Xi'an Jiaotong-Liverpool University

西交利物浦大學

Designed to optimize the daily insulin injection process for patients with type 1 diabetes during daily treatment

by

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Abstract

The incidence of diabetes in children and adolescents has risen rapidly in modern China as a result of changes in food and activity habits and growing urbanization, among other factors. Due to the difference in responsiveness between children and adults, there is a link between diabetes and emotions such as anxiety and depression in the treatment of children. Psychosocial characteristics, particularly emotional discomfort associated with diabetes, contribute to self-management difficulties and treatment resistance, resulting in poor glucose control and negatively influencing therapy.

Therefore, in the case of juvenile diabetes, this project focuses on enhancing children's ability to comply with daily treatment and alleviate unpleasant emotions, particularly in the case of type 1 diabetes.

The project aims to improve and help Chinese adolescents with diabetes, mainly type 1 diabetes, by optimizing the daily insulin injection process experience to alleviate negative emotions during treatment.

First, literature, news, and journals pertaining to the search terms "diabetes in China," "childhood diabetes," and "daily medical treatment in China" were gathered. Second, the quantitative study polled patients and the broader population about existing diabetes care monitoring applications. Qualitative methods included in-depth, one-on-one interviews with diabetic patients aged 7 to 14 years and their parents, as well as expert interviews with medical professionals in the field of diabetes.

Diabefree offers insulin replacement by optimizing the traditional syringe injection process in order to alleviate patients' fear of needles and uncertainty regarding insulin dosage.

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1. Introduction

1.1 Topic and context

Diabetes mellitus (DM) is becoming one of the world's most significant health issues, impacting individuals of all ages, including children, adolescents, adults, and pregnant women. Diabetes and its consequences impose substantial costs on individuals and healthcare systems (Sen et al., 2016). According to a national survey conducted in China in 2010, hundreds of millions of individuals suffer from diabetes. The increased prevalence of diabetes has been attributed to an aging population, the proliferation of high-energy, processed diets, and decreased activity. The obesity epidemic and the beginning of disease at a young age can result in problems and death for both adults and children. In China, the prevalence of childhood diabetes is on the rise. The incidence of type 1 diabetes in children is between 2.0 and 5.3 per 100,000 person-years annually. With China's growing urbanization, the prevalence of type 2 diabetes in children and adolescents has rapidly increased (Wang et al., 2022).

However, as a distinct group in society, children are not yet intellectually and emotionally mature and will suffer more tremendous psychological obstacles during significant events. Everyday emotions consist of anxiety, dread, and loneliness. Emotional stress frequently impairs the body's secretory function, resulting in blood sugar variations that are detrimental to physical and mental health. (Northam et al., 2001a).

1.2 Focus and scope

An increasing body of research supports the advantages of incorporating diabetes prevention and management programs into daily life. Finding quality everyday care might have a stimulating effect on the disease's rehabilitation.

China is also the nation with the highest number of diabetic sufferers worldwide. In addition to placing a significant strain on patients and health systems, the alarming increase in diabetes and diabetic complications has also imposed a significant burden on patients. China's disparate medical resources necessitate early and professional diabetes counseling and patient management programs to invest in early case recovery.

1.3 Problem statement

Initially, China has the most significant prevalence of diabetes in the world. Some individuals visit hospitals frequently for treatment and adhere to medical recommendations to maintain a healthy lifestyle. During the study, it was discovered that due to their lack of mental capacity, youngsters are susceptible to anxiety and terror during the therapy procedure. Children with diabetes struggle to manage their blood sugar levels due to a lack of self-monitoring expertise. Second, parents are concerned with their lack of medical expertise, which prevents their children from seeking competent medical guidance and leads to self-management dissatisfaction.

Secondly, market research indicates that children in China continue to lack access to medical treatment. Most commercially accessible products are generic and do not cater to children's emotions.

Finally, China's metropolitan areas have begun promoting intelligent medical services, but there are currently no items that improve the individual's experience. Existing market items are challenging to use and do not give patients fast feedback on their medical recommendations.

1.4 Research questions and objectives

1. How to help sensitive diabetics have a more convenient insulin injection experience

2. How to relieve negative emotion about exposed medical instruments

1.5 Overview

An introduction to the problem is presented in the chapter 1 and relevant literature is discussed in chapter 2. Various methods are demonstrated in chapter 3 and the result of project is reported in chapter 4.

2. Literature review

Type 1 diabetes is a chronic metabolic condition characterized by the activation of the autoimmune response by a combination of hereditary and environmental factors, resulting in insulin shortage and functional failure. It is one of the most prevalent chronic childhood disorders. There are 1,933 cases of type 1 diabetes per 100,000 Chinese children aged 0 to 14 years. (LUO et al., 2018).

Currently, China's basic medical facilities are insufficient to support early-onset interventions for the diabetic population; therefore, people with diabetes frequently lack access to suitable and timely medical interventions.

The Chinese healthcare system's inequitable access to healthcare resources and services persists despite major reform gains. Personal healthcare applications provide the opportunity to expand access for all individuals. With the growth of digital technologies such as the Internet, big data, and artificial intelligence, the technical basis for digital diabetes management has been established. In addition, the change in user access to medical care has produced a market demand for the digital treatment of diabetes since the number of Internet medical users in China will reach 635 million by 2020.

2.1 Current status of children with diabetes in China

Due to the expanding diabetes pandemic, the worldwide burden of diabetes has increased dramatically over the past decade. Diabetes is becoming one of the most major global health issues, affecting nearly all age groups, including children, adults, and pregnant women (Sen et al., 2016). Recent epidemiological studies indicate that around 11% of the population has diabetes, including many undiagnosed cases (Ma, 2018). China has a current population of 1,4 billion, and an estimated 110 million people have diabetes, making it the country with the largest number of diabetes worldwide.

A joint analysis of data from 14 medical institutes in China demonstrates that the prevalence of type 2 diabetes has surpassed type 1 diabetes among youngsters in China. The frequency of impaired glucose metabolism has reached 28.26% among obese children. (Fu et al., 2013)

2.2 Stress in children and adolescents with type 1 diabetes

According to the Chinese Journal of Contemporary Pediatrics, nearly one-fourth of children and adolescents with type 1 diabetes in China had significant mental stress levels (LUO et al.,

2018). Rechenberg has demonstrated that the level of illness self-management among Chinese children and adolescents with type 1 diabetes is inadequate and worsening. The greater the stress level of children with type 1 diabetes, the lesser their self-management of the disease (Rechenberg et al., 2017). In addition to disease-related stressors, adolescents with type 1 diabetes confront unique challenges resulting from fast changes in physical characteristics during adolescence.

2.3 Useful ways to control diabetic children

According to the research by BMJ, a clinical assessment of 75,880 participants over the age of 18 in mainland China found that the rapid economic development of the past 30 years has led to lifestyle changes. Sedentary behavior and frequent high-energy and fat diet intake are the leading causes of the disease(Li et al., 2020). Research proves that diabetes management with nutritional therapy effectively optimizes glycemic control. Energy intake should follow the principle of total control. The daily energy intake of children with diabetes can be calculated using the formula [total calories (kcal) = age (70-100) + 1,000] and then adjusted according to customized energy recommendations based on nutritional status, physical activity, and stress levels. While controlling total energy intake, it is important to maintain a balanced diet. The daily energy intake should consist of 50 to 55 percent carbohydrates, 25 to 35 percent fat, and 15 to 20 percent protein(Northam et al., 2001b).

2.4 Personal health care systems in China

Personal healthcare applications provide unique chances for monitoring patient progress, providing professional information to patients and family members, receiving individualized advice and support, collecting ecologically valid data, and utilizing self-management interventions as necessary. In China, smart personal healthcare is in its infancy, with the government and private sector collaborating to develop a platform for personal healthcare. In 2013, China implemented healthcare reform (Li et al., 2020). A As a result, individuals with diabetes now have easier access to clinical services that can aid in their diabetes treatment. The White Paper 2021 on Digital Management of Diabetes in China, which was released jointly by Artery.com-Egshell Research Institute, Sanofi, and Jingdong Health under the direction of the Chinese Society of Geriatric Health Care Medicine, reveals that, first, the Chinese diabetic population has poor monitoring compliance. The international guideline for daily diabetes management is monitoring blood glucose seven times a day, yet 80% of people do not comply. Second, insulin injection dosage is primarily determined by experience, and

its precision is low. 31.9% of patients had an average daily insulin injection dosage that is either low or excessive. Through a survey of existing medical platforms, it was determined that online service response is prompt and patient satisfaction is high, with 80.4% of patients receiving an exceptionally fast consultation response within one minute. (*Hao*, 2021.).

2.5 Daily insulin injection treatment protocol

In type 1 diabetes, the pancreas produces minimal or no insulin(Northam et al., 2001b). Therefore, all individuals with type 1 diabetes require insulin. Typically, insulin is administered subcutaneously or continuously via an insulin pump. Most individuals will adjust their insulin dosage based on their daily glucose levels. Typically, patients schedule appointments with a diabetes specialist every three to four months. During these visits, the doctor monitors the patient's blood glucose levels and insulin dosage to fine-tune the patient's diabetes management.

Typically, insulin is injected subcutaneously using a pen syringe or needle. Alternatively, insulin can be administered subcutaneously using an insulin pump.

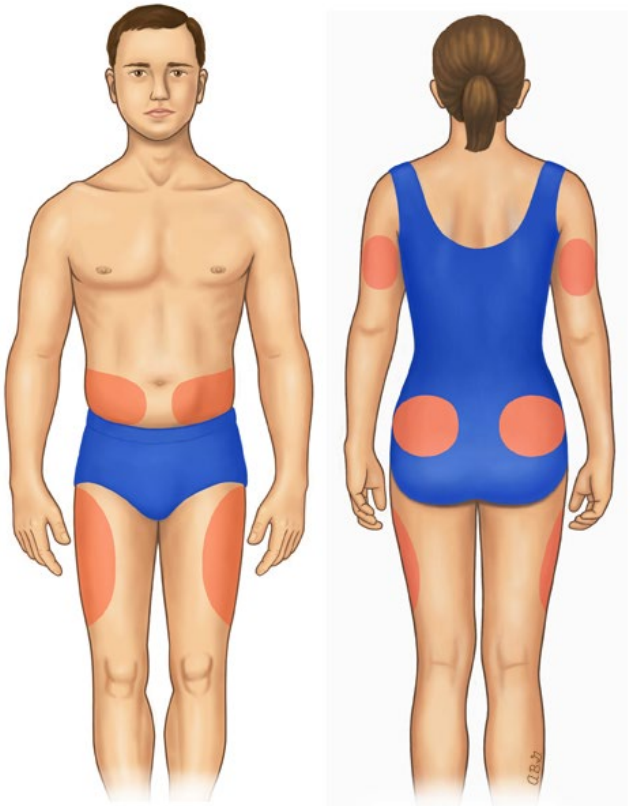


Figure1: Insulin injection location map(Ruth S Weinstock et al., 2022)

The red colored area can be used for insulin injection.

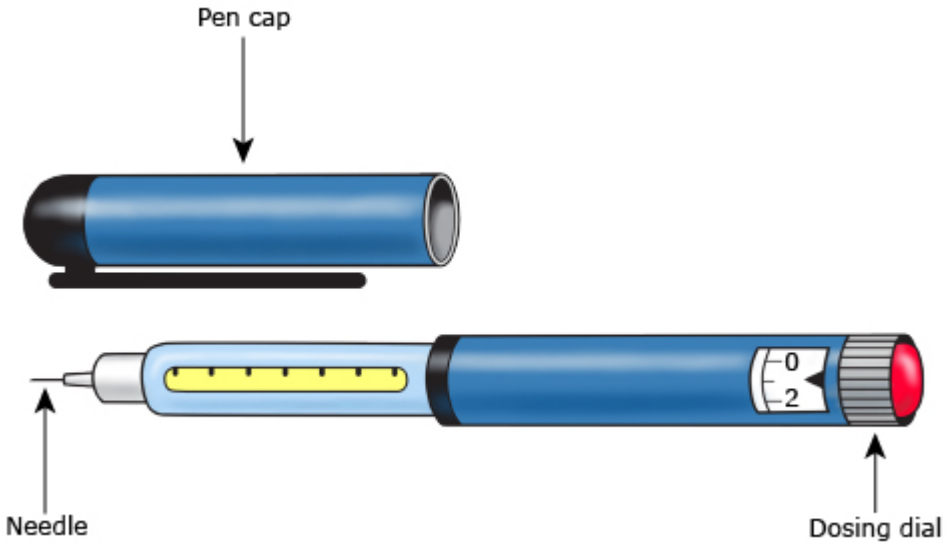


Figure2: Insulin pen(Ruth S Weinstock et al., 2022)

Especially when the patient is on the go, insulin pen syringes are very portable and simple to use. Most are the size of a standard signature pen and contain an insulin cartridge, a dose-setting dial, and an injection button. Before each injection, a new needle must be attached to the pen, and it is vital to remember that insulin cartridges should never be shared. It comes with a pre-filled insulin cartridge and a dial that patients can use to set different doses, but the needle must be replaced prior to each use.

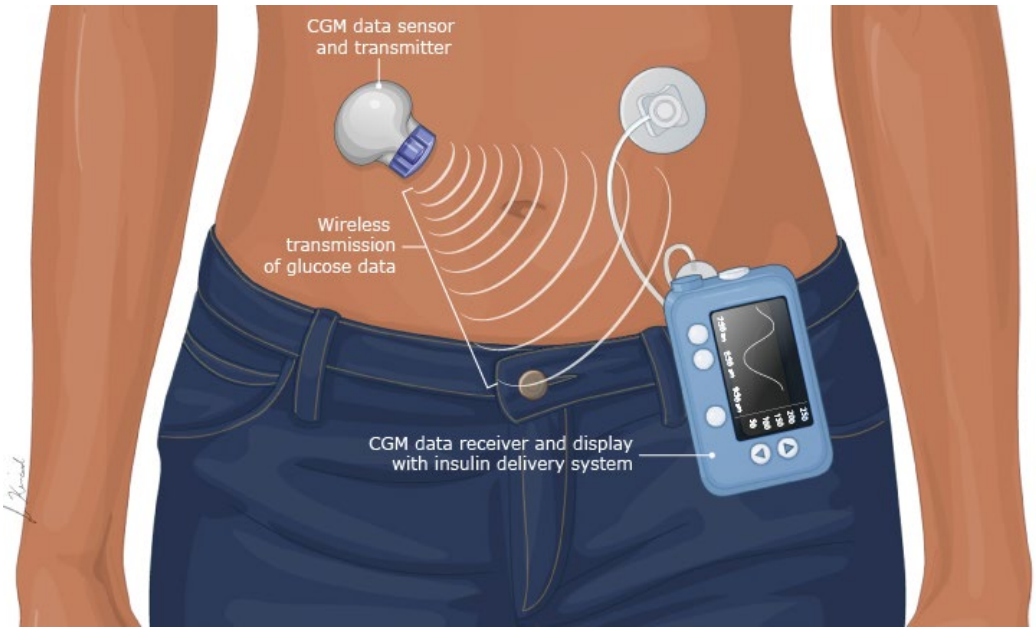


Figure3: Insulin pump with continuous glucose monitor(Ruth S Weinstock et al., 2022)

An insulin pump stores insulin in a cartridge and delivers it to the body via an intradermal tube. It can be used with a continuous glucose monitor (CGM) that measures glucose levels in a subcutaneous fluid using a sensor. The sensor is linked to a transmitter that is adhered to the skin using an adhesive patch. It wirelessly transmits test results to a small recording device, smartphone, or insulin pump.

Continuous dosing, as opposed to multiple daily injections with a pen syringe or needle and syringe, is the basis of the insulin pump. It is possible to recommend an insulin pump based on the user's preference, willingness, and capability. The majority of insulin pumps deliver insulin through a thin, spaghetti-like catheter that is inserted subcutaneously. Approximately every two to three days, the catheter is withdrawn and reinserted.

There are two main benefits of insulin pumps. Increased flexibility in meal times and other daily activities is the most significant benefit, which can be beneficial for children and adults with irregular daily schedules.

Insulin pump users do not require multiple daily injections; most insulin pump users change their injection sites every 48 to 72 hours.

Another significant benefit of insulin pumps is that the amount of insulin absorbed is less variable than when insulin is injected with a needle, syringe, or pen. This reduces the variation in daily blood glucose levels. An insulin pump can deliver insulin in smaller amounts at once than injectable therapy.

The insulin pump has disadvantages as well. Some patients have commented that the product is cumbersome, as there is a risk of skin irritation, infection, or pump malfunction, and that it takes a short time to detach the pump for self-injection.

3 Methodology

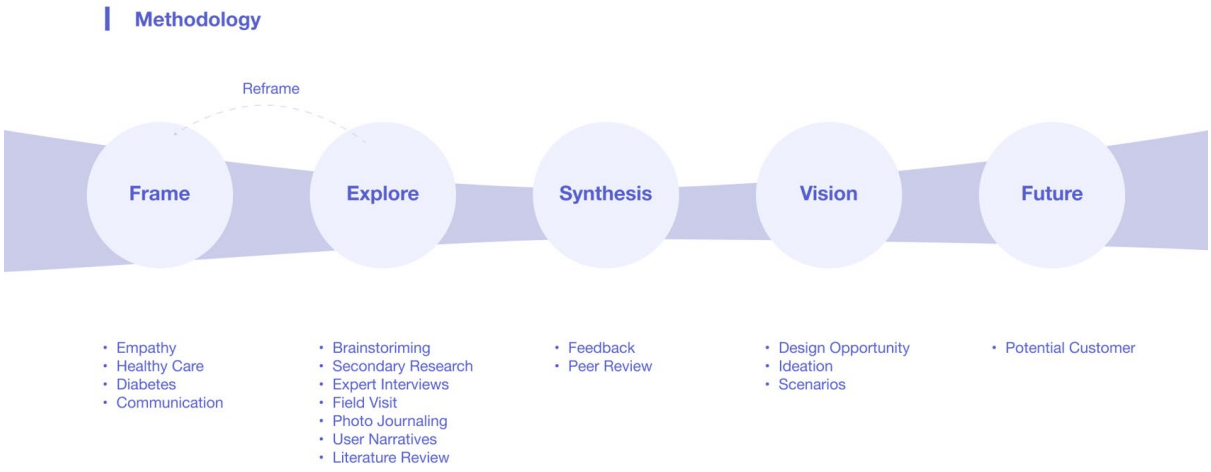


Figure 4: Methodology of Diabefree

Throughout the project, both secondary and primary research were utilized. The endeavor began with desk research that examined all published data and materials pertaining to diabetes. Meanwhile, perspectives on the daily lives of youngsters with diabetes. In addition, an online survey was distributed to determine the happiness of current product users. Subsequently, one-on-one interviews were undertaken to acquire a deeper understanding of the customers' everyday home treatment pain areas. Throughout the duration of the research, we remained in contact with endocrinologists for expert medical advice.

1. **Secondary research**

   Secondary research is essential for specialized topics, including Internet searches, literature reviews, and case studies. The research was conducted on the Internet using the keywords diabetes management, childhood diabetes, and a comparison of literature and data to understand the status of children with diabetes in China. Secondly, for the category of diabetes, the literature was read and compared with diabetes, diet, mobile health, and children's medical care, and a case study was conducted

2. **Primary research**

   Primary research ensures that the trends gathered are current and relevant, allowing designers to interact directly with their target audience, gather user intelligence, and then translate this information into actual design opportunities. Surveys, interviews, and

observation are used to support designers in understanding user needs. Shadowing a day is a good way to understand the true needs of users. After understanding the basic requirements, use generative measures of brainstorming to generate design opportunity points. After determining the primary design goal, focus groups and AB testing are carried out. Users are now directly involved in the design evaluation, and their feedback is an important foundation for design iterations and subsequent iterations.

3. **Market research**

   By investigating market-available portable medical devices, personal mobile smart medical software, diabetes detection software, and medical equipment for children, as well as creating SWOT analyses. Design examples include blood glucose meters, mobile applications, medical stress alleviation solutions for children, and commercially available diabetic products.

4. Field research and primary research

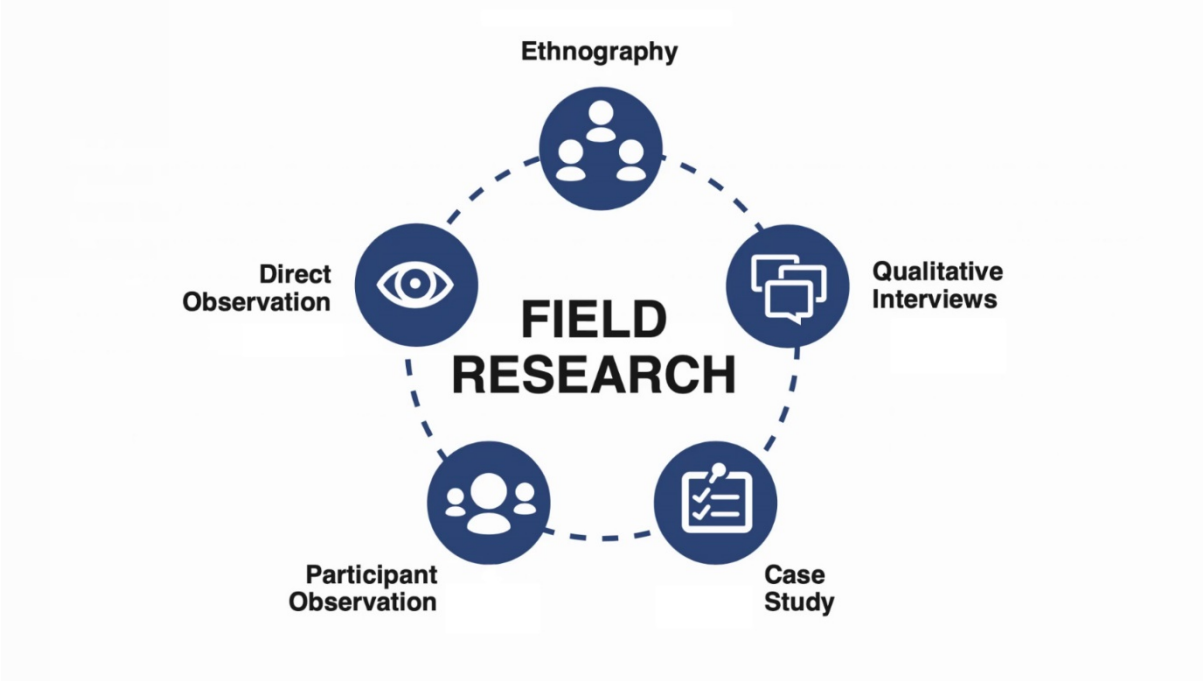


Figure5: The five methods included in the field research

Ethnographic studies help designers identify the people for whom a project is designed.

4 User research

1. Direct Observation

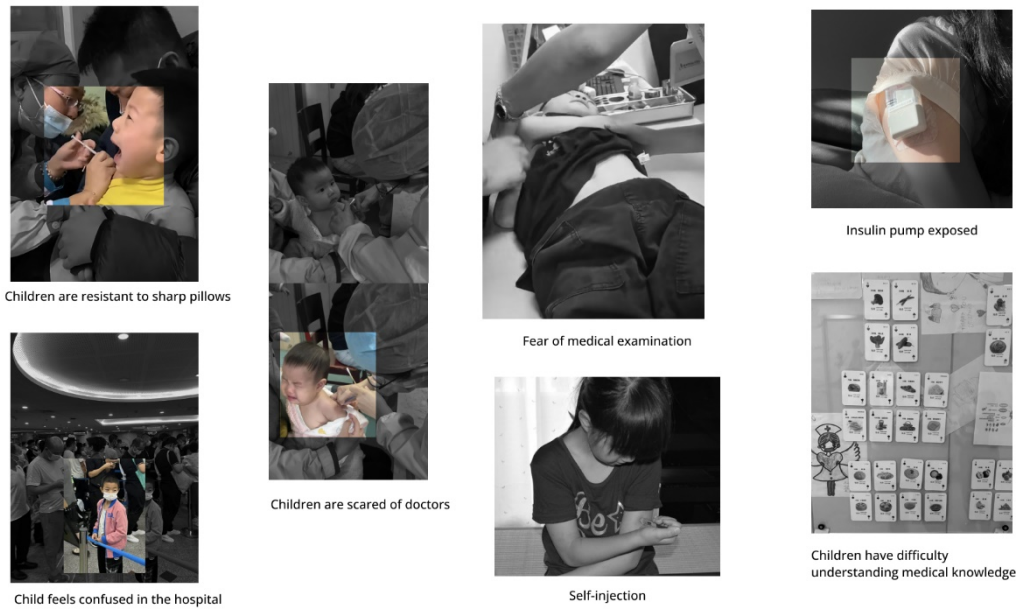


Figure6: Photos taken during a visit to Suzhou Dushuhu Hospital

Through visits to the pediatrics and endocrinology departments of Suzhou Dushuhu Hospital, it was discovered that children fear sharp needle holes, an unfamiliar hospital environment, and doctors' attire.

The initial stage in observation is to assess the child's condition during the medical appointment. During a 3-hour observation at a pediatric clinic, about 60% of the youngsters exhibited dread when confronted by a physician, and 70% exhibited increased resistance when confronted with blood or needles. It is important to note, however, that when parents provide positive counsel to their children, such as telling them what will occur after the visit and the steps to be taken prior to the appointment, the children dread tests and doctors significantly lessened.

Currently, Suzhou Dushuhu Hospital lacks a designated space for children. In the diabetes area, only a few food illustrations are put on the wall. In this aspect, there is less information available for children in hospitals, and the displayed notifications are simplistic and inadequate.

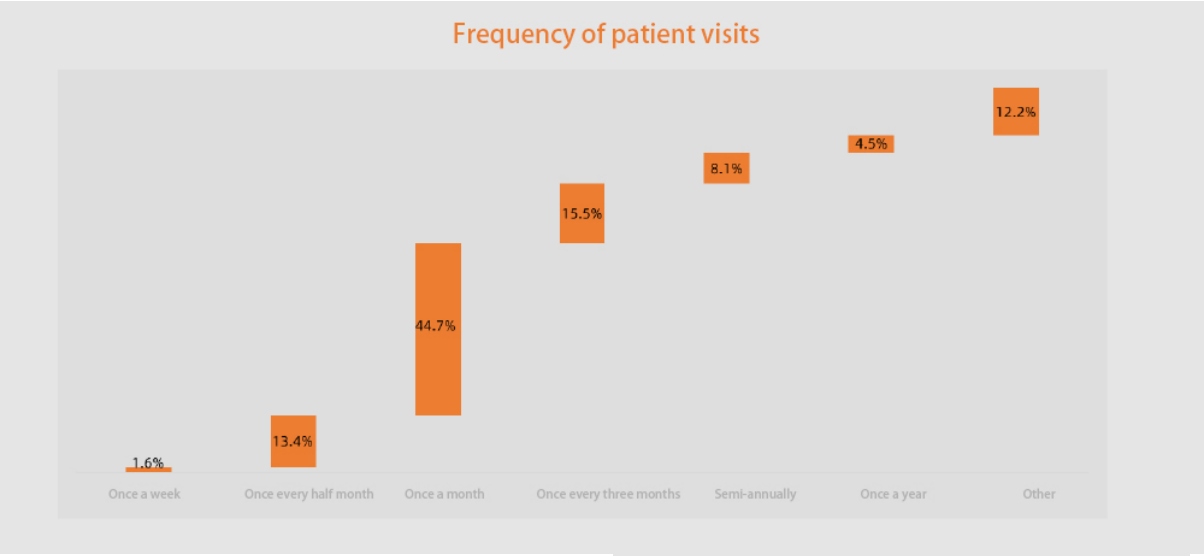
During my visits to dental clinics, I discovered that an increasing number of private dental clinics have set up a children's consultation area, using dolls, anthropomorphic animal design,

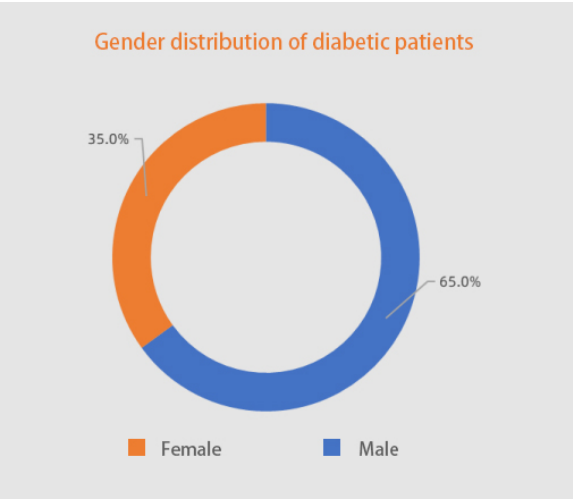
and children's medical teaching aids to reduce children's fears and encourage them to cooperate with treatment voluntarily.

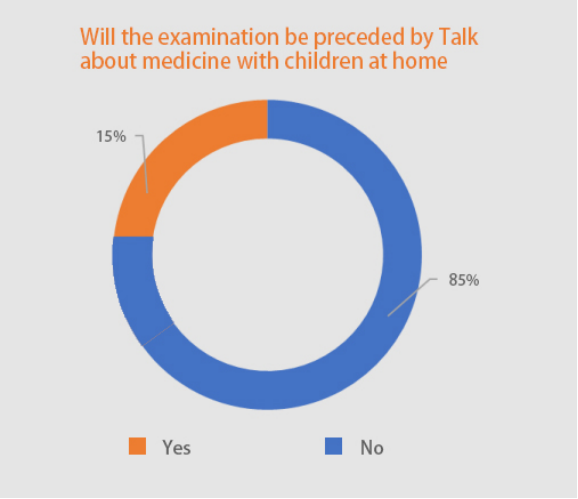
2. Online questionnaires

In order to understand the real needs of Chinese people with type 1 diabetes, I searched for people with diabetes through QQ groups, Douban groups, Weibo, Xiaohongshu, TikTok, and other social media, and distributed more than 400 questionnaires to them. The final number of returned copies was 128, and the final valid questionnaire through noise reduction was 78.

The purpose of the questionnaire was to find out what pain points and feelings diabetics have about the equipment they use for daily home care and whether they feel negative emotions such as an "inferiority complex" because they have diabetes.







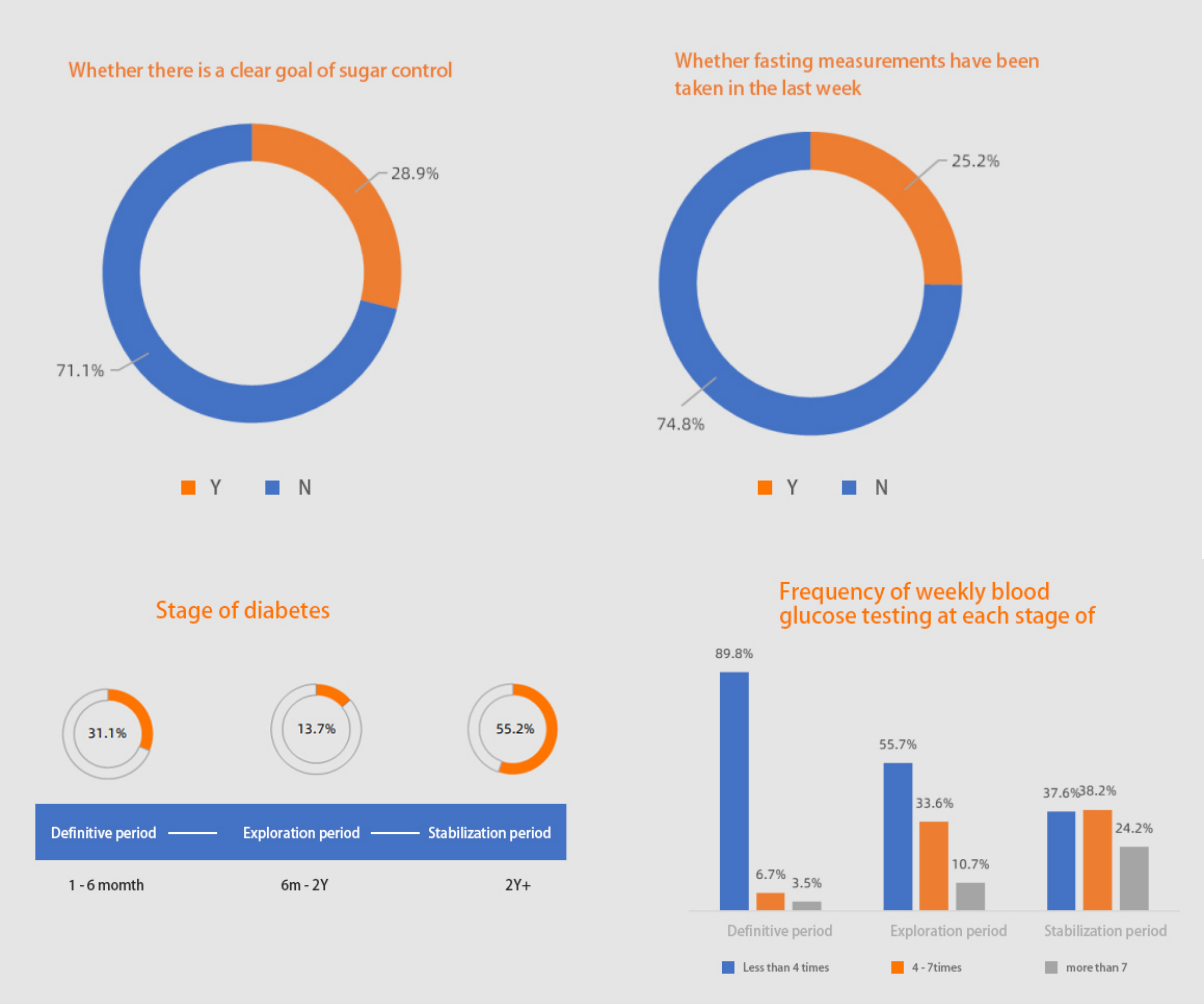


Figure7: Data from the questionnaire

Since the online questionnaire was not administered to diabetic children aged 5 to 10 years, the questions were tailored to adult diabetics and the parents of diabetic children. In the interview, the answers for pediatric diabetes will be presented in greater detail. The findings of the questionnaire are displayed in the following charts:

Overall, it is basically higher in men than in women, both in children and adults with diabetes.

The frequency of diabetic visits is low:

According to international guidelines for the daily care of diabetes, people with diabetes should receive weekly feedback from their physicians regarding their diet and medication dosage. 44.7% of patients chose to visit once a month, and only 15% visited more than two times a month. The questionnaire shows that most patients find it inconvenient to go offline to the doctor, spending at least 3 hours per visit. The feedback

from the questionnaire participants showed that most people do not have a clear plan and goal in their daily care process.

Low frequency of blood glucose testing and poor adherence to daily monitoring:

The development of diabetes can be divided into three stages: diagnosis, fluctuation, and stabilization. During the confirmation period, when a patient has been diagnosed with diabetes for less than six months, he or she lacks fundamental understanding about diabetes and is unable to cope with it. During the diagnostic phase, the patient is diagnosed for six to two years. At this stage, the patient has a rudimentary understanding of diabetes but lacks a scientific approach to sugar control. Patients who have been diagnosed with diabetes for more than two years are considered stabilizers, since they have a thorough understanding of the disease and have learned a number of scientific approaches for sugar control. 31% of the questionnaire population are in the confirmed stage, 13% are in the determining stage, and 55% are in the stabilizer stage, as depicted in the graph. Only 24% of patients with stable diabetes measured their blood glucose more than seven times per week, indicating low compliance with daily monitoring and management.

Most parents do not tell their children about the specific treatment process:

The majority of parents lack fundamental medical information and try to educate themselves about diabetes through the Internet and independent study. When examining the education level and location of the parents of patients, it was discovered that the majority of patients' families resided in first- and second-tier cities, with a higher proportion of patients residing in the east (this data may be skewed due to insufficient sample size, the fact that medical screening conditions in central and western China are not as good as in the east, and the limitations of the Internet). In addition, over 80 percent of parents do not discuss the causes of diabetes with their children or help them overcome the anxiety of screening and the negative aspects of routine care. For instance, when a child must go to the hospital for a routine checkup, the majority of parents do not inform the child beforehand about the specific test. When a stranger asks a child why he or she is poking his or her finger for a blood glucose test, the parents instruct the youngster to ignore the question.

More than 95% of parents have not seen the child-oriented medical supplies and medical scenarios.

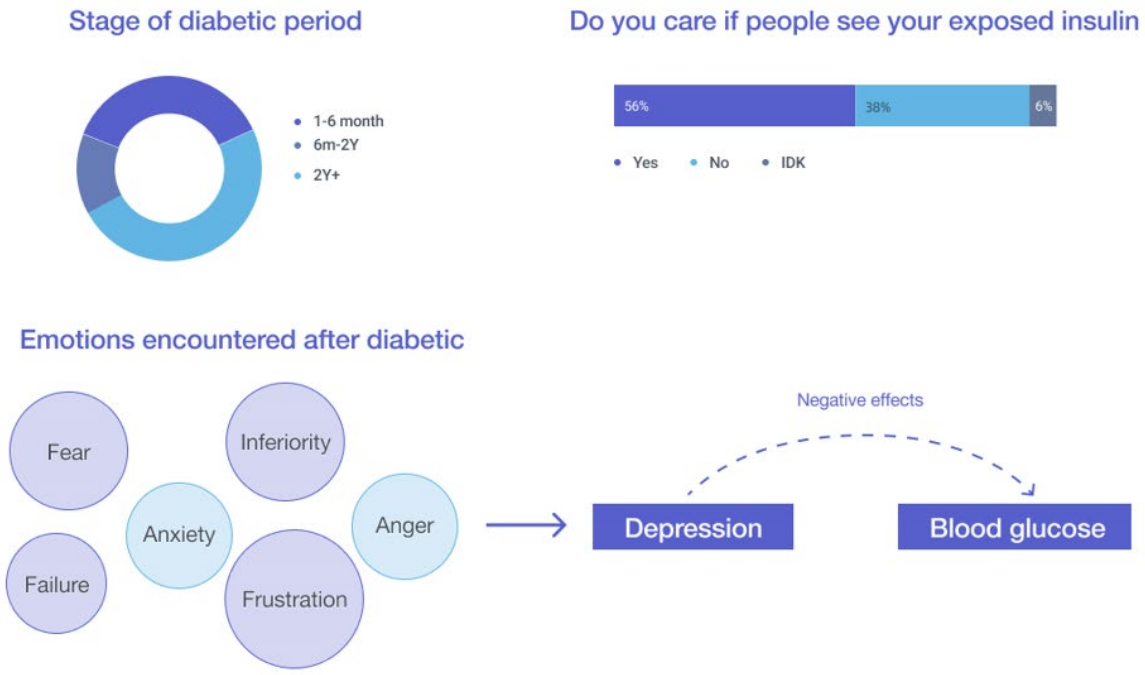


Figure 8: Statistics

More than 56% of patients said they were very concerned about other strangers seeing their exposed treatment devices.

This long-term use of the device has a huge impact on sensitive skin, particularly in pediatrics, although there is little literature to guide patients in managing their skin integrity issues.

3. Interview

Children as patients, their behavior and emotions are crucial to the project's design. However, because the Chinese medical system is still incomplete, there is a dearth of medical and humanistic care for children, and parents lack the medical knowledge to encourage their children to view the sickness positively, which frequently results in worry and worry low self-esteem. At this point, I initiated direct conversations with individuals to comprehend their true requirements and emotions better.

In addition to online questionnaires, I focused a great deal on interviews with diabetic patients and parents of juvenile diabetics and in-person interviews to better comprehend user requirements.

Overall, the interview was semi-structured, following a rough outline framework and requesting open-ended responses from the participants in various contexts. They were thus directed in their thinking and allowed to discuss the daily treatment of diabetes. The entire interview was recorded and transcribed word-for-word into written content at the conclusion, with the spoken narrative removed for standardization purposes.

The study population for this interview consisted of pediatric diabetes kids aged 5 to 10 years and their parents. Using stratified sampling on internet social media platforms and the endocrinology department of Suzhou Dushu Dushuhu Hospital, the researcher sought participants for this study. Each interview session lasted no less than one hour and was performed simultaneously in a combination of online and offline modalities. The interview was taped and transcribed in its entirety.

Basic interview question guidelines are:

1. Personal Information: gender, region, specific age, type 1 or 2, duration of diabetic, monthly expenses for diabetes
2. Are the insulin syringes used in the home care process for children with or without needles? Do you know about Continuous Gauge (CGM) products?
3. If you were asked to rate the product you are currently using on a scale of 1-5, what would you rate it and why?
4. Does the child develop negative emotions about insulin injections in daily life? E.g., needle resistance, low self-esteem, sensitivity, reluctance to bring the pump?
5. Do you describe to your child what is going to happen before the daily checkup? Do you pay attention to the children's area in the hospital? Have you seen any children's medical products?

Interviewer No. 1

Basic situation:

“My family is an identical twin boy, the second one was diagnosed with type 1 diabetes when he was four years and ten months old and was initially hospitalized in the endocrinology department of Jingde Road Children's Hospital to regulate his sugar. ”

Daily use products:

"At the beginning, we used insulin pens for four injections a day, and from the end of September 2021, we started to wear an insulin pump, considering the DMDP[1] and the fact that the insulin pump might be better when the child is in elementary school, we used the Microtek catheterless pump."

Pain points:

"The child usually does not like to be asked by strangers why he needs to test his blood sugar, and he will be more unhappy regarding this aspect. Short-sleeved arms sometimes leak out in summer; when seen by other students will be more mindful. We are looking forward to the closed-loop insulin pump, the price of existing products is high, and we hope to launch a national brand soon. I think children with type 1 diabetes are worthy of attention, but unfortunately, I have not seen any products aimed at that. I am apprehensive about my own children's psychological sensitivity and low self-esteem when they reach adolescence, and I hope that there will be some products that can alleviate the mental pain of some children."

Interviewer No. 2

Basic situation:

I was diagnosed with type 1 diabetes in June and I am currently 22 years old. I have not used the insulin pen much as I have been on a pump continuously since August.

Pain points:

There was a time when I was in middle school that I felt frustrated, not because I was getting worse, but because I felt like I was different from everyone else around me and that I always needed to have a detector on me as well as needing to wear a device. The good thing is that my family was very supportive and gave me a lot of encouragement. They would teach me a lot about sugar control in my daily life to make me less fearful about this disease. At the moment, I don't think this disease has a big impact on my life, I just need to pay attention to my diet.

[1] DMDP refers to a state of early morning hyperglycemia caused by unbalanced secretion of various hormones at dawn (3-9 a.m.) in diabetic patients who have a reasonable and stable glycemic control at night, i.e., no hypoglycemia. This phenomenon was first proposed by Schmidt, a foreign scholar, in 1981.

Figure 9: As type 1 diabetes requires daily device

5. Market research

5.1 Existing product analysis

Figure 10: Several diabetes testing instruments on the market today and how they work

There are two types of blood glucose measuring instruments on the marketplace currently: visible needles and invisible needles. The visible needle works by first sticking it on a sterilized fingertip, squeezing out the first drop of blood to eliminate it, aspirating the second

drop of blood as the collection sample with the test paper, and then waiting for the blood glucose index. The second issue is that the user cannot see the blood collection needle and blood; there are three types: finger pressure, blood glucose pen, and continuous blood glucose testers that can be used continuously for 14 days, as represented by Abbott.

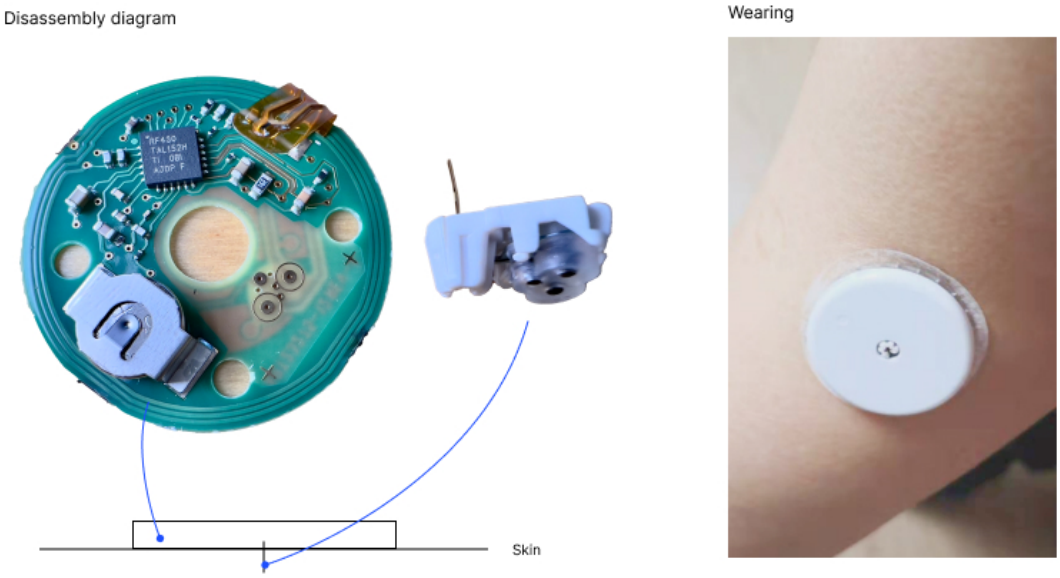


Figure 11: Breakdown of Abbott Shungan Products

Yapei with the principle of high-pressure injection, allowing insulin to enter the subcutaneous through high-pressure injection, and users can scan the sensor placed on the upper dorsal side of the arm to monitor blood glucose at any time, as opposed to the traditional method of collecting blood from fingers and measuring blood glucose with test paper.

Advantage and disadvantages of Continuous blood glucose monitoring (CGM)

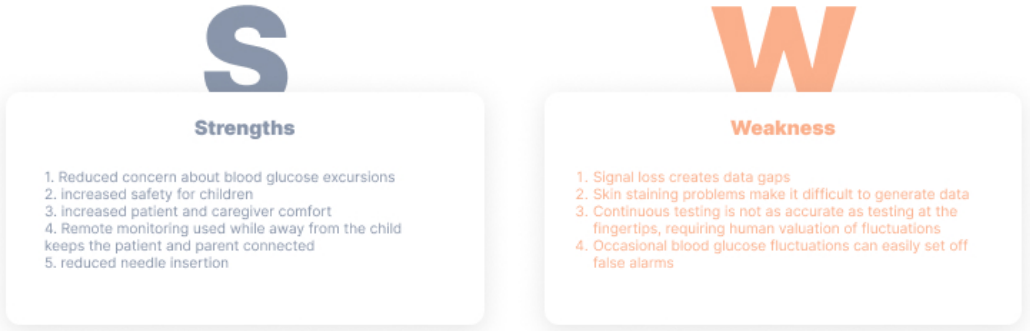


Figure 12: Strengths and weakness of CGM

An analysis of continuous monitoring products produced in China, as represented by Abbott, reveals that it reduces concerns about blood glucose excursions, improves child safety, employs remote monitoring away from children, keeps patients and parents in touch with features that improve patient and family comfort, and, most importantly, reduces the number of needle insertions. There are numerous unresolved issues with CGM products. The fear of using the press-in method for the first time, the difficulty in generating a stable amount of information from CGM due to signal loss, and skin adhesion issues are all issues. Furthermore, it is important to note that the accuracy of CGM products is not as good as that of finger-type products, and there are large errors that patients must assess. Brief blood sugar fluctuations can easily set off the alarm in patients.(Hilliard et al., 2019).

6. Case study

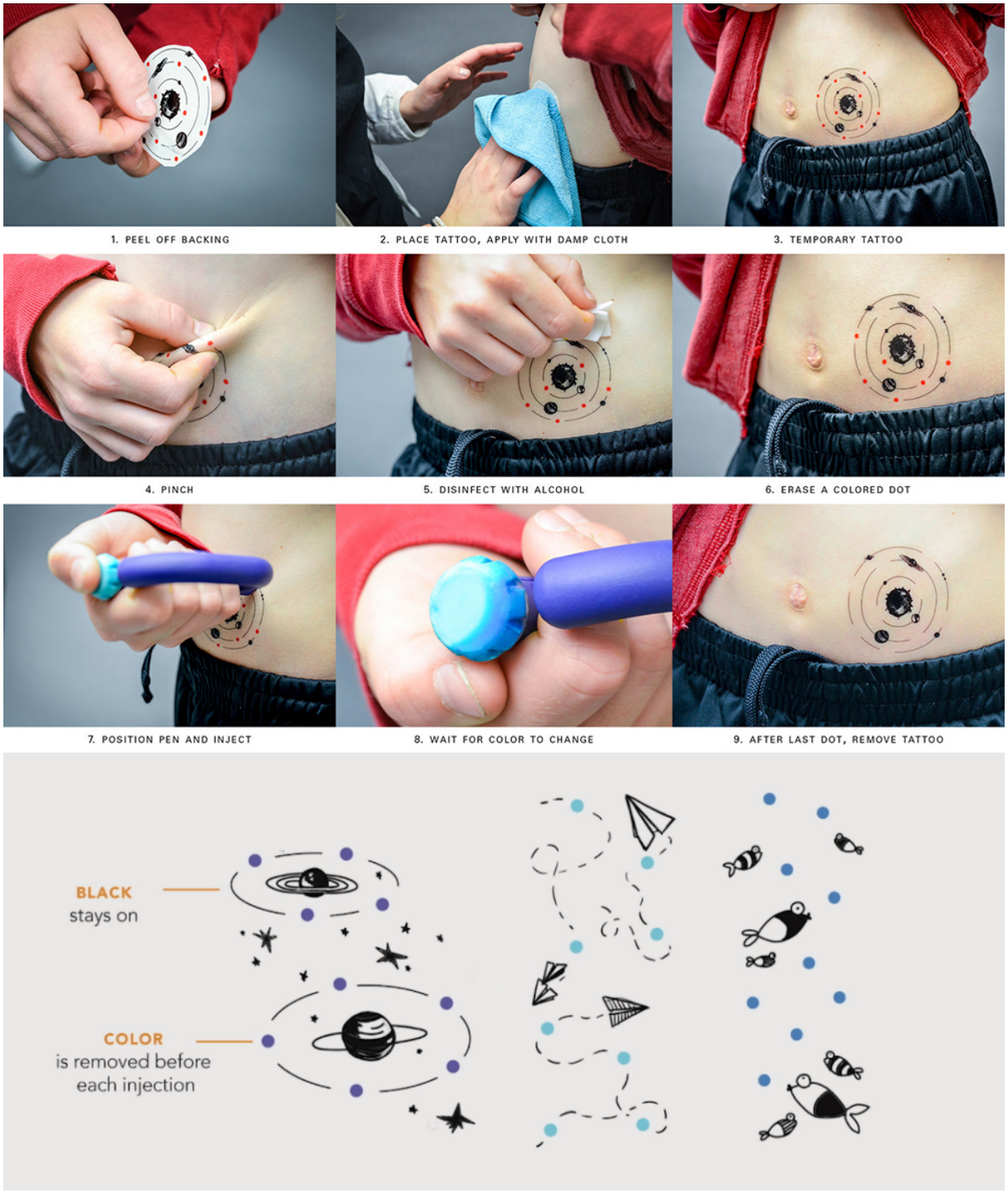


Figure 13: An invention to help children with diabetes by Renata Souza Luque(Guaricci, 2018)

Renata Souza Luque, a designer, discovered that her 6-year-old cousin requires insulin injections two to five times a day, in addition to a strictly controlled diet. However, there are few products on the market that are specifically designed for this demographic - children.

THOMY is an insulin injection medical device. It consists of a syringe and a temporary tattoo. The temporary tattoo has colored dots on it, which the child removes with alcohol one at a time before each injection. When all color stains from the tattoo are removed after about three days, the child has completed one stage of the injection. The temporary tattoos were an important part of the project, and the designers wanted to ensure that the treatment did not cause the child "shame."

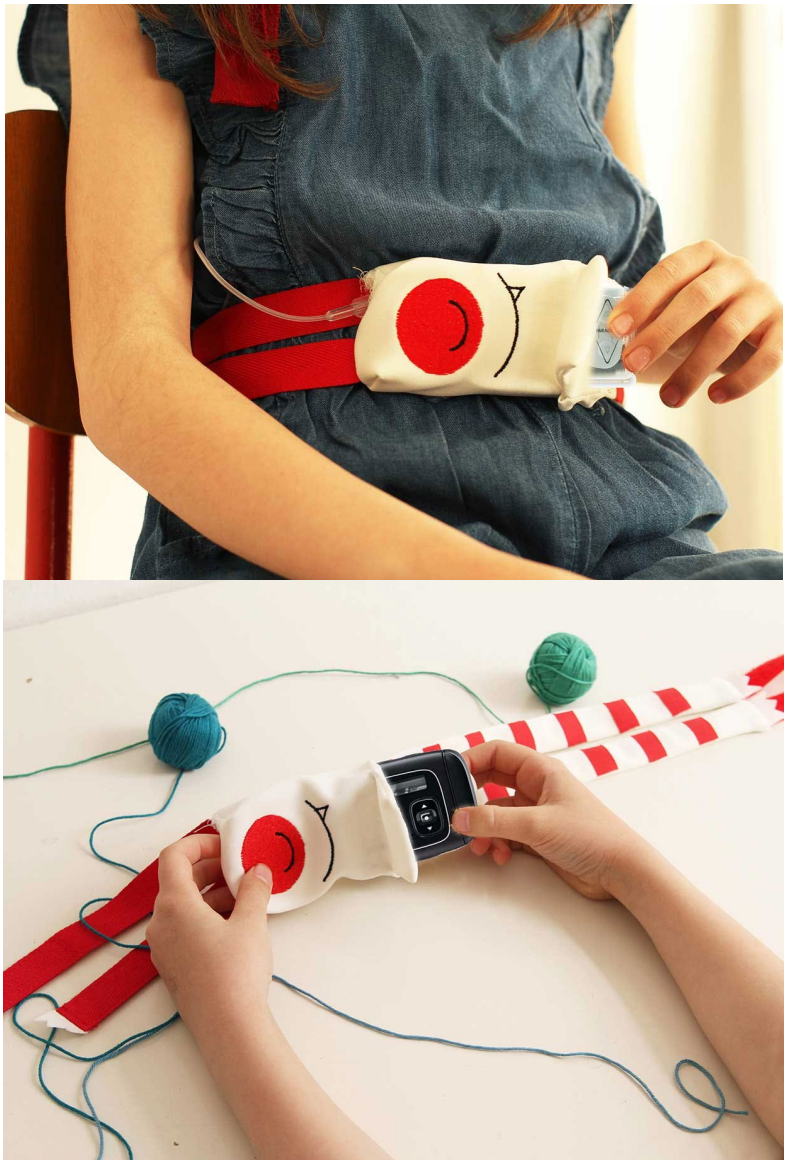


Figure 14:miMi designed by Irene Abarca(Runge, 2021)

miMi is an ergonomically designed bag that allows children with type 1 diabetes to carry their insulin pump throughout the day. Irene Abarca, the product's designer, wanted the product's overall form to resemble a pet so that the child would view the disease as a friend rather than an enemy and feel pampered while caring for the monster. Irene also mentioned that she had begun designing items that would help children with diabetes carry their essentials, such as blood glucose meters and insulin pumps. The primary reason was that she observed that many medical products were not suited to the child's characteristics, as some parents reported, resulting in ineffective treatment. These medical auxiliary products should be more expensive.

7. Design Process

7.1 Photo Journal

Figure 15: Photo journal of type1 diabetic

I made a photo journal of diabetic personal through observation and online research. found that their lives are very different from the daily lives of normal people. As diabetics, they need to pay more attention to their weight, exercise and daily medication. First, they should always measure their own weight. It is important for people with type 1 diabetes to measure their blood sugar on a daily basis. Self-monitoring of blood sugar provides information about an individual's dynamic blood sugar profile. This information can help rationalize food, activities, and medications. It is also needed to understand the timing of blood sugar changes. Usually doctors will make monthly medicine support and insulin use guidelines for patients, but after all, in China, medical resources are still relatively scarce, so it is impossible to make timely improvement, so more patients adopt long-term family treatment. Among them, insulin pumps and insulin pens are the most common instruments used in daily personal care. Compared to the average person, their life has too many unnecessary actions due to diabetes, which undoubtedly reduces the happiness of life

7.2 Persona

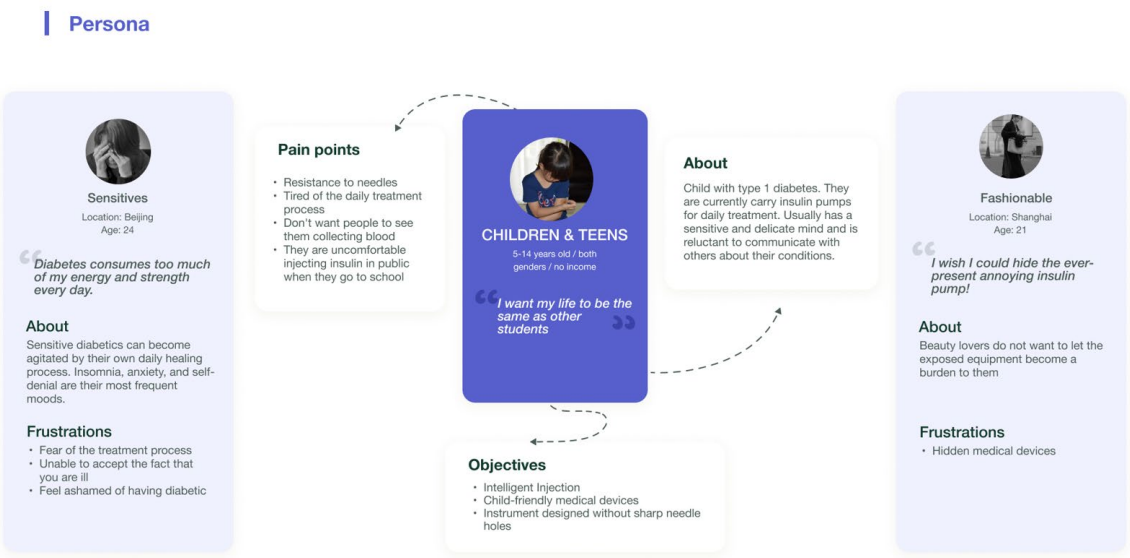


Figure 16: Persona

There are three main groups of Diabefree users: children and adolescents, emotionally sensitive patients and beauty lovers who are resistant to exposed devices.

Children and teenagers are the main audience of Diabefree project. For young people in the age group of 7-14, there is often a sense of shame when suffering from the disease. This negative emotion usually affects the recovery from the disease. Adolescents often go through a difficult time with their illness, and it is worth thinking about how designers can design for the well-being of this group of patients. When children with type 1 diabetes need to inject insulin in public again at school, other peers are puzzled and the questions may cause them a lot of trouble. Through the interview and questionnaire questions back, we found that most children do not want to let others see their injection process or do not want to be asked about their condition.

7.3 User Interview

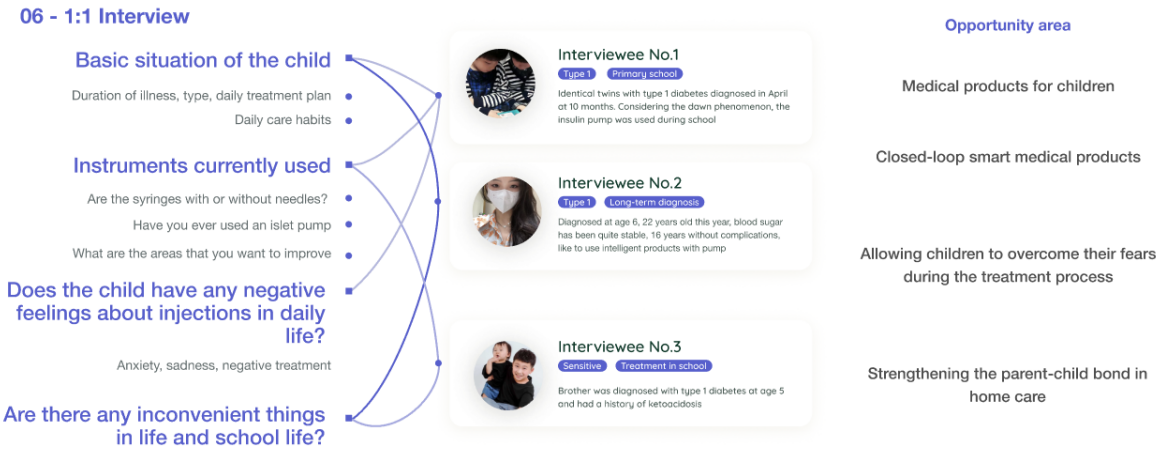


Figure 17: User interview

The project involved in-depth interviews with three individuals, two of whom were children and one of whom was a 22-year-oldadult female. The conclusion from the interviews is that when patients first discover they have type 1 diabetes, which is also the most traumatic time in their childhoods. Most people are eventually able to accept that they have the disease. Some parents and children with the disease respond that the majority of available medical devices lack emotion. They are eager to see something with a caring attitude or a child-oriented product.

Consequently, Diabefree products are positioned to aid type 1 diabetics in their early stages through difficult times and optimize their injection experience.

7.4 Storyboard

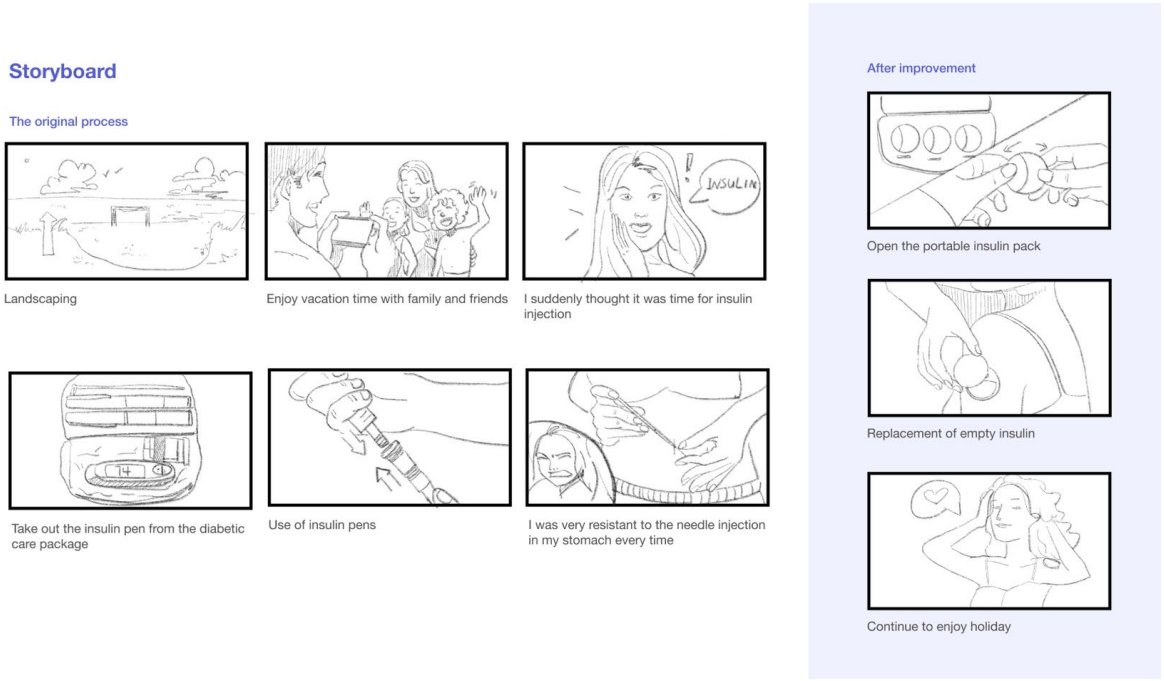


Figure 18: Storyboard

Let's imagine a scenario: Users arrive at the beach to enjoy the beautiful scenery with his family and friends. They suddenly realizes they haven't injected insulin yet, so they dashe to the car to retrieve their daily care kits, draw out the insulin pen, and inject insulin under everyone's eyes or alone. This is somewhat detrimental to the enjoyment of most people. So the modified Diabefree scenario is as follows: In their spare time, users remove the product from the care kit and insert the replacement kit into the product before continuing to intelligently inject insulin.

7.5 Material experiment

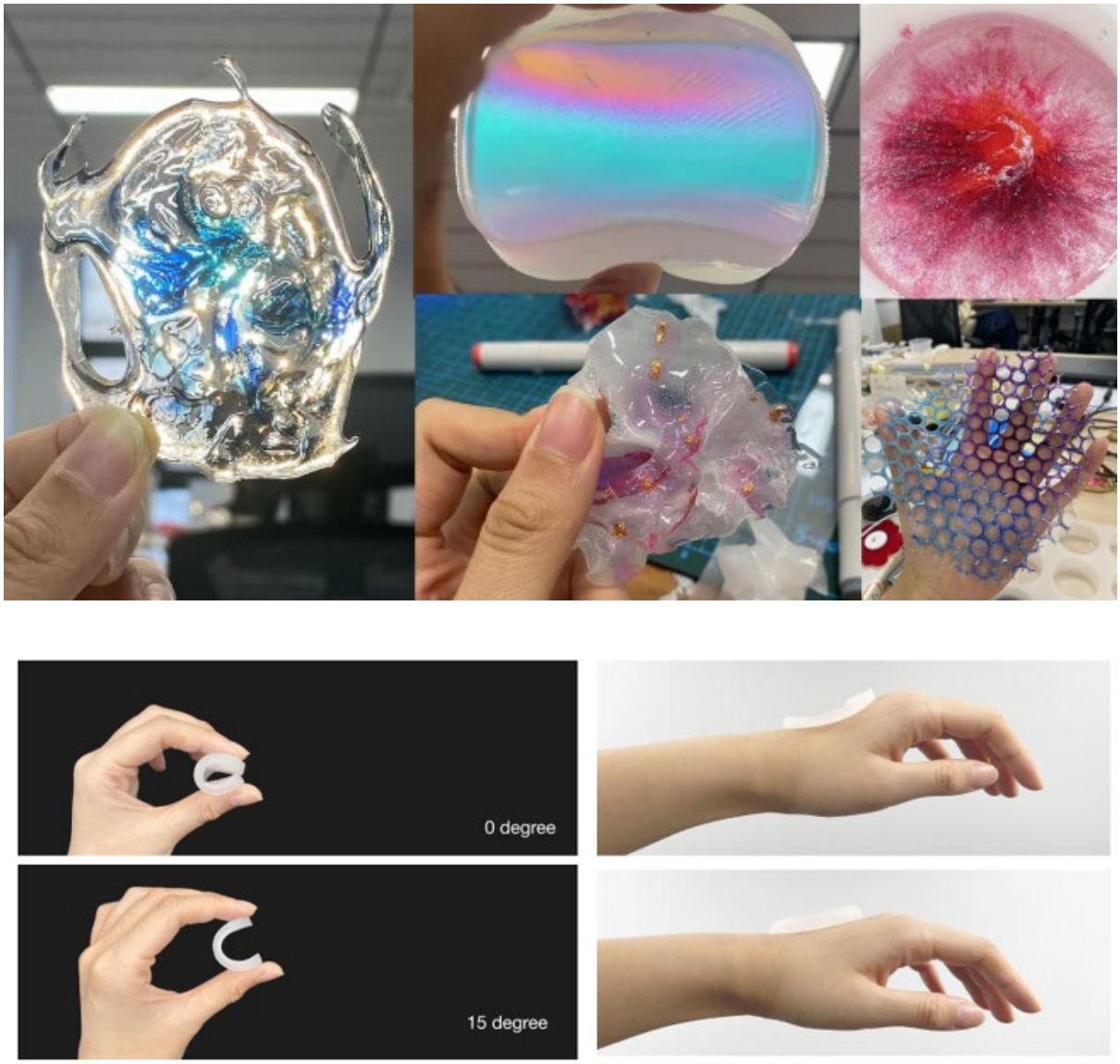


Figure 19: Hardness test

The design process as a whole incorporates numerous material experiments, including drip adhesive, silicone, metal, heat shrink, and fabric. The objective of this project is to bring out the personalities of diabetic patients in order to alleviate the discomfort caused by their condition; therefore, a beautiful appearance is required.

Hardness and fit test

Given that diabefree is worn close to the skin, it is essential that the product be compatible with human skin. During the experiment, 0 degree, 15 degree, 30 degree, 50 degree, 70 degree, and 90 degree silicone were utilized to examine the fit and softness. Finally, after

multiple rounds of testing, 70 degrees was the solution with the highest level of praise and suitability.

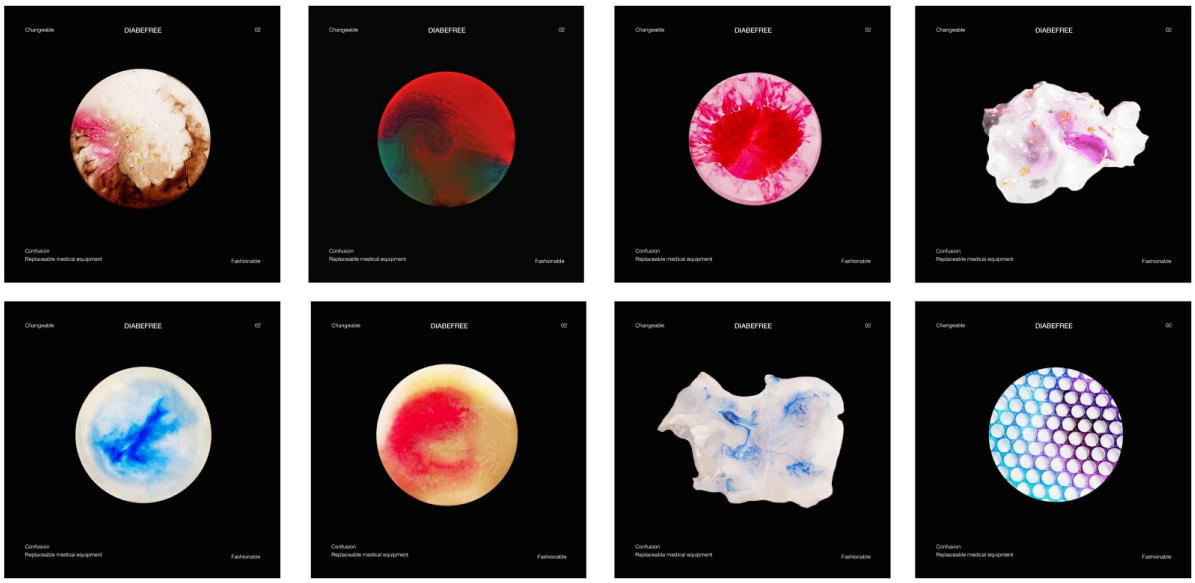


Figure 20: Cover of Diabefree

Color test

Using drip gel color fusion as a starting point, this method was implemented. The procedure considers environmental temperature, relative humidity, and the state of color fusion at various levels of wetness and dryness. Two skins were produced by heat-shrinking sheets, a fascinating raw material. When the heat shrink sheet is heated by a heat gun, it is blown out of its inorganic form, at which point it is a joy to fuse it with color essence pigments. The ultimate honeycomb skin is composed of express bubble paper and dripping color essence.

7.6 Model iteration

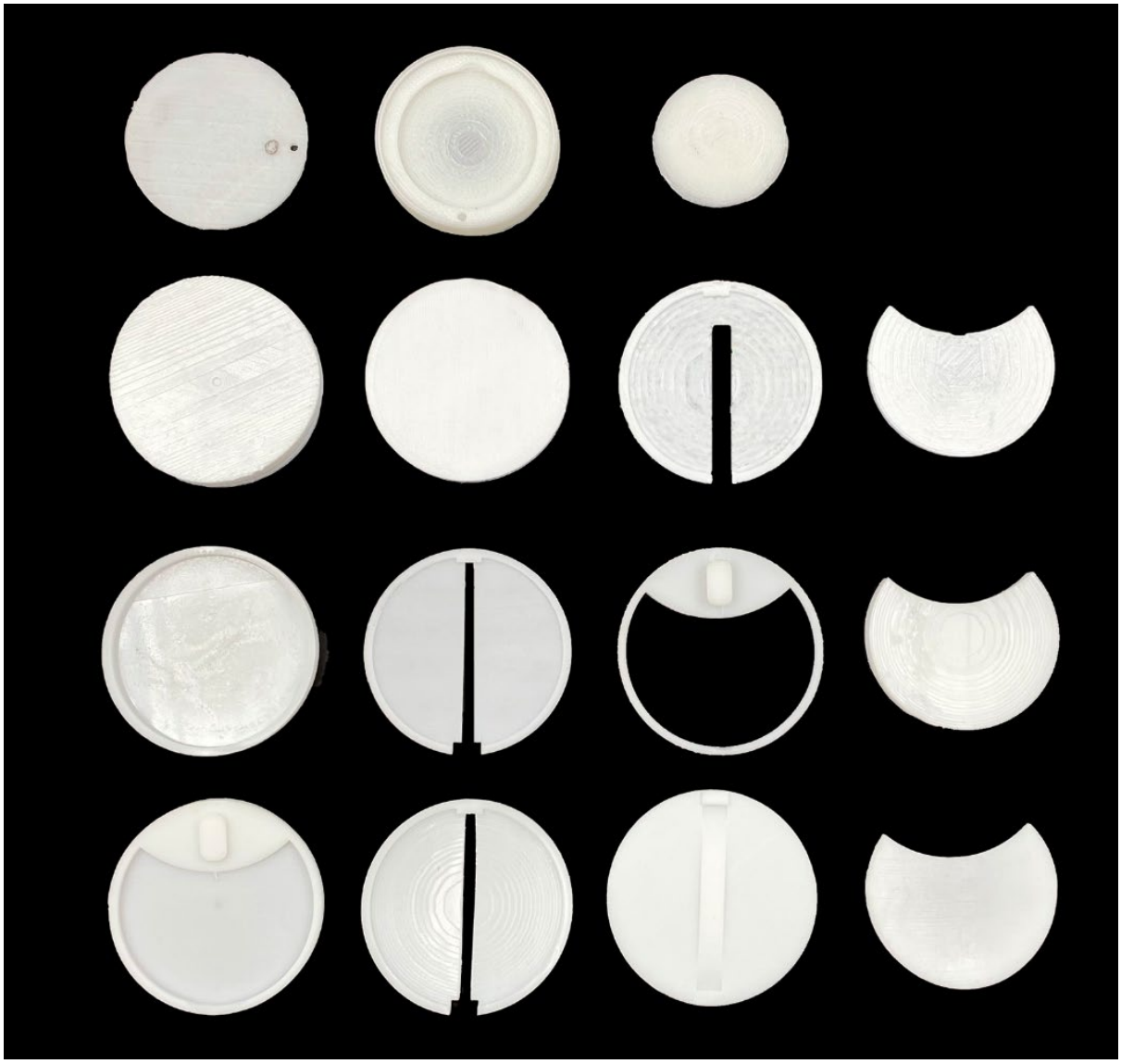


Figure 21: Model iteration

Utilize 3D printing technology for multiple product iterations. Initially, the first-generation model established the concept of embedded insulin carrying and featured a rotating design. The second-generation model absorbed a portion of the wireless headset box opening method, utilizing the slide cover rail method, resulting in a silkier overall experience.

How to transmit insulin is the project's most significant technical challenge. After installing the portable insulin device, the insulin will be administered to the human body via a small needle using the model's final iteration's ampoule opening method.

During production, numerous model flaws were discovered. Upon evaluating the first generation of the product, it was determined that the lid was easily detachable, incapable of

absorption, and warped on both sides because it did not conform to the skin. In order to address these issues, the needles were redesigned and medical stickers were added to the new design.

After prior material testing and model printing, the project finally decided to use soft glue with a temperature of 70 degrees.

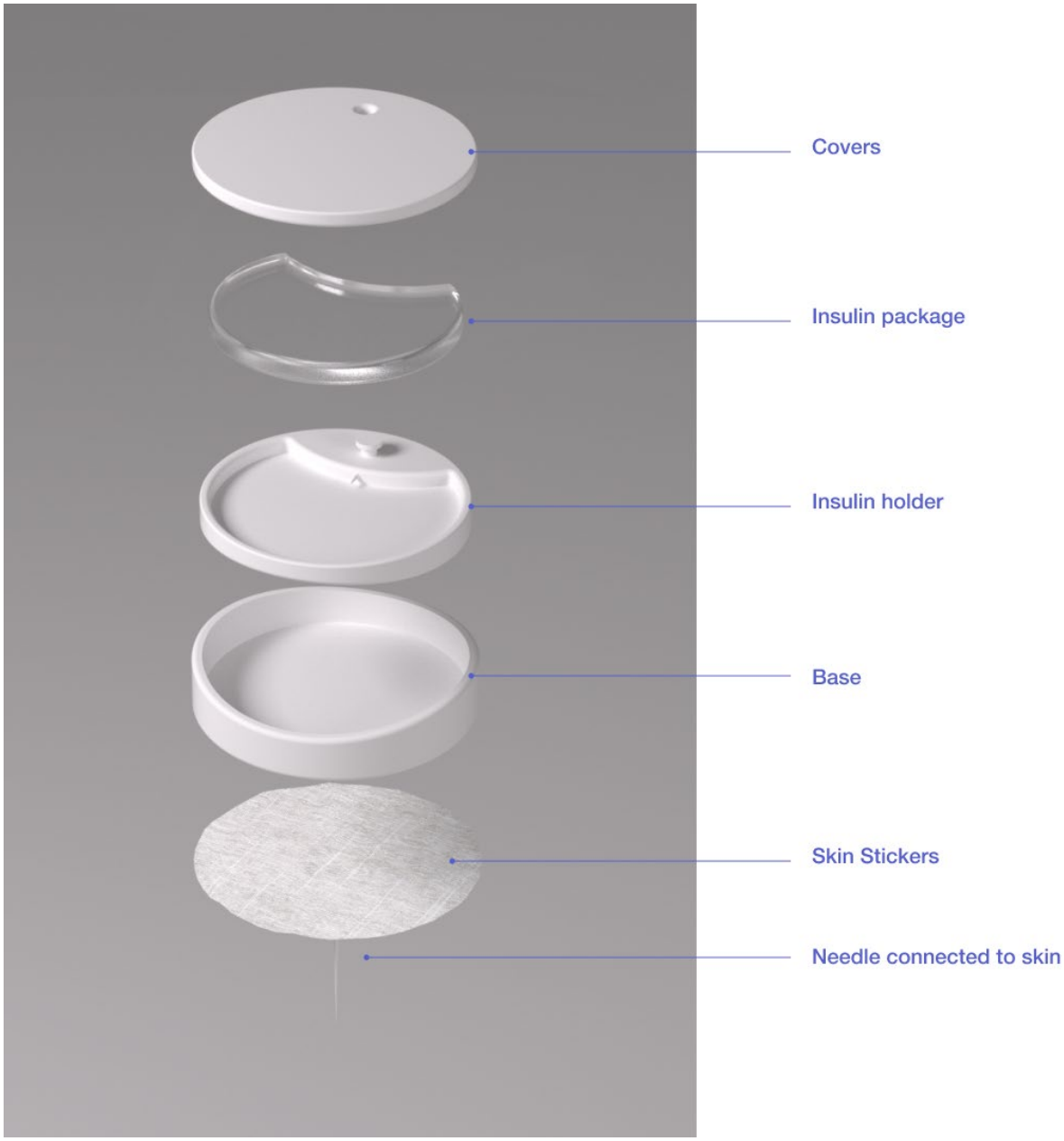


Figure 22: Exploded View of Diabefree

The Diabefree consists of six components: a cover that holds the skin of the entire product, an insulin package that is easy to carry and change, an insulin holder that holds it, a base that is soft against the skin, a sticker that adheres to the skin, and an insulin needle.

Color selection

Diabefree wants its users to feel clean and non-aggressive in terms of color. As a result, white is selected as the primary color for the entire product's body, despite the fact that different materials will result in a variety of white appearances.

Figure 23: Insulin package

The insulin package is opened like that of a medical ampoule. To break open the package and insert the semicircular insulin container into the holder, users need only apply even

downward pressure with their hands. The capacity of the Integrated Insulin Pack is two units, sufficient for an adult to use frequently for two days. After two days, the remaining insulin should be discarded and replaced with a new portable package.

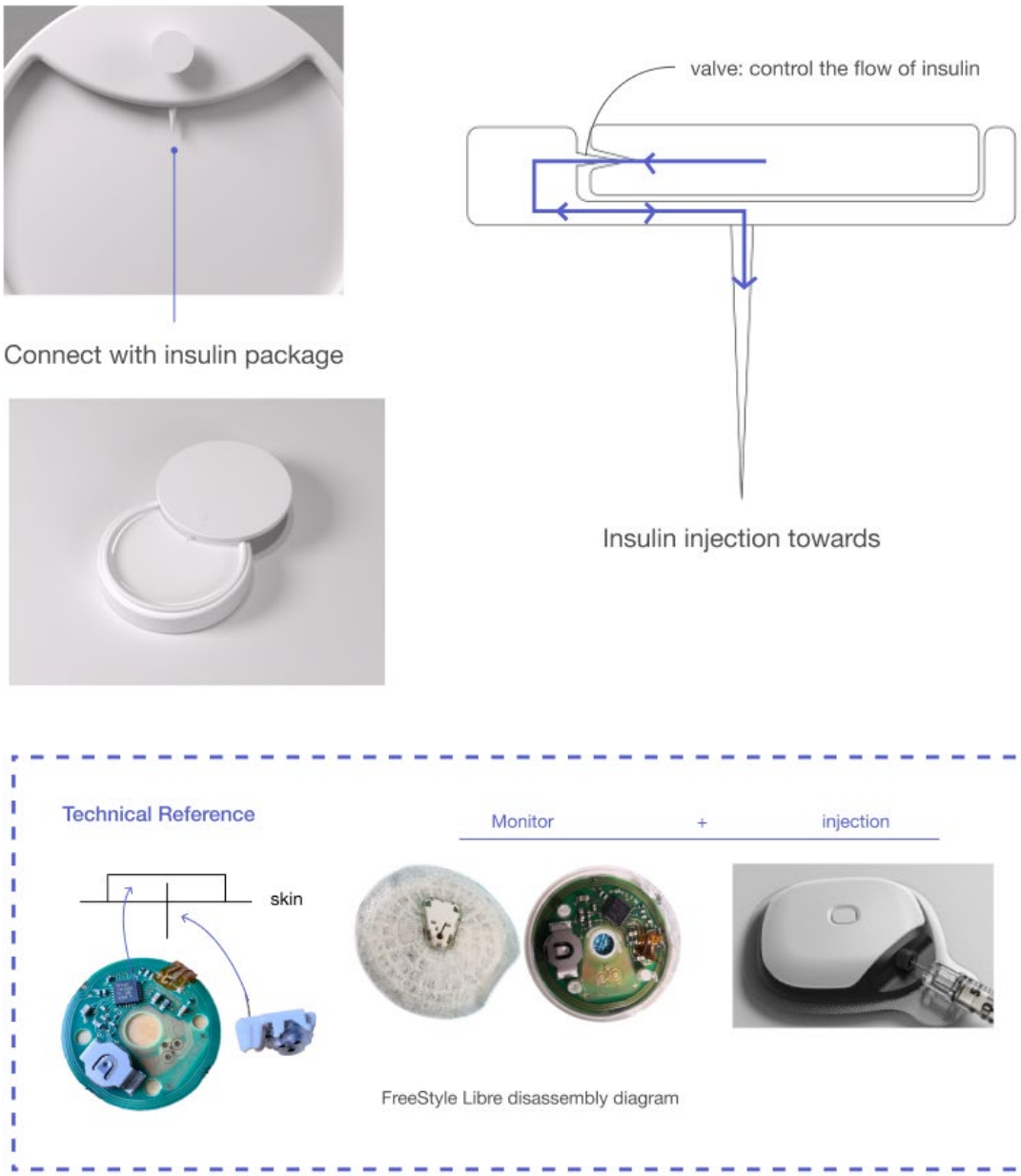


Figure 24: How Diabefree works and the explanation of base

The overall working principle of Diabefree is referenced from the working principle of Abbott's Instant Sense. The overall product design combines both blood glucose monitoring and injection.

Working Principle

Image shows how insulin transfer into human body. When the user puts the package into the holder, the needle in this place will carry the insulin into the person's body by this route. And there is a small valve at this place to control the flow of insulin

Figure 25: How Diabefree adapts to the user's skin

Diabefree is waterproof for bathing purposes. Due to the difficulty of attaching a single needle to skin tissue, medical stickers are required.

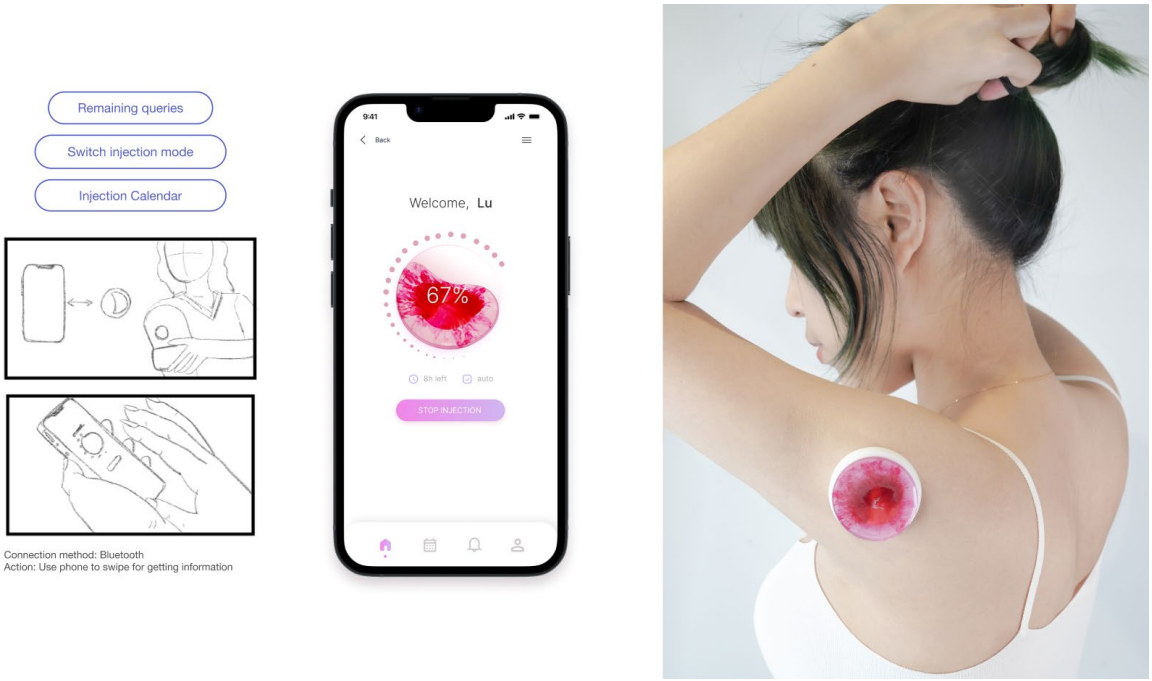


Figure 26: How Diabefree works and the explanation of base

7.7 APP design

Diabefree is also utilized with an app that reminds users of remaining insulin, allows them to change the mode for automatic injection or stop injection, and visualizes the amount of insulin intake.

Usage

As depicted in the figure, users can receive real-time data feedback by swiping and connecting via Bluetooth to the mobile application. In addition, Diabefree supports self-injection due to the unpredictability of the insulin pump, as mentioned in prior research. If users believe that automatic injection is unreasonable, they may also choose to inject themselves manually. This also provides the user with options.

Figure 27: Photo of Diabefree

7.8 Video

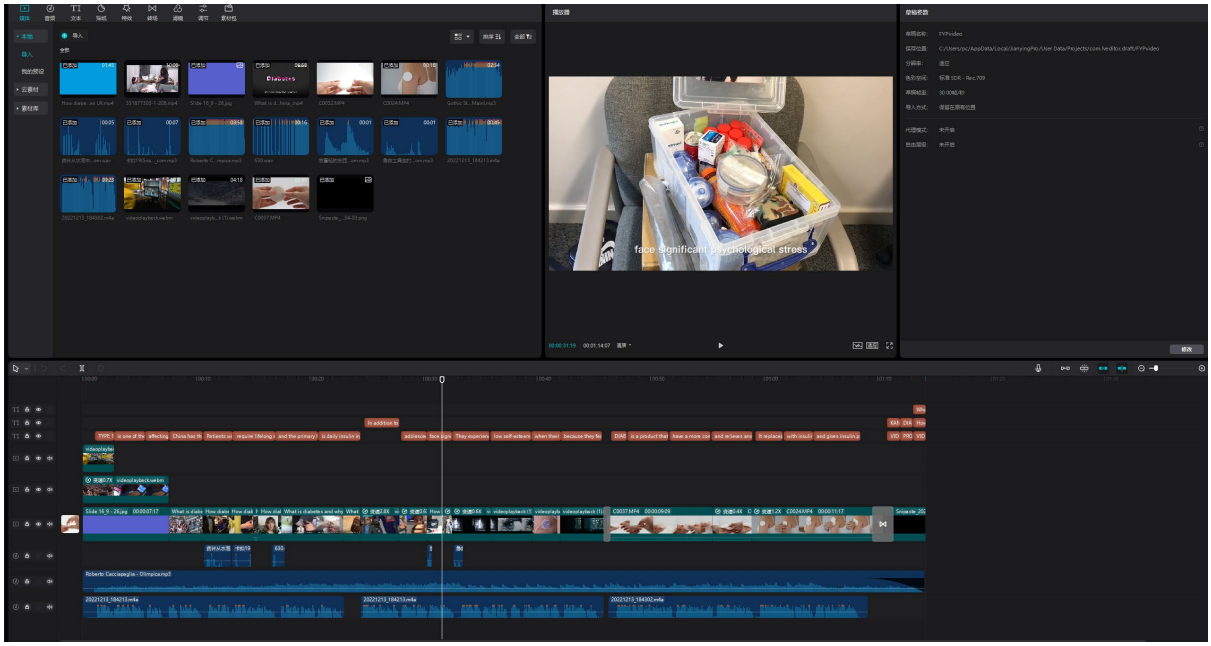


Figure 28: Video Production Process

Video production was required to explain better the project's background, the research process, and the use of Diabefree. This dynamic presentation is ideal for quickly conveying the overall project flow to the audience. Video is an effective content marketing tool. Videos can pique users' interest and instill confidence, making a favorable first impression.

8. Conclusion and further development

This project is intended to result in a product that effectively optimizes daily insulin injections for type 1 diabetes patients. By optimizing existing products on the market and transforming the traditional injection method into a new monitoring and smart injection product that is more user-friendly, Diabefree is able to improve the user experience significantly. Throughout the research project process, questionnaire design, user interviews, iterative testing, user feedback, and product optimization were incorporated. Diabefree was generally effective, but it had certain limitations. For example, the project could only be tested on humans with supervision due to security concerns, and only a few single-user test subjects were available.

As the primary focus of this project is the design of physical products, app development can be used as a future expansion strategy. Because it is so convenient to perform certain tasks, such as viewing historical data, comparing data, and scheduling medical appointments, on mobile devices, the daily treatment experience for patients is further enhanced.

Moreover, Diabefree covers can only be combined with a limited number of covers; however, if users can create their covers, it will be more consistent with the keyword "personalization." DIY or modular construction would be examples of exciting fashion trends.

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