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USER-CENTRIC DIGITAL SOLUTION FOR DIABETIC PATIENTS

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ABSTRACT

Diabetes is a common autoimmune disorder that affects millions of individuals worldwide, necessitating careful management and support. This research paper explores the multifaceted aspects of the user experience (UX) of diabetes patients, understanding their unique needs, challenges, and the potential for improving their quality of life through innovative design solutions. Our research methodology included in-depth interviews, surveys, and user observations, engaging a different types of diabetes patients. The insights underscore the significance of personalized, empathetic, and user-centric design in enhancing the UX of diabetes patients. The paper concludes by discussing key recommendations for future design, emphasizing the need for a holistic strategy that covers both the psychological and physiological aspects of diabetes care.

Keywords: Autoimmune Disorder, Diabetes, Digital Solution, User Experience Design

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1. INTRODUCTION

1.1. WHAT IS DIABETES?

Diabetes is a long-term metabolic disease characterized by elevated blood sugar levels, sometimes referred to as hypoglycemia. This disorder develops when the pancreas either cannot create enough insulin or the body is unable to use the insulin that is produced. Insulin is necessary for the uptake of glucose by cells, which use it as their primary energy source.

There are three main types of diabetes:

- *Type 1 Diabetes:* This is an autoimmune disorder when the immune system unintentionally targets and kills the pancreatic beta cells that produce insulin. People with type 1 diabetes thus either produce very little or no insulin. Typically, this kind

of diabetes appears when blood sugar management is being maintained. Thirteen is the median age at T1D diagnosis. In India, there are roughly 8.6 lakh individuals with T1D[16].

- *Type 2 Diabetes:* This is the most common kind of diabetes, affecting over 90% of total cases. It occurs when the body grows resistant to the effects of insulin and the pancreas fails to generate enough insulin to overcome this resistance. Type 2 diabetes is often associated with factors such as obesity, inactivity, genetics, and age. Initially, diet, exercise, and medication are used to control type 2 diabetes, but in some cases insulin treatment may be needed. About 25 million Indians are pre-diabetic, and 77 million adults over the age of 18 are expected to have type 2 diabetes[17].
- *Gestational Diabetes:* Approximately 90% of cases of diabetes are of this kind, making it the most prevalent type. It occurs when the body develops an immunity to the effects of insulin due to insufficient insulin production by the pancreas. Numerous factors, including age, genetics, inactivity, and obesity, are linked to type 2 diabetes. Type 2 diabetes is primarily managed with food, exercise, and medication; but, in certain circumstances, insulin therapy may be required. About 25 million Indians are pre-diabetic, and 77 million adults over the age of 18 are expected to have type 2 diabetes[18].

1.1.1. WHAT ARE THE CAUSES AND RISK FACTORS OF DIABETES?

The primary cause of diabetes is a complex interaction between inheritance and environmental factors. Risk factors for Type 2 diabetes include aging, obesity, sedentary lifestyle, bad eating habits, poor family history of diabetes, and ethnicity. Diabetes is a severe condition that, if left untreated, can lead to several issues with the kidneys, heart, eyes, nerves, and blood vessels. Diabetes must be managed to reduce the risk of complications by maintaining a healthy lifestyle, checking blood sugar frequently, and according to medication guidelines. Over 50% of people do not realize they have diabetes, which can lead to health problems if it is not detected and treated in a timely manner.

1.1.2. WHAT ARE THE COMMON SYMPTOMS OF DIABETES?

Diabetes symptoms might change based on the kind of diabetes and how it progresses. Diabetes frequently manifests as increased thirst, increased hunger, sluggish wound healing, inexplicable weight loss, and frequent urination. But not everyone with diabetes will show symptoms, particularly in the early stages of the condition.

1.1.3. WHAT ARE THE PROBLEMS RELATED TO DIABETES?

- Hyperglycaemia result in symptoms such as increased thirst, frequent urination, fatigue, and blurred vision.
- Hypoglycaemia can lead to symptoms like shakiness, dizziness, sweating, confusion, and in severe cases, unconsciousness or seizures.
- Cardiovascular Complications can increase the risk of heart disease, stroke, and high blood pressure.
- Itching, numbness, or discomfort in the hands and feet are signs of neuropathy.
- Retinopathy which may cause vision problems and, if left untreated, even blindness.
- Kidney Diseases
- Foot Problems can increase the risk of foot infections.
- Skin Complications such as dry skin, fungal infections, and slow-healing wounds.
- Gastroparesis can lead to symptoms like nausea, vomiting, and delayed stomach emptying.
- Depression and Anxiety: Managing diabetes can be challenging, leading to emotional stress and an increased risk of depression and anxiety.

1.1.4. WHAT ARE THE COMPLICATIONS FACED BY DIABETIC PATIENTS?

Diabetes that is not treated or is poorly managed can have serious side effects on several organ systems and drastically lower a person's quality of life. Cardiovascular disease, neuropathy (damage to the nerves), retinopathy (injury to the eyes), nephropathy (damage to the kidneys), and an elevated risk of foot ulcers and amputations are long-term consequences [19].

1.1.5. DIAGNOSIS AND SCREENING

Blood glucose levels are measured using a variety of procedures, such as the oral glucose tolerance test (OGTT), fasting blood glucose test, and the HbA1c (glycated haemoglobin) assessment, in order to diagnose diabetes. Initiating proper care and preventing complications require early identification.

1.1.6. TREATMENT AND MANAGEMENT

The goals of managing diabetes are to attain and sustain ideal blood glucose levels, reduce complications, and improve general health. Treatment options include insulin therapy, diet and activity adjustments, oral medicines, and, in certain situations, further adjuvant therapies such SGLT2 inhibitors and GLP-1 receptor agonists.

1.1.7. WHAT ARE THE PREVENTIVE MEASURES OF DIABETES?

Since diabetes has a major negative influence on public health, prevention is essential to slowing the disease's course. Programs for preventing diabetes emphasize adopting a healthy lifestyle, increasing public awareness, and changing laws to support exercise and a balanced diet.

2. RELATED WORK

2.1. LITERATURE REVIEW

The studies by Afif Nakhleh and Nami Shehadeh [8] underscore the significance of keeping patients with type 1 and type 2 diabetes from experiencing low blood sugar. Their methodology involves approaches like patient education, dietary changes, exercise recommendations, glucose monitoring, and medication adjustments to manage hypoglycaemia effectively.

Shiwali Goyal, Jyoti Rani et al. [5] explore the potential of transomics in understanding the genetic determinants of diabetes. They prescribe personalized diabetes care using patient molecular genetic profiles that include factors such as physical activity, dietary changes, stress management and optimized diagnostic approaches. Work by Abhijit S. Rayate et al. [10] addresses foot wound healing, highlighting methods with antibacterial effects and wound healing actions supported by clinical human studies. Research of Kimberley J. Smith et al.'s [12] focuses on understanding lifestyle changes that contribute to anxiety and depression in patients. Their findings emphasize the importance of promoting the mental health of people with diabetes by effectively treating symptoms of anxiety and depression.

Sebnem Çinar et al. [15] focus on Type 2 diabetic patients' depression, anxiety, quality of life, and sleep and provide an overview of the interaction between diabetes and mental well-being. Maureen Monaghan, et al. [7] update behavioural research in young toddlers with diabetes type 1 and outline current priorities and future directions for treating this disease in children.

G. Alexander Fleming et al. [3] explore obstacles to the use of digital medical technology, namely applications in diabetes treatment and self-care, while noting the rapid integration of such technologies and the issues that come with it. A study by Dante Salvador et al. [11] shows an association between type 2 diabetes and an increased risk of death, after factors such as heart failure are taken into account the relationship between diabetes and other health conditions.

Eduardo Tibiriçá et al. [13] indicate that patients with type 1 diabetes and vascular difficulties have higher skin capillary density, which might provide insight into diabetic complications. Xian Wang et al. [14] focus on skin problems in patients with T2D and treat those most affected by such problems Arielle G. Asman et al. [1] highlight how people with diabetes, anxiety, and depression often associate these symptoms with their condition or prescribed medications, emphasizing the importance of addressing mental health perceptions

Maria Felicia Faienza et al. [2] propose interventions to prevent poor bone quality in type 2 diabetes and suggest possible strategies to mitigate this complication. The study by Katherine Ogurtsova et al. [9] provides point estimates for diabetes but lacks measures of uncertainty, which may reflect the need for further refinement of the data. Lara Frommer and George J Kahaly [4] compare social, medical, and biological characteristics of patients with isolated type 1 diabetes and related autoimmune diseases (AIDs) to improve clarity of the complexity of autoimmune diseases

Reza Mohebi et al. [6] suggests a possible role for insulin-like growth factor (IGF) biology in CVD risk in T2D and offers insight into the complicated link between diabetes and cardiovascular health.

2.2. COMPETITIVE ANALYSIS

The competitive analysis of various digital products available in the market is performed. This study helped to understand the current market trend, available features and techniques to help diabetic patient and opportunities where the work can be done.

Table 1: Competitive Analysis of Applications Currently Available for Diabetic Patients

	MySugr	BlueStar Diabetes	Diabetes Connect- Blood Sugar Control	One Drop	BeatO
Target Audience	People with diabetes who want to track blood sugar levels, medication, and daily activities.	People with T1D or T2D looking for personalized diabetes management.	Individuals with diabetes seeking blood sugar control and monitoring.	People with diabetes seeking personalized coaching and community support	T1D and T2D Patients
Competitors	Glucose Buddy, Glooko, Diabetes:M.	One Drop, mySugr, Glucose Buddy.	Glucose Buddy, mySugr, Glooko	BlueStar Diabetes, mySugr, Glucose Buddy	mySugr
Services	Blood sugar tracking, insulin dosage, carbohydrate counting, data visualization, reminders.	Blood sugar tracking, personalized coaching, medication management, nutrition guidance.	Blood sugar tracking, medication management, diet and exercise monitoring	Blood sugar tracking, in-app coaching, medication reminders, food logging, community forum	Blood glucose tracking, diabetes-friendly recipes, doctor consultations, medication reminders
Strengths	User-friendly interface, extensive data tracking, integration with glucose	Clinically validated, personalized support, integration with connected devices.	Easy-to-use interface, medication reminders, ability to track meals and exercise	Personalized support, educational resources, social engagement features	Comprehensive diabetes management services, access to diabetes experts, recipe library

	meters and fitness trackers				
Weaknesses	Some advanced features may require a premium subscription, occasional syncing issues with external devices.	Requires a prescription for full access, potential cost barrier for some users	Limited features in the free version, occasional app stability issues	Subscription-based model, may not have all the advanced data tracking features of other apps	Limited integration with third-party devices, may require a subscription for certain features
Threats	Competition from other diabetes tracking apps, potential data privacy concerns.	Competition from other well-established diabetes apps, changes in healthcare regulations	Strong competition from other diabetes apps, changing user needs and expectations	Competition from other coaching-focused diabetes apps, potential user retention challenges	Competition from other established diabetes management apps in India.
Opportunities	Expanding to international markets, collaborating with healthcare providers for data-sharing integrations.	Partnering with health insurance companies for coverage, expanding to international market	Collaborating with healthcare providers for data exchange, integrating with smartwatches and wearables.	Expanding the coaching platform to other chronic conditions, partnering with health insurers for coverage.	Partnering with healthcare providers for better integration and data sharing.

2.3. INTERVIEWS AND SURVEYS

We performed some interviews and surveys using the desk research as a basis. The questions were constructed in a way that can help in understanding the difficulties patients may encounter in daily life and the features that may be necessary for them. How the patients managing their diabetes and other activities in another important factor. The below graph shows the results of the primary research.

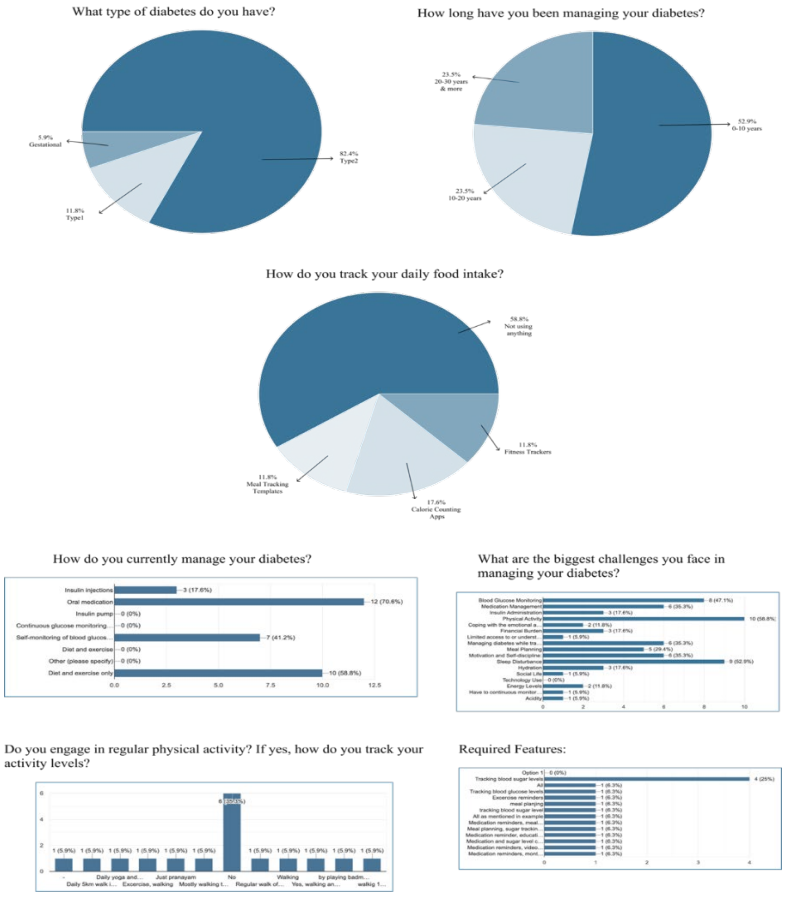


Figure 1. Survey Insights Representation

Insights of Primary Research about the Diabetic patient

- Do not take proper care of physical health and meals
- Forget to check sugar level on regular basis
- Negative impacts on daily life
- Forget to take medication properly
- Doesn't know about the communities available that are primarily working for them

- Diabetes affects mental health as well

2.4. UNDERSTANDING PROBLEM

2.4.1. FLOW MODEL

The flow model offers a clear and detailed visual representation of how different people and elements come together to support diabetic patients. It starts with the initial diagnosis and moves through treatment planning, where doctors prescribe medications and suggest lifestyle changes. Pharmacists play a key role by dispensing medications and providing crucial information. The model also highlights the daily management of diabetes, showing how friends and guardians provide emotional support and help with meal planning, encouraging physical activity, and reminding patients about their medication and appointments.

Additionally, the flow model emphasizes the importance of regular check-ups with healthcare providers to monitor progress and make necessary adjustments to the treatment plan. It also includes the role of support groups and community resources in offering extra help and education to both patients and their caregivers. Overall, this model visually captures the interconnected and dynamic nature of managing diabetes, illustrating how different people work together to ensure the well-being of diabetic patients throughout their journey.

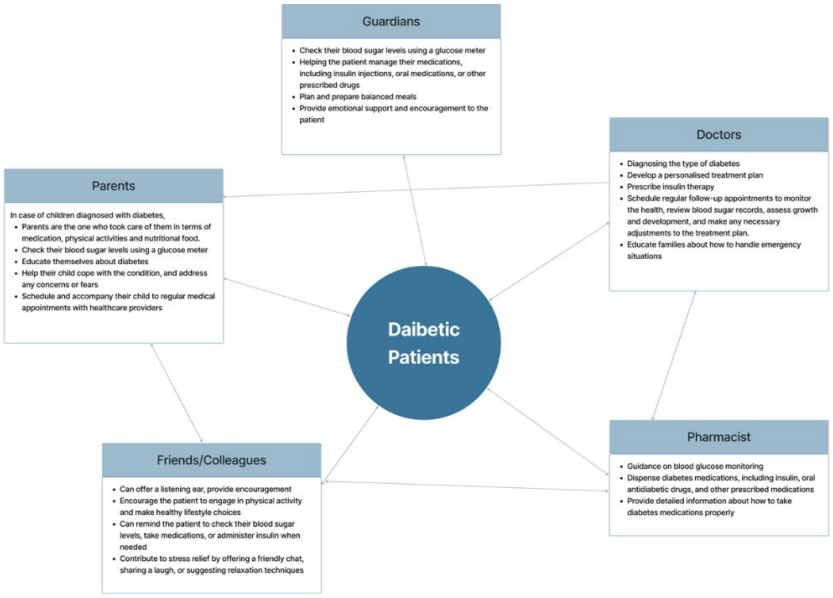


Figure 2. Flow Mode

2.4.2. HOFESTEDE'S CULTURAL MODEL

The Hofstede cultural model has helped us grasp how cultural factors influence people with diabetes, their loved ones, and medical professionals. This model highlights the diverse cultural attitudes and practices related to diabetes care in India, emphasizing the need for cultural sensitivity and awareness when providing support and treatment.

By understanding and respecting these cultural differences, healthcare workers and loved ones can more effectively help diabetic patients manage their condition and achieve better health outcomes. This cultural awareness is essential for creating personalized care strategies that fit patients' values and lifestyles, ultimately enhancing their quality of life.

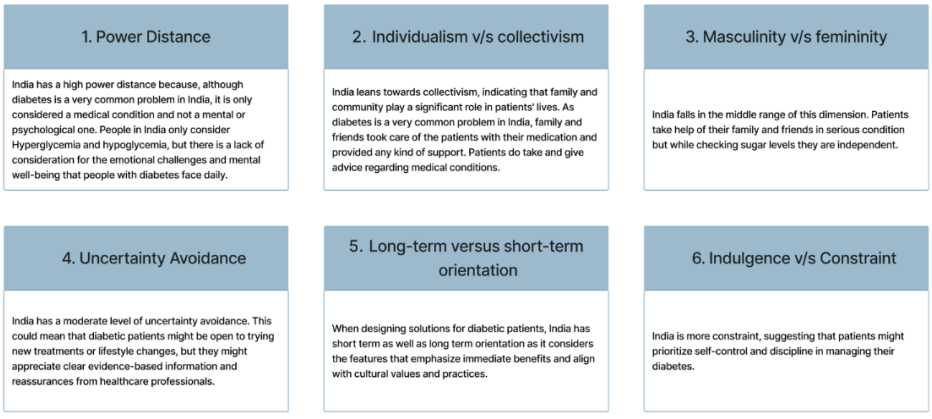


Fig. 3. Hofstede's Cultural Model

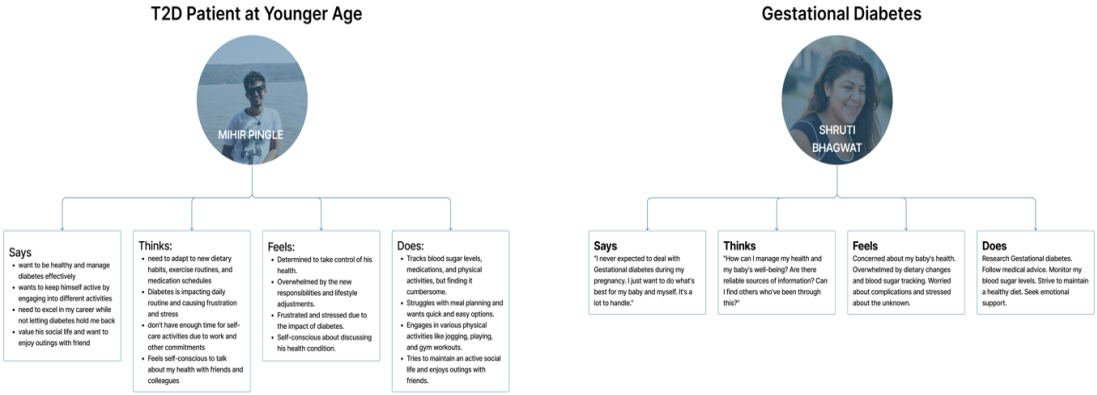
2.4.3. USER PERSONAS

When developing personas for diabetic patients, we identified four distinct groups. The first group consists of younger individuals with Type 2 diabetes, and the second group includes older adults with the same condition. The third group comprises patients experiencing gestational diabetes. Finally, the last group includes parents whose children have been diagnosed with diabetes.

Fig. 4. User Personas

2.4.4. EMPATHY MAPPING

Empathy mapping is a collaborative strategy that facilitates a better understanding of the specified groups and helps understand the emotions and thoughts of a diabetic group. We have performed empathy mapping for T2D patient at younger age, gestational diabetes, T2D patient at old age and T1D in child age.



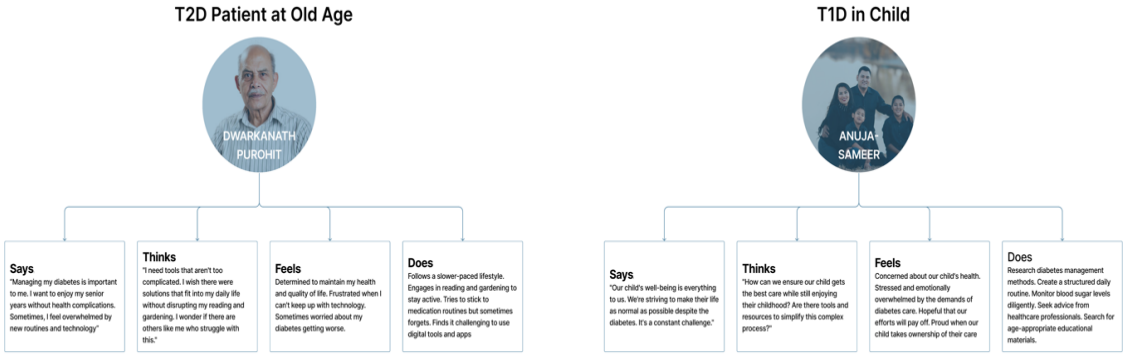


Fig. 5. Empathy Mapping

2.4.5. RESEARCH GAP

One of the significant research gaps in the domain of Human Computer Interaction (HCI) and Diabetes is the limited focus on understanding the emotional and psychological aspects of managing diabetes through technology.

2.4.6. PROBLEM STATEMENT

Individuals with diabetes often overlook the importance of consistent blood glucose monitoring and medication adherence. Neglecting proper dietary management and physical activity can contribute to feelings of anxiety and depression. This statement emphasizes the need for a more engaged approach to diabetes self-care to prevent psychological distress.

3. PROPOSED SOLUTION

At the ideation stage we have performed various methods such as mind mapping, card sorting and information architecture to find the possible solutions to deal with the diabetes using digital solution. These methods are discussed below.

3.1. MIND MAPPING

To better manage diabetes, we used a detailed mind mapping method to understand and represent the many aspects involved. This process helped us dive deep into several important areas. We talked about the different types of diabetes, such as Type 1, Type 2, and gestational diabetes, and looked at the risk factors, which include things like genetics, lifestyle choices, and environmental influences. We also identified common symptoms that diabetic patients experience, such as frequent urination, excessive thirst, and fatigue.

We explored the daily challenges that people with diabetes face, from managing their medication schedules to dealing with the emotional and psychological impacts of the disease. It was essential to understand what patients expect, like having access to reliable healthcare information, user-friendly digital tools, and robust support systems to help them manage their condition better.

Preventive measures were another critical focus. We discussed the importance of a healthy diet, regular exercise, and routine medical check-ups to prevent or slow down the progression of diabetes. We also reviewed the existing solutions available to patients, including current medical treatments, technological aids like continuous glucose monitors and insulin pumps, and lifestyle changes.

All these discussions and findings are summarized in Figure 6. This figure provides a clear and structured overview of the various dimensions of diabetes management, highlighting the interconnected elements that are crucial for effective disease control and better patient.

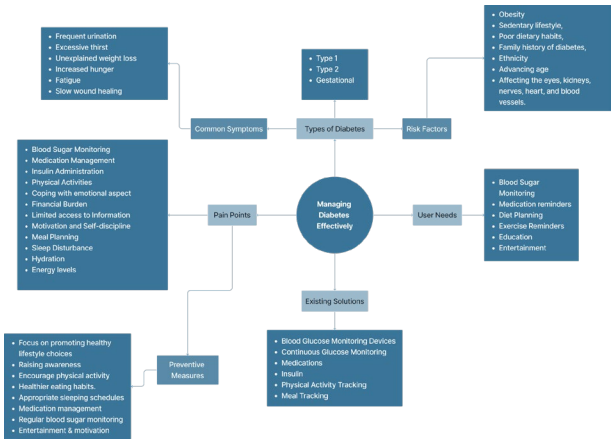


Figure 6. Mind Mapping for Managing Diabetes Effectively

3.2. CARD SORTING

At the ideation stage, many features were listed that can be included in the diabetic management digital product. Then we performed a card sorting to categorize the features and its hierarchy. The figure 7 shows the details of the card sorting.

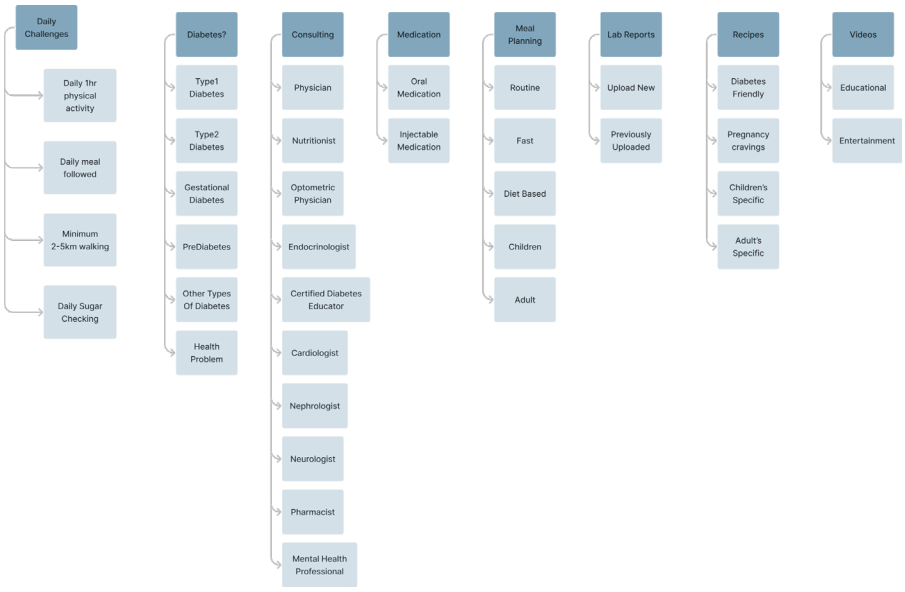


Figure 7. Card Sorting for product feature categorisation

3.3. INFORMATION ARCHITECTURE

When designing our system, we took a user-centric approach. The process began with card sorting, where users organized product features into meaningful categories. Based on their insights, we created an information architecture with seven main sections:

1) Profile: Users manage their personal information and preferences here.
2) Notification: This section handles alerts, reminders, and updates.
3) Chatbot: Users can interact with our friendly AI chatbot for assistance.
4) Prizes: Rewards and incentives are tracked in this category.
5) Daily Challenge: Engaging tasks and activities are organized here.
6) Calendar: Users can plan, and track events related to their health journey.
7) Our Services: A comprehensive overview of what we offer.

Additionally, the daily challenge and our services sections have subcategories, which you can explore further in figure 8. Our goal is to create an intuitive structure that empowers users in managing their diabetes effectively.

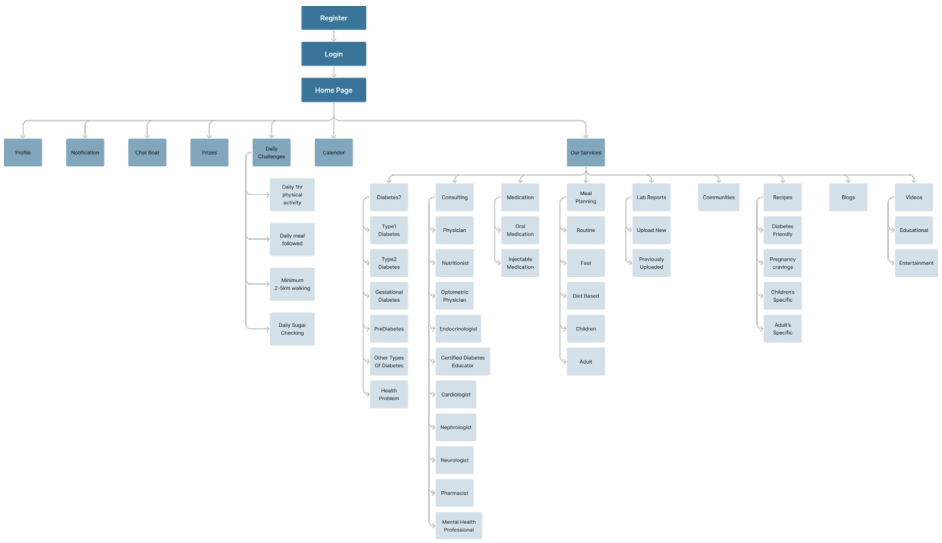


Figure 8. Information architecture of proposed system

3.4. MOBILE APPLICATION USER INTERFACE

The following figure shows the mobile user interface designed for the user centric design solution for diabetic patient.

1) Home Screen: The screen is all in one screen. It shows patient's daily progress for challenges, their status of daily exercise, Keep track of their sugar level. Also motivate them to handle the diabetes in an appropriate way by showing them motivational quotes. It also consists of all the services that help patients/user to maintain their diabetes. Menu bar includes calendar, chatbot, challenges which will help patient to keep them informed about the important dates and help them to tackle with diabetic condition in a positive way.

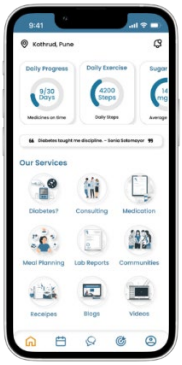


Fig. 9. Home Screen

Personalisation: These screens contain few questions that will help to personalized the users experience.

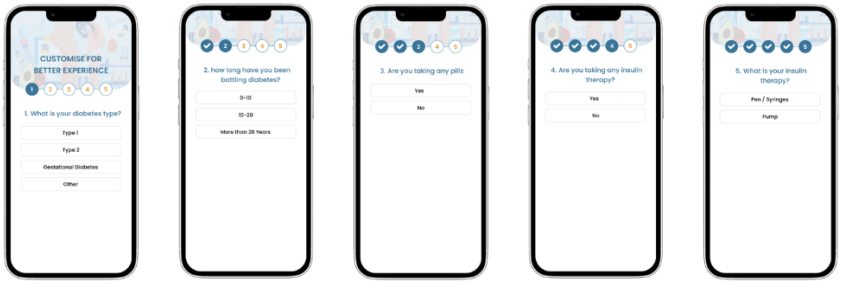


Fig. 10. Personalisation Screens

Other Features: The features in Fig. 11 will help patients and their family in better understanding the condition and caring for their diabetic issues.

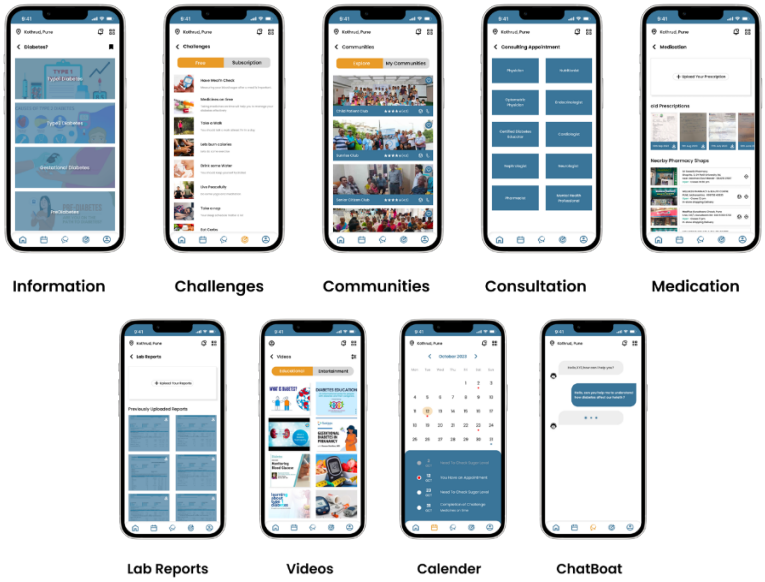


Fig. 11. Features for Diabetic Patients to Better Manage Their Condition

4. TESTING

4.1. USABILITY TESTING

6 users were recruited for the usability testing for the following tasks. We performed user task analysis.

Table 2: Book an Appointment

	User 1	User 2	User 3	User 4	User 5	User 6
Task Completion	Pass	Pass	Pass	Pass	Pass	Pass
Time Taken	30 Sec	42 Sec	10 Sec	15 Sec	45 Sec	25 Sec

Table 3: Upload Lab Reports

	User 1	User 2	User 3	User 4	User 5	User 6
Task Completion	Pass	Pass	Pass	Pass	Pass	Pass
Time Taken	42 Sec	30 Sec	20 Sec	31 Sec	40 Sec	38 Sec

Table 4: Join a Community

	User 1	User 2	User 3	User 4	User 5	User 6
Task Completion	Pass	Pass	Pass	Pass	Pass	Pass
Time Taken	14 Sec	30 Sec	30 Sec	23 Sec	54 Sec	38 Sec

Table 5: Start a Challenge

	User 1	User 2	User 3	User 4	User 5	User 6
Task Completion	Pass	Pass	Pass	Pass	Pass	Pass
Time Taken	34 Sec	43 Sec	36 Sec	29 Sec	25 Sec	49 Sec

4.2. USABILITY METRICS

- *Task 1: Book An Appointment*
  Success Score : no. of Task Completed/no. of attempts X100 = 1/6 X100 = 16.66%
  Error Rate : no. of errors/no. of attempts X100 = 0/6 X100= 0
  Task Time : Time per User/no. of Users X100 = 167/6 X100= 2,783.3%
- *Task 2: Upload Lab Reports*
  Success Score : no. of Task Completed/no. of attempts X100 = 1/6 X100 = 16.66%
  Error Rate : no. of errors/no. of attempts X100 = 0/6 X100= 0
  Task Time : Time per User/no. of Users X100 = 201/6 X100= 3,350%
- *Task 3: Join a Community*
  Success Score : no. of Task Completed/no. of attempts X100 = 1/6 X100 = 16.66%
  Error Rate : no. of errors/no. of attempts X100 = 0/6 X100= 0
  Task Time : Time per User/no. of Users X100 = 189/6 X100= 3,150%
- *Task 4: Start a Challenge*
  Success Score : no. of Task Completed/no. of attempts X100 = 1/6 X100 = 16.66%
  Error Rate : no. of errors/no. of attempts X100 = 0/6 X100= 0
  Task Time : Time per User/no. of Users X100 = 216/6 X100= 3,600%

5. CONCLUSION

As a result, this study provides insightful information on the patients with diabetes and provides a comprehensive overview of the process of managing the chronic disease. Our research shows that people with diabetes experience a range of challenges that go beyond purely physical problems, with emotional and psychological components as well. The importance of this study is that it can highlight areas where people with diabetes are currently dissatisfied with their care and demonstrate opportunities for design innovation to address these issues. Personalization, empathy, and user-centered design are essential components to improve the overall standard of living and user experience (UX) for diabetic patients. Add to this the importance of digital health solutions such as smartphone apps.

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