, complications of T2DM, and the patient's progress in T2DM management (Weston et al., 2015). Education about the health condition and self-awareness about the progress is an integral part of health coaching process. And this is associated with positive engagement with the DHI and thus effectiveness on the individual's health (Weston et al., 2015; Yardley et al., 2016). Enabling the patient with relevant and timely health information is an essential benefit seen in mHealth app adoption (Shan et al., 2019).

One aspect of engagement is related to the user's interaction with the digital intervention and is defined as the "quality of user's experience with technology" (O'Brien & Cairns, 2015; O'Brien & Toms, (2008). To address this definition of engagement, some aspects such as feedback, awareness, aesthetics, attention, interactivity, and challenge are considered in building an engaging technology (O'Brien & Cairns, 2015; O'Brien & Toms, (2008).

Another aspect of engagement with digital health interventions focuses on the patient's engagement with the process of achieving behavioral and physiological change (Yardley et al., 2016). Here, engagement with a DHI is considered similar to engaging with face-to-face intervention (Yardley et al., 2016).

3 METHODS

In this project, the CeHReS roadmap (Van Velsen et al., 2013) is being adopted for developing this T2DM mHealth app. The initial set of designs were explicitly focused on the content design of the app. This has been done by taking into account the various attributes of health coaching. We will not be discussing about the app design process further since it lies outside the scope of this paper.

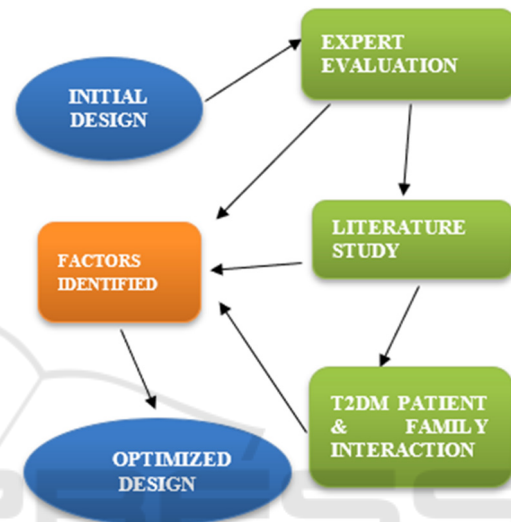


Figure 1: Outline of the steps taken in identifying the sociodemographic factors affecting user engagement.

As shown in Figure 1, three steps were taken in identifying the sociodemographic factors influencing user engagement with the T2DM app. Expert evaluation on the initial set of designs, literature study and, questionnaire response by patient and family caretaker are the three steps. These steps are described below.

3.1 Expert Stakeholder Evaluation

The initial set of designs were created and as a part of stakeholder evaluation, a qualitative evaluation with a group of experts was conducted. In total, five experts participated in this evaluation. The expert panel consisted of an mHealth specialist, Artificial Intelligence (AI) expert, knowledge in the area of behaviour change, diabetes and pharmacology specialist, software developer along with a regular non diabetic fitness app user. To conduct this evaluation, a short video explaining the core functionalities of the content design was pre-recorded and sent to the expert panel prior to the expert session. This was done one week before the expert session.

During the expert meet up, the questions related to engagement aspect were posed and discussed. The questions discussed are as follows:

1. Do you think the app is engaging to the user?
2. How is sustained engagement affected in this?
3. What factors can be addressed to make the app engaging in terms of long-term user engagement?

3.2 Literature Study

Based on the feedback received in this expert evaluation session, a decision to update the current designs based on a revised literature study was taken. For the literature study, scientific papers from JMIR (open access journal) were found through the combination of the following keywords: T2DM, diabetes, user engagement, mHealth, eHealth, telemedicine, self-management and social demographics. This literature study was conducted in December 2020.

3.3 T2DM Patient and Family Caretaker Questionnaire

Based on the expert evaluation feedback and conclusions of the literature study, a decision to collect insights from the T2DM patients and their family caretakers was taken. Here, T2DM patients and family caretakers of T2DM patients were recruited to participate in a short questionnaire survey. Two different questionnaires were made. One was for the T2DM patient and the other was for the family caretaker. The purpose of the questionnaire was to understand the interest of the patients and family in the scope of the app with emphasis on the role of T2DM care education in remote self-management and the possible involvement of a family member as a caregiver in T2DM management. 13 people filled the questionnaire. 4 of them were patients and 9 of them were family members. In addition, 1 family member did a think aloud session for 20 minutes discussing about the designs. The patients were recruited through acquaintances of the people conducting this research.

With the expert evaluation feedback, the content analysis results of the literature study and the questionnaires results along with the think aloud session, the current designs were further optimized. In this paper, as illustrated in Figure 1, we report the findings explicitly focusing on the engagement

dependent on sociodemographic aspect for an optimal T2DM management.

4 RESULTS

From the methods discussed in the previous section, three sets of results are obtained. These are discussed in this section.

4.1 Expert Evaluation

Through the expert evaluation, the scope of user engagement with the mHealth app was elaborately explored. All the experts reinforced the point of the current set of designs being engaging and effective for the user in T2DM self-management. However, a strong recommendation was provided by all the experts to look into the long-term or sustained engagement aspect. The expert panel felt that factors such as age, ethnicity, education status, health literacy, and digital skills could affect user engagement.

In order to address this, the experts suggested exploring the possible role of sociodemographic factors in adopting and engaging with mHealth technology for successful T2DM self-management.

4.2 Literature Study

For the literature study, ten articles from JMIR were selected. The ten articles selected focused on T2DM management via mHealth and eHealth (web-based) solutions and had at least one barrier listed which focused on the lack of engagement aspect. The articles selected are based on studies conducted on T2DM management through ICT in diverse geographic locations such as the USA, Canada, Norway, China and India. In this literature study, ten barriers affecting the engagement have been identified. Figure 2 provides an outlook of the sociodemographic factors identified in the literature study implementation.

Five articles identified low health literacy as a barrier affecting the user engagement (Alvarado et al., 2017; Desveaux et al., 2018; Williams & Schroeder, 2015; Zhang et al., 2019). When compared to patients with high health literacy, patients with low health literacy dropped out of mHealth and eHealth studies (Alvarado et al., 2017; Williams & Schroeder, 2015).

Five articles identified ethnicity of the patient as a barrier in engaging with the developed eHealth and mHealth solutions for T2DM management (in the

context of this paper, ethnicity can be understood as a sense of belonging to a particular cultural or social group) (Huang et al., 2019; Mold et al., 2018; Muralidharan et al., 2017; Tataru et al., 2019; Williams & Schroeder, 2015, 2015).

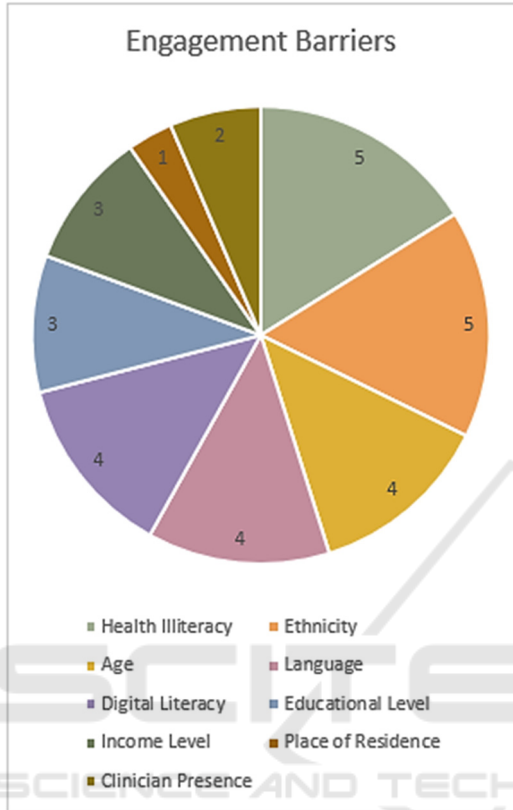


Figure 2: List of barriers affecting T2DM care engagement of the patient (with their frequency of occurrence).

Four articles identified that age of the patients affect their engagement with the T2DM care solution. Elderly people face difficulty in this aspect (Agarwal et al., 2019; Huang et al., 2019; Peters et al., 2017; Williams & Schroeder, 2015).

Four articles have identified language as a barrier in engaging with the T2DM solution (Alvarado et al., 2017; Mold et al., 2018; Tataru et al., 2019; Williams & Schroeder, 2015). A study conducted in the U.S.A identified Latino population residing in the U.S.A had issues in adopting the eHealth solution as the solution was in English (Williams & Schroeder, 2015).

Four articles have identified digital or technical illiteracy as a barrier for a successful engagement with the T2DM services (Alvarado et al., 2019; Huang et al., 2019; Peters et al., 2017; Tataru et al., 2019). T2DM patients with lower digital skills have dropped out of investigative studies faster in comparison to patients with higher digital skills.

Three articles have identified educational level as a barrier in adopting T2DM digital interventions (Alvarado et al., 2019; Tataru et al., 2019; Williams & Schroeder, 2015). Educational level has affected the self-management aspect of T2DM causing lower engagement in low level educated groups (Alvarado et al., 2019).

Three articles have identified income level as a barrier in T2DM ICT-based care (Alvarado et al., 2019; Mold et al., 2018; Peters et al., 2017). Other factors include specific lack of knowledge of medical terms (Mold et al., 2018), cultural awareness (Alvarado et al., 2019) and place of residence of the patient (Mold et al., 2018).

Belief in the benefit of the solution (Agarwal et al., 2019; Desveaux et al., 2018; Huang et al., 2019), referral of the solution by the clinician team (Agarwal et al., 2019; Huang et al., 2019) and continuous interaction between the clinician team and patient (Agarwal et al., 2019) have also been identified as barriers for engagement.

Figure 2 shows the list of ten barriers identified in the ten articles during the implementation of the literature study. In Figure 2, cultural awareness has been combined with ethnicity, specific lack of medical terminology knowledge has been combined with health illiteracy and the barriers listed in relation to the clinician and patient engagement have been grouped under clinician presence.

4.3 Patient and Family Caretaker Questionnaire

13 participants filled in the questionnaire survey. 4 participants were T2DM patients and 9 participants were family caretakers of T2DM patients. All the 13 participants were of the Indian origin.

Among the T2DM patients, 3 men and 1 woman filled in the questionnaire. 2 of the participants have indicated their age group. One person belonged to the age group of 50 to 60 and another between 60 to 70 years.

Among the family members who filled in the questionnaire, two participants were Indians based out of Germany and the Netherlands. 4 men and 5 women filled in the questionnaire. 3 people were less than 30 years, one person belonged to the age group of 30 to 40, 4 of them belonged to the age group of 50 to 60 and one person to the age of 60 to 70.

Out of the 4 T2DM patients, 3 have indicated that they have good knowledge about T2DM care and 1 patient has indicated that they want to have T2DM care knowledge. All 4 have indicated that they like

their family members being involved in the care. Out of 9 family caretakers, only 2 have indicated that they have good knowledge about T2DM care, 4 gave a neutral response and 3 have indicated they don't have any knowledge about T2DM care. 7 family caretakers have indicated that they want to have T2DM care knowledge. All 9 participants have indicated that they like to be involved in their family member's T2DM care.

One female family member participated in the think aloud session. She is from India and belonged to the age group of 50 to 60 years. Her spouse has T2DM. During the session, she reinforced the idea of the app was good and needed in T2DM management. Further, she provided insights into how the health information can be conveyed better to a potential user based on the current content design of the app.

5 DISCUSSION

From the feedback received in the expert panel discussion for the initial set of T2DM mHealth app designs, the literature study implementation and the interaction with T2DM patients and family caretakers through questionnaires and interview, sociodemographic factors which influence the user engagement were identified.

Some of the factors identified during the expert panel discussion are concurrent to the factors identified during the implementation of the literature study. These were the factors of age, education level, health illiteracy, and digital illiteracy.

From the results of the literature study, it can be understood that the factors are related to each other. For instance, the article by (Williams & Schroeder, 2015) identified health illiteracy, age, language, ethnicity and education level as barriers to the user engagement. The article by (Alvarado et al., 2017) identified health illiteracy, language, digital literacy, education level, and cultural awareness as factors of barrier for the user engagement. Articles by (Tatara et al., 2019; Williams & Schroeder, 2015) reveal that immigrant populations who form the minority ethnic groups and Hispanic population in the U.S.A. face the concerns of health illiteracy.

From the expert panel discussion, it was realized design in terms of aspects such as aesthetics, feedback or challenge alone would not be sufficient in engaging the user. From literature, it can be understood that these aspects arise from the definition of engagement that is inclined towards the quality of the user experience with the digital intervention and

focus on the initial reaction of the user to the digital intervention (O'Brien & Cairns, 2015; O'Brien & Toms, (2008).

The panel discussion yielded a strong conclusion that inclusion of sociodemographic elements and clinician presence to the existing design which already focused on the areas of aesthetics and feedback would benefit the part of user engagement. The findings from the literature study implemented also concurs with this.

In the work of (Yardley et al., 2016), "engagement is understood as a dynamic process which involves a trigger, followed with an initial use by the patient, which may further lead to a sustained engagement, disengagement or maybe a shift to another intervention". Thus, it can be realized that for engagement to be effective, it should satisfy the criterion of engagement with technology and engagement with the behavior change pursuit (O'Brien & Cairns, 2015; Yardley et al., 2016).

From the previous sections, it can be understood that self-management is crucial for successful T2DM management and diabetes education is an important part of self-management as it plays a role in inducing self-care behaviors in the patient.

The article by (Yardley et al., 2016) emphasizes that digital health interventions need to address the target group of people with low health literacy and include design solutions to alleviate health illiteracy. Health literacy focuses on the aspects of applying knowledge and the ability to access, understand and apply health-related information.

Interaction with subjects is an inherent component of CeHReS roadmap as it is based on human centred design. In the expert session, the experts strongly recommended to address countries in Asia and Africa as it would give a global perspective in the project. Hence, as an initial step, the patient interaction took place with the Indian patients and family members. Although the number of participants were less, the feedback from the participants concurred with the expert evaluation feedback and literature study. The insights from the questionnaire response of T2DM patients and family caretakers also indicate that knowledge of T2DM care would support optimal T2DM self-care. These responses concur with the feedback of expert session and literature study.

From the conclusions of the expert session, the conduction of literature study and, responses of T2DM patients and family caretakers, we realize the role of health literacy in T2DM management. Hence, in this paper, we come to the conclusion of health illiteracy about T2DM being the most crucial factor among the list of sociodemographic factors

identified, which affects the user engagement with the T2DM mHealth app intervention.

In the next phase of our project, we are optimizing the initial set of designs by modelling the sociodemographic factors into an Artificial Intelligence model to drive the app content and explicitly focus on addressing the T2DM education aspect through chatbots and avatars (Das et al., 2019). From the questionnaire, it was understood that family caretaker also forms an important stakeholder group and hence they would be included in the mHealth intervention along with the physician team. The designs would be developed into a functional prototype and would be tested as a part of iterative longitudinal studies with T2DM patients, their family caretakers and clinician for aspects of usability, sustained user engagement, and T2DM management effectiveness.

6 CONCLUSIONS

The objective of this paper was to identify the sociodemographic factors affecting user engagement of a T2DM patient with an mHealth T2DM intervention. Health illiteracy, digital literacy, education level, age, ethnicity, language, place of residence, income level, cultural awareness and patient clinician interaction were found to be the barriers for an effective user engagement with the mHealth intervention.

Health illiteracy was identified as a crucial factor in affecting the user engagement as it is closely linked to diabetes education, an integral feature of self-managing T2DM. These engagement barriers were identified through an expert panel discussion, followed with a literature study implementation and questionnaire responses from T2DM patients and family members.

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