User-centered '*Swayam Diabetes*' m-Health application for self-care management of Type 2 diabetes in urban home settings, the usability and utility testing of mobile application and perspectives

Abhijeet Prasad Sinha, Manmohan Singhal, Ashish Joshi, Bhavna Kumar, Neeraj Kumar Sethiya

1. *Ph.D. fellow at DIT University Dehradun, India.*
2. *Associate Professor at DIT University, Dehradun, India.*
3. *Dean and distinguished professor at The University of Memphis in Tennessee, USA.*
4. *Associate Professor at DIT University in Dehradun, India.*
5. *Associate professor at DIT University in Dehradun, India.*

Abstract

Diabetes mellitus type 2 (T2DM) is one of the most common and widespread diseases in the world. It affects people in both rich and developing countries. With a growing population, it's getting harder and harder for healthcare services to provide good care. Given the nature of the disease and the setting of the healthcare system, it has become much more important to focus on self-care management to deal with the complications of T2DM. To reach the goal of self-care management, mobile can be leveraged and mostly accessible to the urban population. The Self-care management Swayam m-health app was therefore built while keeping users in mind for self-care management in urban home settings. Self-care management includes checking the blood glucose level, keeping the ideal weight, and focusing on a healthy and nutritious diet, physical activity, and medications regularly. It is very important that the m-health application designed to track self-care management goals would bring an integrated approach to self-care management and would be beneficial in the Chronic Care Model (CCM). The Swayam Diabetes health app was developed to include important features and most importantly a diary and information on nutrition informatics. This application design would also be beneficial to people who have comorbidities diabetes, and cardiovascular disease and at the same time, like people with high blood pressure and diabetes. m-Health interventions would help people stick to their self-care management plans, and in the future, this application could include a nutrition informatics module that focuses on the local/regional diet of India. So, it would give a person with diabetes a combined way to take care of themselves when they have diabetes. Patients are more likely to use m-Health for self-management of disease if they seem to have some control over their complications and improvement in their conditions. Most importantly the designed mHealth app Swayam Diabetes app caters to the user's needs and follows human-centered, keeping people at the core for the usability and utility of the mHealth application Swayam Diabetes Care was rated high in the System Usability Scale (SUS) global quality assessment tool which was used to evaluate this mobile application its utility and usability from users perspective has rated high with N=55 users >80% core in the SUS global tool.

Full length article   *Corresponding Author*, e-mail: *abhijeetpsinha@gmail.com*

1. Introduction

Diabetes mellitus (DM), a metabolic condition with long-term high blood sugar, is one of the biggest health challenges of the 21st century. More than 537 million people have it, and that number is projected to grow to 783 million by 2045 [1, 3]. In 2019, 1.13 million people, or 7.3 million people of all ages, had diabetes. 37.1 million were people between the ages of 18 and 64. Diabetes has been found in 28.7 million people of all ages, which is 8.7% of the population. Over 18 years old made up 28.5 million of them. Undiagnosed: 23% of adults with diabetes, or 8.5 million people aged 18 and up, did not know they had diabetes.[3].

Because the disease gets worse over time, it affects more and more organs and can lead to neuropathy, heart disease, and retinopathy if it isn't properly watched and treated [3,4]. Even though T2DM is more common in middle age, more and more people over the age of 20 are also getting it early. People younger than 40 years old are more likely to get the disease early. Environment and genes are the most important risk factors for T2DM, along with a few other things [5]. One of the hardest things for healthcare workers to do today is to meet the ongoing needs and wants of people with chronic conditions like diabetes [6]. Follow-ups are much more important and significant for diabetic people who want to

avoid long-term problems [6]. Many types of scientific studies show that diabetic complications can be slowed down or reversed with self-care management [5]. As far as diabetic patients' needs go, they aren't just about keeping their blood sugar level stable; they also include rehabilitation and limitations due to ill health [4]. There is a lot of scientific proof that shows the lack of knowledge about diabetes and negligence in the management of the conditions that affect the treatment of Diabetes Mellitus) DM. Since there is no cure for DM, it is always important to take care of the disease scientifically and practically [5,6,7]. Patients with diabetes must live amidst such challenges for the rest of their lives, and since it's almost impossible for them to go to the doctor regularly, self-care management becomes very important [7]. Both the European Association for Diabetes study and the American Diabetes Association support the self-centered care management method. This includes self-monitoring of glycemia level, physical activity, foot care, good nutrition, and taking medications regularly. People should have enough knowledge, courage, and skills to do this. The main goal of person-centered care for T2DM is to help people live healthier lives [5,6].

A healthy way of life includes doing physical activities daily, eating a balanced diet by managing nutrition, keeping a healthy weight, and not smoking. Self-care management and practices would not be possible without the help of technology, which has been used to track and improve the lives of diabetic patients and continues to do so. People with T2MD need health-tracking tools to measure and keep an eye on their blood sugar levels and blood pressure. These tools are important in both preventing and treating T2MD. The other main reason to use a person-centered method is to make it easier on a healthcare system that is already having to deal with the problems of a growing population [4,6].

2. Self-care management and Nutrition informatics

People who ate a balanced diet had a much lower chance of developing type 2 diabetes, which has been linked to better glucose metabolism and less diabetes in general [8]. Every day, one should eat fruits, low-fat dairy products, veggies, and whole grains. It is advised one should also eat less poultry, fish, legumes, red meat, and tree nuts [7]. In Chronic Care Management (CCM), self-care or management of self-care can improve health outcomes and may lower the chance of diabetic complications. M-health interventions which use mobile phone technology, are used in several global programs that focus on self-care management. A lot of research is being done to help people improve their self-efficacy, self-care, health-related quality of life, and clinical outcomes. But most of the m-health apps that have been made are clinical and don't focus on self-care management like the importance of nutrition informatics, food, and exercise, nor do they test blood glucose levels. The m-health application healthcare has the potential to improve support for patients with type 2 diabetes mellitus. It is important to improve patient outcomes by improving self-care, comprehensive self-care management, and incorporating nutrition informatics, and psychological support can help patients deal with Type 2 diabetes and adherence to self-care management activities. Most studies looked at good lifestyle habits like being active and checking your blood sugar. But for people with diabetes, taking care of their signs and symptoms and following a diet plan can be the hardest part of self-care and

can improve their health. Mobile phone technology is very popular among people of all ages and income levels, and it opens new possibilities in health care, such as preventing Type 2 diabetes and helping people take care of themselves. The future seems to be in mobile health applications (mHealth) that use existing technology to make better use of smartphones to help avoid and treat chronic diseases like diabetes type 2. Diabetes can be reversed and even cured with food [9]. Dietary tactics, on the other hand, have changed over time and science has learned more [8, 9]. In the past, nutritional control meant limiting foods that were high in sugar, like fruits, starches, bread, and refined carbohydrates [10]. Since the diet has less carbs, it may have too much protein and fat. But now, the major focus is still on a diet with few fats, especially saturated fats, which can raise cholesterol levels, and as little protein as possible for people with kidney problems [10]. The new method puts more focus on fat because people with diabetes have more trouble with fat [11]. When there is a lot of fat in the body, insulin doesn't work as well. This makes it hard for glucose to get into the cells, which causes diabetes. On the other hand, insulin can do its job better when body fat is smaller and fat intake is limited [12].

3. Technological advancement and self-care management

In the field of diabetes, changes in technology are becoming more unpredictable. By giving patients more power, they are giving patients the chance to take charge of their care [13]. But they might be hard for both patients and doctors at the same time. So, to understand how to use diabetic technology and get the most out of it, one must be aware of the unmet needs in controlling diabetes right now. Human-centered design apps are working better because they take into account the needs and wants of both healthcare providers and patients [14]. Human-centered designs (HCD) have become a powerful way to make mobile health (mHealth) apps that are satisfying and easy to use [15]. For a specific plan, both quantitative and qualitative methods are changed to provide the best self-centered care [15]. Even though different mobile apps work in different ways, the main idea behind them all is the same: to use data from the patient to keep track of ongoing health problems.

4. Mobile Health Apps and Self-management

The mHealth app can be used on personal mobile devices and is often geared toward the user's needs. The number of people who use these apps keeps going up, and they are now the second most popular type of app [16], just behind apps for mental health. These apps do a lot of different things, such as keeping track of physical activities, measuring carbs, keeping a nutrition database, keeping track of weight, sharing data with peers or doctors, setting alerts, sending messages, and providing social support. The most important thing that makes it different from other monitoring devices is that it can connect a healthcare worker and a patient even when they are not in the same room [16]. Different apps use different ways to report, such as graphs, detailed reports, or text data that can show the daily amount of sugar or another important physiological parameter [18]. Because these apps keep the person up to date on their current self-care management parameters, they make it easier for the person to stick to their exercise, food, management plans, and medications, which improves their diabetes over time. It's

important to note that mobile apps aren't always made to do more than one thing. Patients can always choose whether they need an app with limited functions or one that can do more to improve self-care management [18].

5. Human-centered design of the Swayam Diabetes Health application

The Human-centered design (HCD) of the m-health application is very important. It would bring an integrative approach to self-care management to the Chronic Care Model (CCM). It would also help patients with co-morbidities, such as those who have both high blood pressure and diabetes. m-Health interventions would help people stick to their self-care management plans. In the future, this application could include a nutrition informatics module that focuses on local foods. So, it would give a person with diabetes a combined way to take care of themselves when they have diabetes. Patients are more likely to be ready for self-management and to use m-Health for self-management of disease if they seem to have some control over their illness. Integrated self-care management of type 2 diabetes using a health application with a human-centered design that was made keeping users, the patient at the core to better handle their Self-care management at home. The quality of the app needs to have several features, such as a self-diary where daily entries can be made about diet, exercise, and medicines. DBMS-integrated self-assessment questions with built-in features such as rewards, setting the goals for self-care management, chat with FAQs, and WhatsApp group- Keeping the user at the center.[21]

6. Complete the Feedback Loop and its role in controlling T2DM.

The most important way apps give useful information to healthcare providers is through the ability to talk back and forth [19]. Important choices about the diabetic patient are made based on the information about their body. Recently, a full feedback loop between healthcare workers and participants has helped reduce HbA1c by a lot. Many studies have shown that contact that goes both ways is better. Also, the developer and the healthcare worker work together to make the app as useful as possible. For example, the medical or expert team's useful information is used in a good way to improve the design of the app and make it easier to use [19, 18]. Based on the user-centered factors, the Swayam Diabetes healthcare apps were developed, and possible actions to be tested with users n=18 with qualitative In-depth interviews are to be made with prototype application and taking inputs into the design of this health application example, recent research showed that the patient's glycosylated hemoglobin level went down with the help of technology intervention and a full feedback loop. This application has users' daily diaries to track physical activity information, food and nutrition, blood glucose level, and exercise, daily weekly diaries were evaluated feedback from the users on their utility and usability(N=55). The old way of sharing information always leads to mistakes, called "artifacts," because environmental factors and personal circumstances affect physiological information.[21] However, these problems can be prevented by using the

above important feature Figure 2 which is embedded into the prototype design of the Swayam diabetes care health app. Currently, about 9–17% of apps have personal information and daily monitoring, and very few in the local context, and if this number goes up in the coming years, things could get better [19, 18, 17]. As per international professional standards [15], it is important to learn about diabetes as part of taking care through a self-care management approach. Taking care of oneself through the mhealth Swayam diabetes platform is an important part of managing diabetes through the right information on daily regimes and a holistic approach. However, most interventions in Self-care management that try to assist people living with diabetes don't have any learning materials focused on FAQs. A lot of research has shown that people with T2DM who know a lot about the disease are much better at taking care of themselves, which helps them hit their HbA1c goal. The T2DM self-care management apps help the person learn what they need to know, like what to eat, and how to take care of their diabetes, and get answers to their questions from experts. [15, 19].

7. Importance of Physical Activity in self-care management

Mobile apps are made to track physical activity and measure how the body changes as a result of exercise. For example, they can measure the level of oxygen saturation, record the activity, and rate it as slow, average, or high. Based on the information given, these can also set goals for the patient and send messages based on the goals set. Exercise is the best way to keep diabetes under control [20]. When you work out, especially if you have T2DM, insulin becomes more sensitive. Importantly, the exercise works right away and lowers the amount of glucose in the blood. Also, many studies have shown that blood glucose levels stay the same after exercise when a person is fasting, but they go down when a person exercises after eating [20]. The System Usability Scale (SUS), a tool that has been used a lot of times around the world, was used to rate the app. You can use SUS apps to test any kind of software or system, including websites, mobile apps, digital booths, computers, and other tech [16]. Something can be given a general SUS number [17] based on how well it works and how simple it is to use. N=18 people who used the Swayam diabetes app gave it a score for usability, ease of use (graph 1), and usefulness in terms of giving information on self-care management.[18]. To find out how well diet and mobile health informatics improve self-care and care at home for people with type 2 diabetes, the SUS tools study used qualitative methods. FGDs, IDIs, in-depth interviews, and SUS tool tests were used to gather information for the project. To find out how useful the app is for people with type 2 diabetes and how easy it is to use for self-care at home. The SUS, which is made up of 10 items, is a simple scale for qualitative testing with users on usability and utility [21]. The SUS is a Likert scale. N=55 people were tested with the SUS evaluation and feedback questionnaire; the utility and usability scores are above 80 on the SUS usability scale which suggests the app which is developed has scored high by users in utility and usability for self-care management.
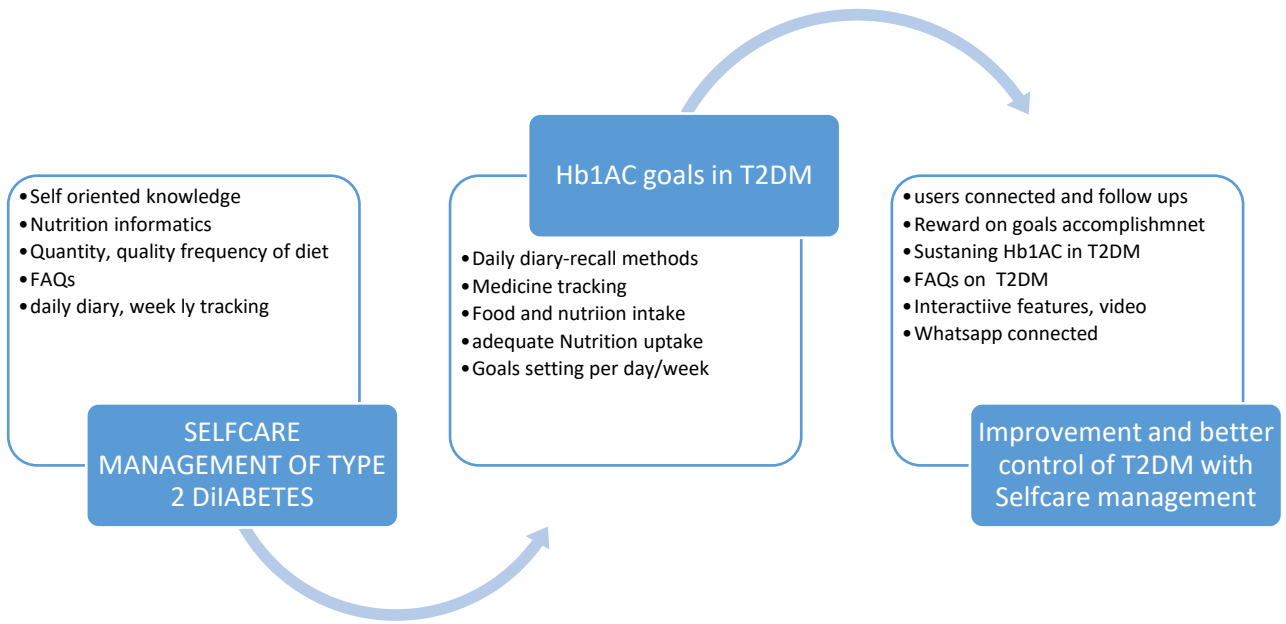
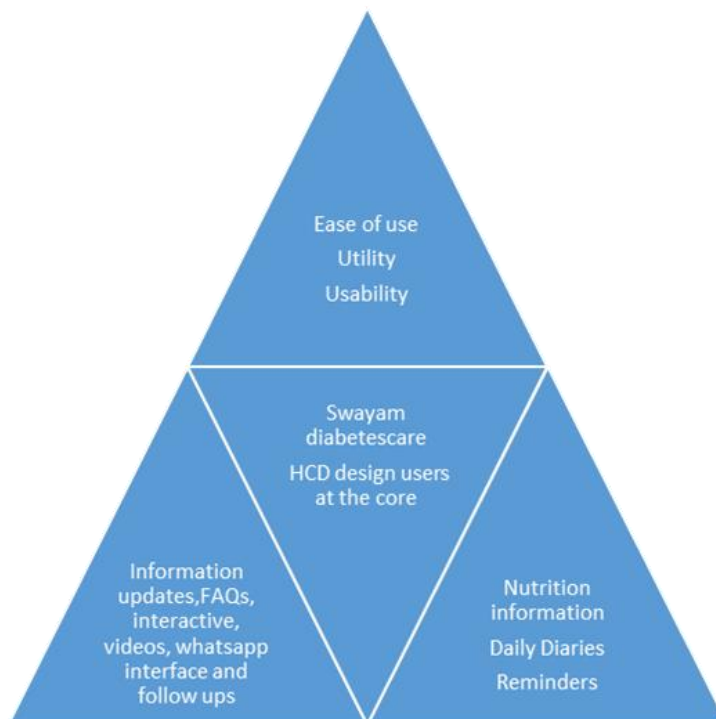**Figure 1**: Swayam Diabetes Care Health HCD design model for self-care management

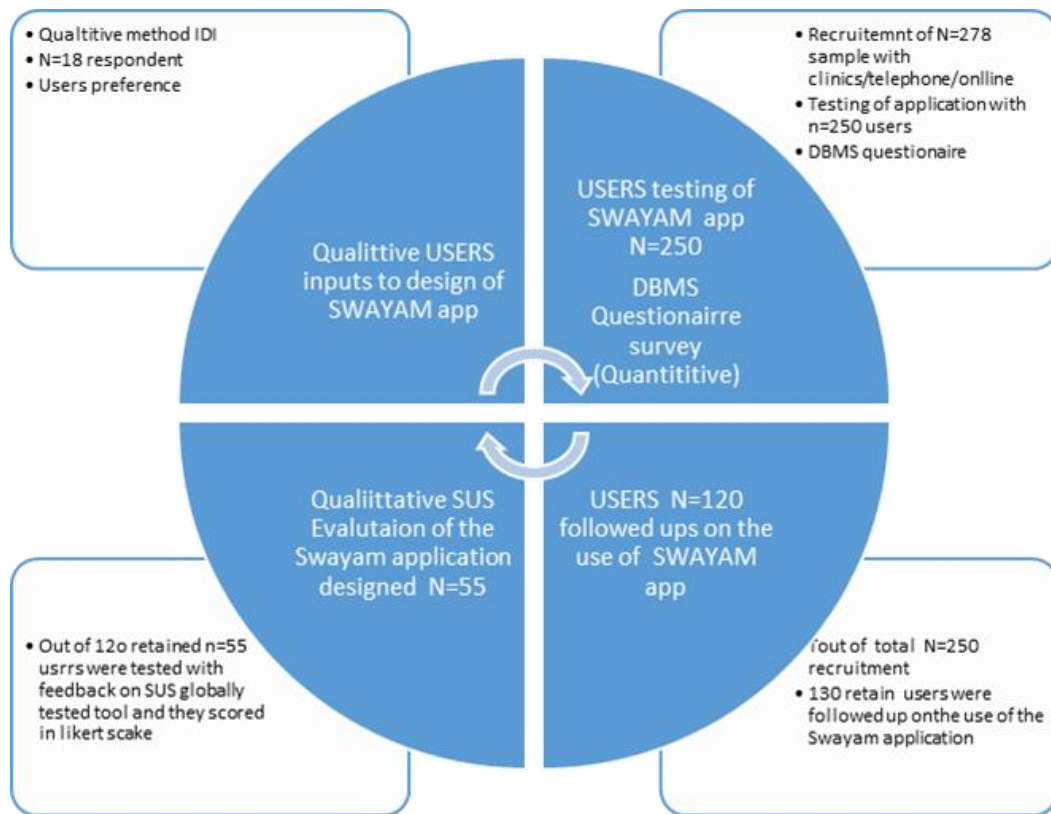**Figure 2**: SWAYAM Diabetes care application, HCD design, and features

Figure 3: Abhijeet P Sinha et.al SWAYAM Diabetes app

8. Conclusions

The m-health application's human-centered design is critical from the user's perspective on the feature important to consider for self-care management of type 2 diabetes. m-health such as Swayam Diabetes can add a more complete way to handle complications in Type 2 diabetes using self-care management goals, daily diary weekly diary, and nutrition information. The Swayam Diabetes Care is an android backed up with a nutrition informatics part that focuses on local food. In this way, a person with diabetes would be able to take care of themselves in more than one way. Users who would have some control over their illness are more likely to be ready for self-management and to use m-Health for self-management of disease. People with type 2 diabetes can go through this self-care management regime at home settings. The design features of this mobile application were designed with the users and keeping users' suggestions at the core, the design has been patented. The Swayam Diabetes application has a lot of useful features, like a self-diary where users can write every day about what they eat, how much they exercise, and their medications. Diabetes-based management (DBMS) is a built-in feature, with tools like setting goals, running chats with frequently asked questions, and a WhatsApp group. Patients are more likely to use m-Health to take care of their illnesses if they feel like they have some control over them. Most importantly, the mHealth app was made with the user's needs in mind and is human-centered, which means that people are at the center of how easy it is to use and how useful it is. A global quality rating tool called the System Usability Scale (SUS) was used to rate this mobile app very highly for Swayam Diabetes Care. The Swayam Diabetes application can be further built with Artificial intelligence tools (AI) and local-level diet can be integrated into a self-care diabetes management system(SBDMS)

Acknowledgment

Contributions of Authors

Everyone who wrote the paper helped in this study, All of them have also agreed that the manuscript can be released**.**

Conflicts of Interest
None

References

[1]   A. Sapra. (2023). *Diabetes*. StatPearls - NCBI Bookshelf.
        http://www.ncbi.nlm.nih.gov/books/NBK551501/.

[2]   Fujimoto WY. The importance of insulin resistance in the pathogenesis of type 2 diabetes mellitus. Am J Med. 2000 Apr 17;108 Suppl 6a:9S-14S. doi: 10.1016/s0002-9343(00)00337-5. PMID: 10764845.

[3]   J. Kazibwe., M. Gad., E. Abassah-Konadu., I. Amankwah., R. Owusu., G. Gulbi., S. Torres-Rueda., B. Asare., A. Vassall., and F. Ruiz. (2023). The Epidemiological and Economic Burden of

Diabetes in Ghana: A Scoping Review to Inform Health Technology Assessment. medRxiv (Cold Spring Harbor Laboratory); Cold Spring Harbor Laboratory. https://doi.org/10.1101/2023.04.19.23288806.

[4]   R. Goyal., M. Singhal, and I. Jialal. (2023). Type 2 Diabetes. In: StatPearls [Internet]. Treasure Island (FL): StatPearls Publishing; 2023 Jan-. Available from https://www.ncbi.nlm.nih.gov/books/NBK513253/.

[5]   M. Darwish. (2015). Diabetes Mellitus: The Epidemic of the Century. World Journal of Diabetes (DOI: 10.4239/wjd.v6.i6.850, page 850).

[6]   C. Solis-Herrera, R. A. DeFronzo, C. Triplett, C. Reasner, and E. Cersosimo's. (2018). Classification of Diabetes Mellitus. www.ncbi.nlm.nih.gov/books/NBK279119.

[7]   M. Asif. (2014). The Prevention and Control of type-2 Diabetes by Changing Lifestyle and Dietary Pattern," by M. Asif, Journal of Education and Health Promotion.

[8]   A. Brown. (2019). Intensive dietary lifestyle interventions in type 2 diabetes, Endocrine Abstracts. DOI: 10.1530/endoabs.61.ou6.

[9]   "Primary Prevention of Type 2 Diabetes Mellitus by Lifestyle Intervention: Implications for Health Policy," published in Annals of Internal Medicine in June 2004, vol. 140, no. 11, p. 951, doi: 10.7326/0003-4819-140-11-200406010-00036.

[10]   J. B. Marks. (2015). Lifestyle Modification and Weight Control in Diabetes Prevention and Treatment. Clinical Diabetes. 2005, 23(3), 129–129, DOI: 10.2337/diaclin.23.3.129.

[11]   V. Naik., R. Dave., J.W. Stephens, and J.S. Davies. (2015). Evidence-Based Prevention of Type 2 Diabetes: Role of Lifestyle Intervention as Compared to Pharmacological Agents. Int J Diabetes Clinical Research. 2:049. 10.23937/2377-3634/1410049"

[12]   W. Sami., T. Ansari., N.S. Butt., and M.R.A. Hamid. (2017). Effect of diet on type 2 diabetes mellitus: A review. International Journal of Health Sciences (Qassim).11(2):65-71. PMID: 28539866; PMCID: PMC5426415H. B. Santoso, M. L. Hakim, P. K. Nursalamah, and P. O. H. Putra, "Development of Mobile Self-Monitoring Tool Prototype Based on User-Centered Design," in IJET (International Journal of Emerging Technologies in Learning), December 2019, page 42, doi: 10.3991/ijet.v14i24.12043.

[13]   P. Asthilingam. (2016). A Mobile Application to Improve Self-Care of Patients with Heart Failure. Journal of Cardiac Failure. 22(8) S102–S103. DOI: 10.1016/j.cardfail.2016.06.327.

[14]   Z. S. Boonviriya, P. Nimmanterdwong, and P. Tangkijvanich. (2021). Human-Centered Design of Mobile Health Applications for Older Adults: Systematic Review and Narrative Synthesis (Preprint). JMIR mHealth and uHealth.DOI: 10.2196/29512,

[15]   C. M. Lohnert, S. Eberle, and S.T. Itching. (2020). Efficacy of certain mobile health applications (mhealth-apps) in Diabetes mellitus: A scoping review (Preprint). JMIR mHealth and uHealth, 9(2) DOI: 10.2196/23477.

[16]   K. S. Capra and J. Hale Bauer. (2015). A Framework to Assist Health Professionals in Recommending High-Quality Apps for Supporting Chronic Disease Self-Management: An Illustrative Assessment of Type 2 Diabetes Apps. JMIR mHealth and uHealth. 3(3):e87, DOI: 10.2196/mhealth.4532.

[17]   H. Alaslawi., I. Berrou., A. Al-Hamid., D. Alhuwail., and Z. Aslanpour. (2022). Diabetes Self-management Apps: Systematic Review of Adoption Determinants and Future Research Agenda. JMIR Diabetes.28;7(3):e28153. doi: 10.2196/28153. PMID: 35900826; PMCID: PMC9377471.

[18]   N. Abbas, R. Joshua, and J.-H. Lee. (2022). M-Healthcare Model: An Architecture for a Type 2 Diabetes Mellitus Mobile Application. Applied Sciences. 13(1) 8. DOI: 10.3390/app13010008.

[19]   M. Borade Singh's "Diabetes Mellitus and Exercise," PubMed in 2022,

[20]   A.P. Sinha, M. Singhal et. al. (2022). The development and use of an M-Health-enabled nutrition informatics intervention for self-care management of type 2 diabetes in home settings. Journal of Positive School Psychology. 6(12) 1261–1279.