Revista Mexicana de Ingeniería Biomédica

RESEARCH ARTICLE

Techani: Use of technology as an ally in the management, monitoring, and control of Type 1 diabetes mellitus

Techani: El uso de la tecnología como aliada en la gestión, seguimiento y control de la diabetes mellitus tipo 1

Rocío Contreras Jiménez[1], Juan Carlos Olivares Rojas[1,*], Adriana del Carmen Téllez Anguiano[1], Jesús Eduardo Alcaráz Chávez[1], Enrique Reyes Archundia[1], José Antonio Gutiérrez Gnecchi[1]

[1]*Tecnológico Nacional de México/Instituto Tecnológico de Morelia, Ave. Tecnológico #1500 Col. Lomas de Santiaguito, Morelia, Mich., C.P. 58120*

[*] Corresponding author(s); contact in the panel below.

Abstract

Type 1 Diabetes Mellitus (T1DM) is an autoimmune, unpreventable, and incurable disease in which insulin production ceases due to pancreatic beta-cell destruction. This work presents Techani, a web and mobile system designed to enhance treatment adherence and patient monitoring through a culturally adapted interface tailored to the Mexican context. The system integrates Artificial Intelligence tools and incorporates a broader range of variables than current applications, including mood, hydration, sleep, and atypical days, in addition to traditional clinical data. A mixed-methodology approach combining Scrum, UI/UX design, and empirical data collection through physician surveys was used to identify relevant determinants of glycemic control. The proposed system aims to strengthen patient autonomy, facilitate physician follow-up, and improve adherence by automating carbohydrate counting using the Mexican Food Equivalents System (SMAE). Compared to existing mHealth tools, Techani increases the number of monitored variables by more than 40% and enables potential data integration for predictive glucose modeling. Limitations include manual data entry and a small convenience sample for usability testing. Future validation studies will evaluate its clinical impact on glycemic control and treatment adherence, and integration with CGM data to assess its clinical impact on glycemic control.

Resumen. La diabetes mellitus tipo 1 (DMT1) es una enfermedad autoinmune inevitable e incurable en la que la producción de insulina se detiene debido a la destrucción de las células beta pancreáticas. Este artículo presenta Techani, un sistema web y móvil diseñado para mejorar la adherencia al tratamiento y el seguimiento de pacientes mediante una interfaz culturalmente adaptada al contexto mexicano. El sistema integra herramientas de inteligencia artificial e incorpora una gama más amplia de variables que las aplicaciones actuales, incluyendo el estado de ánimo, la hidratación, el sueño y los días atípicos, además de datos clínicos tradicionales. Se utilizó un enfoque de métodos mixtos, combinando Scrum, diseño de UI/UX y recopilación de datos empíricos mediante encuestas a médicos para identificar determinantes relevantes del control glucémico. El sistema propuesto busca fortalecer la autonomía del paciente, facilitar el seguimiento médico y mejorar la adherencia al tratamiento mediante la automatización del conteo de carbohidratos con el Sistema Mexicano de Alimentos Equivalentes (SMAE). En comparación con las herramientas de salud móvil existentes, Techani aumenta el número de variables monitoreadas en más del 40% y permite la integración de datos para el modelado predictivo de la glucosa. Las limitaciones incluyen la introducción manual de datos y la pequeñez de la muestra en las pruebas de usabilidad. Los estudios de validación futuros evaluarán su impacto clínico en el control glucémico y la adherencia al tratamiento, así como su integración con los datos del sistema de monitorización continua de glucosa (MCG) para evaluar el impacto clínico en el control glucémico.

Keywords: Adherence to prescribed treatment in Diabetes, Carbohydrate Counting, Diabetes Monitoring and control, M-health, Type 1 Diabetes.
(Palabras clave: Adherencia al tratamiento en diabetes, Conteo de carbohidratos, Diabetes tipo 1, M-health, Monitoreo y control de diabetes.)

Revista Mexicana de Ingeniería Biomédica
ISSN 2395-9126 • SOMIB

Vol./No./Year	47/SI-TAIH/2026
Article no.	e2026-1559
DOI	10.17488/RMIB.47.SI-TAIH.1559
Received	30 April 2025
Accepted	18 April 2026
Published	23 June 2026
Corresponding	juan.or@morelia.tecnm.mx

1. Introduction

Diabetes Mellitus is one of the leading causes of death worldwide and a significant public health challenge. In Mexico, it represents the second cause of mortality, only surpassed by cardiovascular diseases. According to the National Institute of Statistics, Geography, and Informatics (INEGI), in 2024 there were 84,095 deaths due to diabetes mellitus [1]. Globally, the World Health Organization reported in 2022 that 14% of adults over 18 years live with diabetes, doubling the prevalence observed in 1990 [2]. Although Type 2 Diabetes receives most public health attention due to its association with obesity and lifestyle factors, T1DM remains a life-long autoimmune condition with no cure or prevention. In most countries, Diabetes Mellitus is a primary concern as the figures are already approaching a global pandemic level. Most government programs in various countries, including Mexico, are focused on the prevention and treatment of Type 2 Diabetes Mellitus, trying to avoid, as far as possible, obesity, sedentary lifestyle, consumption of refined sugars, and sugary drinks. However, there are several subtypes of diabetes: type 1, type 2, gestational, Maturity-Onset Diabetes of the Young (MODY), latent autoimmune diabetes of the adult (LADA), and that caused by medications or other diseases [3].

T1DM is usually diagnosed in children or young adults and requires lifelong insulin therapy to sustain life. Achieving and maintaining target glucose levels (typically 80–130 mg/dL before meals and <180 mg/dL two hours after eating) is a significant daily challenge for both patients and physicians. Comprehensive management of T1DM involves insulin therapy, a balanced diet, regular physical activity, and continuous glucose monitoring. Education is also crucial; as Dr. Elliott Joslin stated, "Education is not part of the treatment of diabetes, it is the treatment itself." However, in countries such as Mexico, access to specialized care remains limited, and patients often bear the financial burden of supplies, glucose meters, and insulin. Poor glycemic control increases the risk of complications, including neuropathy, retinopathy, renal failure, and cardiovascular disease.

Recent technological advances, including continuous glucose monitoring systems, insulin pumps, and mobile health (mHealth) applications, have significantly improved diabetes management. Nevertheless, many available systems are costly, incompatible with locally used devices, or not culturally adapted. Furthermore, most commercial apps focus only on carbohydrate intake [4] and [5], pre-meal glucose, and insulin dose, ignoring other relevant factors that affect glycemic variability, such as sleep, hydration, emotions, or atypical days related to illness or stress. Although numerous commercial applications exist for glucose, insulin, and food recording, several studies have shown that their long-term adoption among people with T1DM is limited by usability barriers, data capture burden, and a lack of meaningful patient feedback [6][7]. Considering these limitations, the present study proposes Techani, a technological solution tailored to the Mexican context that integrates multiple clinical, behavioral, and emotional variables. This system aims to enhance patient self-management, facilitate communication with healthcare professionals, and improve treatment adherence through an accessible, culturally adapted, and AI-enhanced platform.

1.1 Theoretical Foundation

Many factors influence a patient's glucose levels in patients with any form of diabetes. Currently, patients with type 1 diabetes, especially those treated in the healthcare sector, are required to maintain a record of at least the data shown in Table 1. This record includes the date, time, pre-meal glucose level, insulin dose, food consumed, post-meal glucose level, exercise, correction doses, and any relevant observations. This record is used to identify factors that influence the patient's glucose levels manually and to analyze the times and even the foods during which glucose fluctuates.

Source: Prepared by the authors based on online examples [1] [2] [3]

Table 1. Example of a diabetes self-monitoring log glucose table with fields that patients manually use.

Date	Basal Insulin (units)	Preprandial glucose (mg/dL)	Insulin bolus (units)	Food for breakfast (Carbohydrates)	Postprandial Glucose (2h, mg/dL)	Preprandial Glucose dinner (mg/dL)	Insulin Bolus (units)	Food dinner (Carbohydrates)	Postprandial Glucose (mg/dL)	Preprandial glucose exercise (mg/dL)	Exercise (type/duration)	Insulin bolus dinner (units)	Food dinner (Carbohydrates)	Postprandial Glucose (mg/dL)	Observations
20/04/25	10	128	10	60	196	120	8	60	214	120	1TKD	100	2	60	65 at 3:00

With these records, patients, caregivers, and the treating medical team can identify factors or patterns that allow them to adjust insulin doses. However, this is often a matter of trial and error, primarily because it is based on pre-meal glucose levels, the amount of carbohydrates ingested, and the size of food portions.

In [8], it is mentioned that, when designing an intensive regimen, a basal or background insulin dose, a bolus insulin dose to cover carbohydrates from food, and a bolus insulin dose to lower glucose levels when they are out of range should be considered. This is a correction factor to return glucose to a normal level from high levels (hyperglycemia).

Typically, traditional formulas calculate that one unit of insulin corresponds to 12–15 grams of carbohydrate, but it can range from 6–30 grams, depending on each patient's insulin sensitivity. It can also be affected by physical activity, time of day, mood, and water intake, among other factors.

On the other hand, with a correction bolus, 1 unit of insulin is required to lower blood sugar by 50 mg/dL, which ranges from 30 to 100 mg/dL, depending on each patient's insulin sensitivity and other factors.

In [8], the daily insulin requirement is calculated based on the formula shown in Equation 1.

However, the patient's body may already have developed insulin resistance, requiring higher insulin doses. Alternatively, they may be insulin-sensitive at the time of diagnosis and need less. Additionally, factors beyond the amount of food eaten may affect their insulin requirements on an atypical day.

Until now, many intensive treatments have been based on traditional formulas, including total daily dose estimates and carbohydrate-to-insulin ratios expressed as grams of carbohydrate per unit of insulin. However, many additional factors influence blood glucose in a patient with diabetes beyond chemical processes within the body and cannot be monitored without blood tests or in a hospital or laboratory setting. In 2022, Adam Brown documented up to 42 factors that influence glucose [9], many of which can be monitored daily by patients or family caregivers. This could help us better identify what increases or decreases blood glucose. The more factors that are included in the monitoring record, the more accurate the insulin bolus calculation will be, allowing the patient to stay within the normal glucose range established by their medical team for an extended period and, consequently, reduce the risk of the consequences of uncontrolled glucose.

The specific problem to be solved is accurate patient monitoring, enabling technological tools to aid treatment adherence through applications accessible to any patient, adapted to the Mexican idiosyncrasy, free, and reliable. This, derived from this rigorous control that is recommended particularly for Type 1 Diabetes, since patients permanently and continuously record pre- and post-meal glucose, food, among others, either manually or through applications, one area of opportunity in current research and existing commercial applications is that many of them focus on continuous glucose monitors, glucometers of a specific brand, or insulin pumps, which are not available to all patients, especially in low-resource countries like ours. Most of this only works with estimating carbohydrates from the foods to be consumed, pre-meal glucose, and active insulin [10][11]. However, glucose control is complex, as multiple additional factors influence each patient's glucose level. Therefore, a tool that considers many more factors is needed for proper monitoring and control. While it is true that carbohydrate intake and insulin are key factors that influence glucose levels, they are also affected by exercise, hydration, mood, hormonal factors, sleep, the quantity and combination of foods, and possible atypical days that illness, vaccinations, menstrual periods, exams, and overwork, among others, can cause. Additionally, most applications do not support carbohydrate counting or are not based on foods commonly consumed in Mexico.

1.2 Critical analysis of current relevant literature

Currently, there are mobile applications that support the glucose logbook required by patients, enabling data recording via mobile devices, smartwatches, Smartphones, or links to specific brand glucometers. Some of these applications also work in closed-loop systems, such as insulin pumps and sensors, or in Continuous Glucose Monitors (CGMs). In some countries of the European Union or the United States, there are already regulations that apply to mHealth, which according to the Global Observatory for eHealth report reviewed in 2016 by the World Health Organization, defines as "mHealth or also known as Mobile Health or mobile health, as the use of mobile devices: smartphones, patient monitoring devices, Personal Digital Assistants (PDAs) and wireless devices, for medical and public health practice [12]. "

Systematic reviews have shown that many commercial applications feature complex screens, a lack of clinical feedback, non-intuitive registration structures, and few robust behavior-change techniques, thereby reducing their usefulness in comprehensive T1DM management [13] [14].

Some of the applications applicable to the monitoring and control of Diabetes that have received a good evaluation by considering them suitable or reliable, were evaluated in a SANOFI article published in 2020 [15], in the same way Internet, Health and Society (iSYS) evaluates more than 300 mobile health applications, with the iSYScore scale [16], Table 2 summarizes some of the functionalities of the currently best-rated applications. The functionalities proposed by the Techani system can also be seen.

Source: Prepared by the authors using data from the Sanofi and iSYS Foundation evaluation [15] [17] [18] [19] [20] [21] [22] [23] [24] [25] [26].

The development of this project will help identify the different factors and their importance in a particular patient's glycemic control. It will also generate a patient-specific dataset in the application. This will enable the graphic and tabular representation of the impact on postprandial glucose levels. Integrating a dataset that includes all data from this development will allow further development to generate an automated model that calculates and adjusts the required insulin bolus and predicts glucose behavior using a real patient dataset. The patient can ensure these data are accurate, thereby minimizing

Total daily insulin requirement = 0.55 x total weight in kilograms	Equation 1: Formula for the insulin requirements of a patient by day

the risk of hypoglycemia or hyperglycemia.

By using the Mexican System of Foods and Equivalents as the source of the food catalog data, it will allow the calculation of the carbohydrate count to be performed automatically, without the need for the patient or caregiver to memorize the amount of carbohydrates that a particular food contains, also achieving that this count adheres to our idiosyncrasy, there is evidence in the literature about the efficacy of a how a correct count of carbohydrates can help in the glycemic control [5] and [11]. Additional factors are considered in the current applications, allowing the registration of a greater number of variables that influence glucose control, and being able to create "Big Personal Health Data, considered one of the bases for an effective glucose prediction [27]. This will allow data to be collected and a personal database to be built for the patient, which will allow, through the use of technology, to facilitate glycemic control in patients with Type 1 Diabetes, which could be an excellent support for the patient to be able to keep their glucose within the established values for as long as possible, to avoid the appearance of complications and side effects, such as blindness due to diabetic retinopathy, kidney failure and circulatory problems, among others. This will mean not only a social impact, but also an economic one, allowing patients to have a more economically active life and much less expensive annual treatment costs for both patients and their families, as well as for the public health service, given that a controlled patient, according to the Mexican Diabetes Federation, incurred annual costs of 88,024 Mexican pesos. In comparison, an uncontrolled patient can incur costs of up to 1,163,028 Mexican pesos [28].

2. Materials and Methods

2.1 Study design and participants

A descriptive, cross-sectional pilot study was carried out to evaluate the usability and perceived usefulness of the Techani system among healthcare professionals. The target population comprised general practitioners working for the Mexican Social Security Institute (IMSS). A total of 40 physicians were recruited by convenience sampling under an institutional collaboration agreement.

Inclusion criteria were active clinical practice with diabetic patients and willingness to participate and complete the survey. Exclusion criteria included incomplete responses or lack of access to the online instrument.

2.2 Survey instrument development and validation

A structured 20-item questionnaire was designed following a review of current literature and clinical guidelines on diabetes self-management and digital health solutions. The instrument assesses usability, perceived utility, relevance of recorded clinical variables, perceived impact on clinical decision-making, and openness to using digital systems in practice.

The instrument underwent two stages of validation:

(1) Content validation: An endocrinologist and two general practitioners reviewed the questionnaire for clinical adequacy, clarity, and alignment with diabetes self-management requirements.

(2) Pilot testing: A preliminary version was administered to eight physicians to verify timing, flow, and comprehension. Minor linguistic adjustments were performed based on feedback. Formal psychometric testing (e.g., reliability coefficient) is planned for the next development phase.

2.3 Data collection

Data was collected through an online survey distributed via institutional channels. Participants accessed the study materials voluntarily and provided informed consent before completing the questionnaire. No personal or identifiable data was captured.

2.4 Ethical considerations

The study adhered to the ethical principles outlined in the Declaration of Helsinki. Participation was voluntary and non-remunerated. Ethical approval was obtained from the relevant institutional review board at the Technological Institute of Morelia.

2.5 Data analysis

Survey responses were analyzed using descriptive statistics. Closed responses were summarized using frequencies, percentages, and measures of central tendency. Open responses underwent thematic categorization. The results, shown in the graphics in Figure 1, indicate the influence of each factor on the patient's glucose, based on the medical staff's experience as reported in the survey, A Likert scale was designed to evaluate aspects such as patient characteristics, treatment aspects, emotions, hydration, among others, where 1 means it does not influence the patient's glucose and 5 means it has a decisive influence, either positive or negative, on the patient's glucose. According to the surveyed physicians, two of the most important characteristics influencing glucose are weight and BMI.

2.6 Development process

Techani was developed using an iterative development and evaluation process inspired by agile methodologies, including the Scrum Agile Framework. Each development cycle ("sprint") lasted four weeks, for two years until now, and included:

- Requirement refinement based on medical practitioner feedback,
- User interface prototyping,
- Implementation: Web page with React frontend and Supabase/PostgreSQL backend, the Mobile App is implemented with FlutterFlow frontend and Supabase/PostgreSQL backend, security followed the OWASP Mobile Security Testing Guide, and testing was

Table 2. Summary of commercial applications for diabetes management

Application	Functionality
SocialDiabetes [17].	An app that tracks and monitors diseases in a digital diary, recording data such as diet, glucose levels, insulin levels, medications, physical activity, glycosylated hemoglobin levels, weight, blood pressure, and ketone levels. It receives recommendations, such as whether there is a risk of hypoglycemia. An intelligent system that creates graphs and connects to the cloud allows sharing diets and records with other users or family members. It manages alarms and reminders and has an insulin bolus calculator. With in-app purchases available for both Android and iOS, it is considered a Class II Medical Device. It facilitates remote connection with other patients and with treating physicians. Selected in 2024 as one of the Best in Class by the iSYS Foundation.
SERGAS Diabetes [18].	A diabetes tracking app developed by the Galician Health Service (SERGAS). It facilitates self-management for diabetics. Available on Android and iOS, it has earned a trust score for entity transparency, as it offers web support, was developed by a healthcare institution, and facilitates condition monitoring. Selected among the best iSYS apps in 2024.
One drop [19].	An app that allows to record weight, blood pressure, glucose levels, food, medications, physical activity, and glycated hemoglobin. It includes automatic carbohydrate counting, an alert system for insulin administration, and anonymous information sharing between users. It covers areas such as managing blood sugar, weight loss, healthy eating, exercise, maintaining a specific diet, lowering cholesterol, reducing blood pressure, and managing stress. Medication settings are configured, health data is imported from devices like Dexcom, and health topics are managed as support. It records the amounts of sugar, fiber, protein, sodium, fats, carbohydrates, and calories in food. It generates reports and graphs. Available on iOS and Android, it is considered a medical device.
DIABTREND: Diabetes Diary [20].	A diabetes tracking app that takes pictures of meals and uses AI to calculate their composition, among other condition-tracking features. Available on iOS and Android, it provides web support and simplifies monitoring the condition. Patients voted it the most popular app in 2024.
mySugr: App Diario de diabetes [21].	An app for patients with type 1 and type 2 diabetes. It records diet, physical activity, insulin doses, medications, and alerts. It offers both a free and premium version, syncing with the Accu-Check Instant glucometer to download blood glucose measurement reports directly to your phone. It is considered a registered medical device. It has a bolus calculator module. Available on iOS and Android platforms. It features a bolus calculator module, currently available only in Europe. It has risk class IIb approval, and the company is ISO 13485 certified. It has the CE mark for medical devices. Evaluated as Best in Class in 2024 by the iSYS Foundation.
Diabetes: M Blood Sugar diary [22] [23].	It tracks diet, medication, insulin doses, and physical activity. It allows to import data from various brands of glucometers and insulin pumps. It features a nutrition database, tracking logs, and reminders. It's compatible with smartwatches and shares data with your doctor via email. It can import values from multiple glucometers and insulin pumps. Available on iOS and Android, it has web support and is classified as a Class 1 medical device. It was named the Top Diabetes App in 2024 by the iSYS Foundation evaluation.
Freestyle LibreLink [24].	An app for exclusive use with Freestyle Libre 1 and 2 sensors. Glucose levels are scanned using either the scanner or your phone. It sends alerts when glucose levels are high or low, allowing to check them on the fly. The sensors are only valid for 14 days, and readings can be downloaded, providing graphs and trends, as well as calculated glycosylated hemoglobin levels. It is considered a medical device and is available on iOS and Android. It offers transparency and support through a website. Selected in 2024 as one of the Best in Class by the iSYS Foundation.
Contour Diabetes [25].	An app that helps detect and correct blood glucose patterns, sends notifications, and tracks these patterns over time. It displays data using a color scale and presents them in timelines, combining data on insulin, carbohydrates, physical activity, and summaries from the past week. It allows real-time information sharing. Available on iOS and Android, it is considered a medical device with CE certification. The iSYS Foundation named it among the Best in Class of 2024.
Techani	It is a web system and a mobile application that allow the monitoring and control of any Diabetes, but especially type 1, with a record of all the necessary information, such as type of insulin, dose, type of measurement, glucose levels, food data, amount of carbohydrates with support for their counting based on the SMAE, observations, record of mood in the emotion diary, exercise performed, hydration and atypical days (caused, for example, by illness, vaccines, menstrual period, exams, overwork, etc.), as well as control of the appointment schedule and management of medical records in the cloud, with reminders for the patient and alerts for registered family members, allows the download of tables and graphs for monitoring and control, and also sends positive messages that will enable increasing self-care and generate historical information of the patient in a unique dataset per patient.

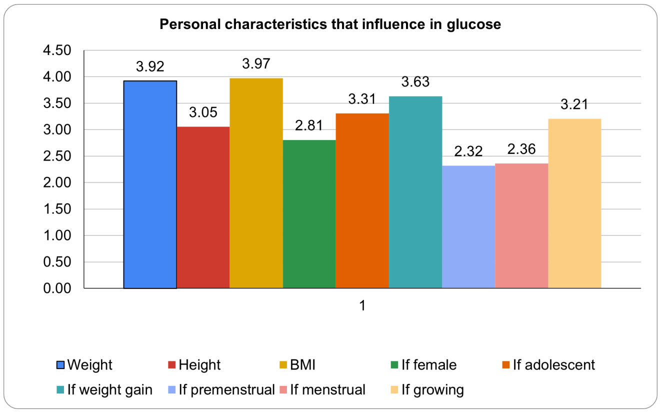


Figure 1. Example of results from surveys of medical workers at the Mexican Social Security Institute in Morelia, Michoacán; each bar represents the mean Likert score assigned by surveyed physicians to the perceived influence of each factor on glycemic variability in patients with T1DM. Source: Own elaboration

performed with Flutter Test, Jenkins, and Firebase Test Lab. In Figure 2, examples of user stories are presented using JIRA.
- Internal testing and debugging.
- User-centered evaluation with physicians.
All improvement requests were documented in the project repository and prioritized based on clinical relevance, feasibility, and impact on user experience.

2.7 System Diagrams

The use case diagram for Techani System is shown in Figure 4, which shows the options or functionalities available to each user.

2.8 System description

Techani is part of a comprehensive technological framework designed to support the management, monitoring, and control of Type 1 Diabetes Mellitus. The system consists of two interconnected subsystems. The first, described in this paper, is a web and mobile platform that enables patients to record, monitor, and visualize their clinical and behavioral data. The second subsystem, currently under development, applies Artificial Intelligence to identify glycemic patterns and optimize insulin bolus calculation.

Techani is a web page and a mobile health system designed to support diabetes monitoring by enabling structured recording, visualization, and interpretation of multiple clinically relevant variables. The application was developed using React for the web page, FlutterFlow for the mobile app, and Supabase/PostgreSQL as the backend platform, ensuring interoperability and scalability.

The system is organized into several functional modules, including:

(1) **Patient registration and clinical profiling**. Basic demographic and medical information is captured on first use.

(2) **Self-monitoring of diabetes management.** Users can register variables such as:

- Pre-prandial and post-prandial glucose.
- Insulin bolus and basal doses.
- Meal carbohydrate content (estimated using SMAE)
- Physical activity.
- Hydration.
- Mood.
- Sleep diary, with hours, quality, and recommendations for better sleep.
- Atypical days: like exams, menstrual period, vaccine applications, stress, diseases, among others.
- Observations.

(3) **Data visualization and feedback.** The system generates graphs and structured logs to facilitate clinical interpretation and support patient–physician communication.

(4) **Medical review dashboard.** A companion medical interface allows summarizing the patient's history and supports professional evaluation and adjustment of therapeutic plans.

(5) **Utilities.** Alarms and reminders for the patient, medical appointments, glucose records, motivational messages and recommendations, as well as messages for registered family members when glucose measurements are out of range.

(6) **Files and reports.** The system can generate PDF files containing the patient's historical records in tables and graphical reports.

2.9 Implementation

The Techani system enables comprehensive recording and monitoring of clinical, behavioral, and emotional variables. Unlike most current applications, Techani integrates additional factors influencing glycemic variability, providing a holistic view for personalized management. Its automatic carbohydrate calculation based on the SMAE ensures cultural and nutritional relevance. Motivational tools and family alerts strengthen patient adherence and engagement. A comparative analysis (Table 3) revealed that Techani covers over 40% more variables than leading apps, such as Social Diabetes or mySugr. Its accessibility and open architecture make it suitable for a wide range of clinical contexts. Clinically, the system supports individualized datasets that can serve as input for predictive insulin models. Preliminary feedback highlighted its usability and potential clinical value; however, validation studies are still required. Strengths include adaptability, cultural contextualization, and low implementation cost; limitations involve manual data entry and limited initial sampling. Future development will integrate CGM data and AI-based bolus prediction through the complementary GIO subsystem, which will be presented in other work. Figures 5-14 show the Techani system's functionalities.

The mobile app also includes a pedometer. In the My Records option, patients can filter by date and download a table of records for the selected period as a PDF. The patient

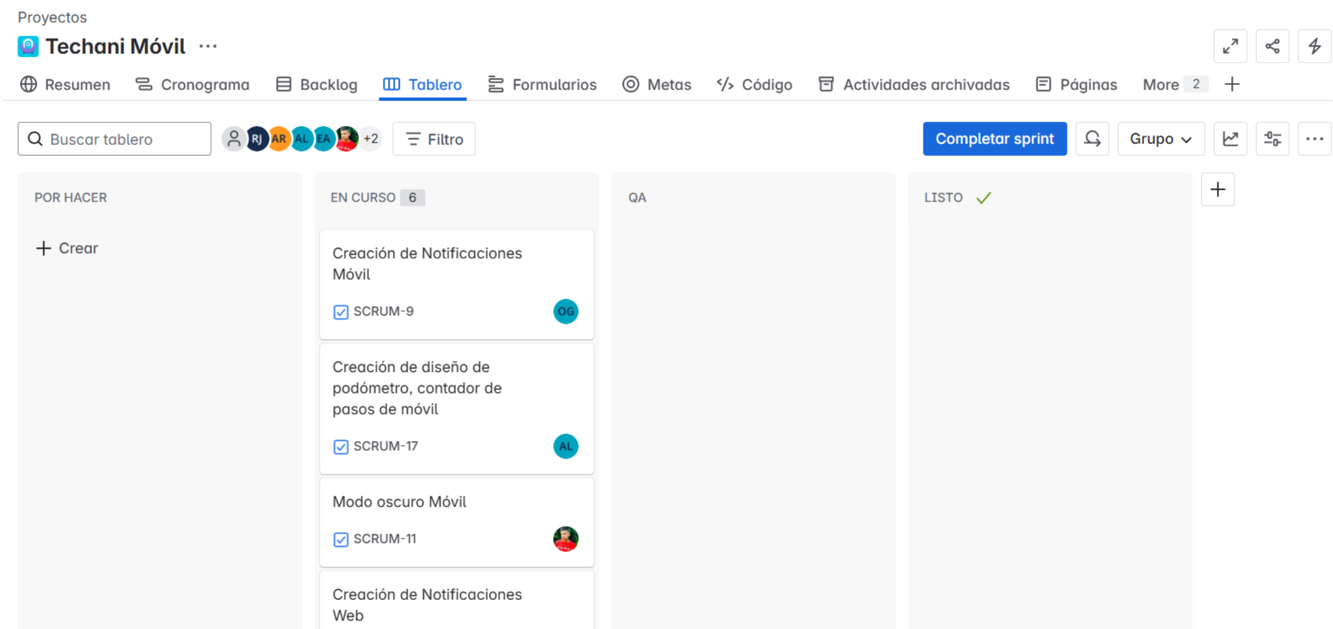
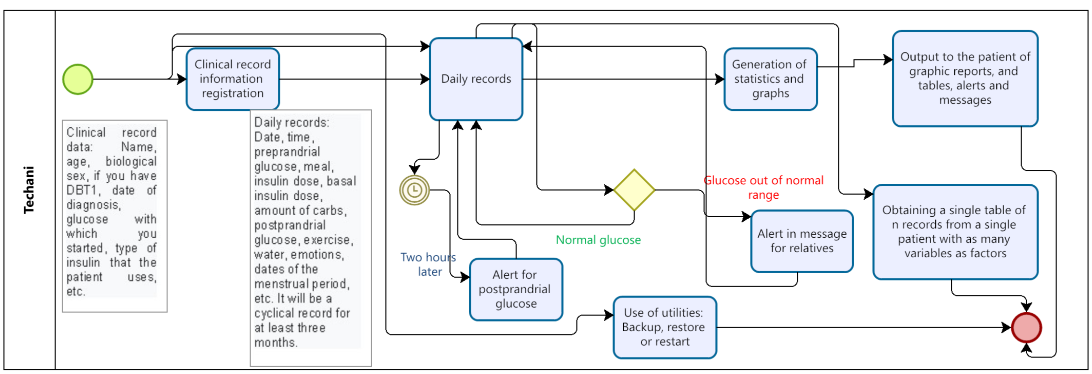
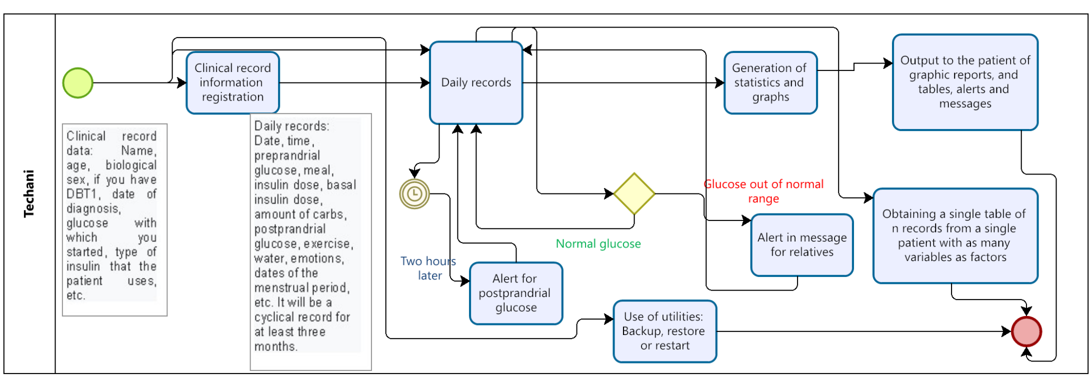


Figure 2. Examples of user stories using the JIRA tool for Sprint Control



(a)



(b)

Figure 3. Techani Type 1 Diabetes Management, Monitoring, and Control System Process. Source: Own elaboration

can then send the table to the treating physician or print it, as shown in Figure 6.

In the food record, as shown in Figures 7 and 8, foods and the number of servings can be selected from a catalogue of previously captured foods based on the SMAE, making it easier for the patient or caregivers to count carbohydrates automati-

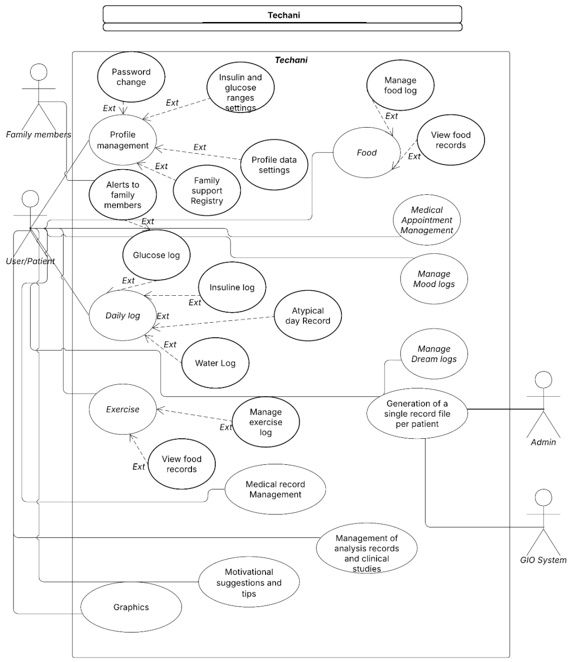


Figure 4. Use case diagram. Source: Own elaboration

cally. Many applications do not have this particularity; patients must manually count and record their carbohydrates, which can improve the precision of carbohydrate calculation compared to having users do it themselves, as has been demonstrated in other systems [29].

As shown in Figure 9, the patient's exercises are recorded and tracked and can be filtered by date. The records also appear in the downloaded report.

The patient's mood is an essential factor often overlooked in current applications and significantly influences glucose levels. This variable was deemed necessary to better monitor and manage the condition and to keep the patient within range for as long as possible. Figure 10 shows how this record is made, which was designed to be patient-friendly:

Additionally, patients can upload documents from their studies and clinical analyses, as shown in Figure 11, ensuring they always have a digital record on hand.

Another valuable tool for patients and their medical teams is the generation of graphs, such as time-in-range, glucose, glucose vs. carbohydrates, cholesterol, and triglycerides, as shown in Figure 12.

An essential element in glucose control is undoubtedly the quantity and quality of sleep, which is why a record of this is also made, as can be seen in Figure 13. Here, the Techani system shows suggestions that have been reviewed with an endocrinologist. In other parts of the system, motivational messages are also sent to the patient to help them improve treatment adherence and not be discouraged if, at any time, they have inadequate records.

3. Results and Discussion

4. Results

The results obtained from the SUS evaluation and the comparative analysis are presented below. Subsequently, these findings are discussed in relation to existing mHealth tools.

4.1 System Usability Scale

A usability evaluation of the Techani website yielded 68 responses. Additionally, a System Usability Scale (SUS) questionnaire was administered, with the following questions evaluated using a Likert scale. The results are shown in Table 3, with the average final score per question. The questionnaire was administered to 68 people: 1 patient, 4 graduate students, 1 professor, 1 engineer, and 61 undergraduate students in Computer Systems Engineering enrolled in Software Engineering and a specialty program. Feedback was also provided by an endocrinologist who guided us through the design process and requirements aspects, and by four patients and a psychologist who is also a patient. Most SUS respondents had a software development background, which may introduce usability bias and limit generalizability to real-world T1DM patients. However, early-stage usability testing with technically trained users is a common practice in iterative system design to identify interface and interaction issues before clinical validation. The final usability evaluation is planned to take place during the next stage of clinical trials with real volunteer patients.

In general, the actual results indicates that the review of the site is good, given that they do not consider it to be challenging to use, or that it is complex or inconsistent, nor do they consider that they need specific knowledge or technical assistance to be able to use it and although it was the first time they used the application, they were able to do so without problems or additional questions about its use, so can be considered that it is intuitive and that although the evaluation in some questions was neutral, they were able to use Techani System and made the solicitated registers quickly and without additional complications. The observations and suggestions primarily relate to form rather than substance, but they will help us improve the user experience and identify priorities for future clinical evaluation.

Participants were asked to perform the following actions:

- Glucose log reported with a completion time of 27 seconds. Insulin log with a completion time of 63 seconds. Water Consumption with a recording time of 20 seconds. Record of an atypical day with a time of 73 seconds. The food log was reported with a time of 55 seconds per food. The registration of new foods into the system was reported in 29 seconds. The registration of exercise takes 27 seconds. Registering a new medical appointment took an average of 14 seconds. Mood checks were reported as taking 11 seconds. Uploading PDF files of clinical analysis reports took 24 seconds, even after the PDFs were available. The recording of hours and sleep quality was reported to have taken 13 seconds.
- View graphs of entered data, which was reported in 20

Figure 5. Records screen

Figure 6. Downloading log report

seconds.

- Reviewing file data takes 16 seconds.
- View existing reports in the menu takes 22 seconds.
- Log out was completed in an average of 8 seconds.

These actions led to suggestions and feedback to improve the system's design and user experience. Some relevant suggestions were:

(1) I recommend checking the box for the food already added when selecting, so you can also delete it.

(2) Adjust the modal to select the food responsively at the top.

(3) Make the buttons slightly larger and include warnings in case they can't be used and make it more practical when entering dates and times. Similarly, fields that could be filled with pre-defined data would be more intuitive and easier to implement.

(4) Include a timeline that could be Glucose Log -> Food Log -> Exercise Log -> Emotions Log.

The questionnaire that was applied for the usability evalua-

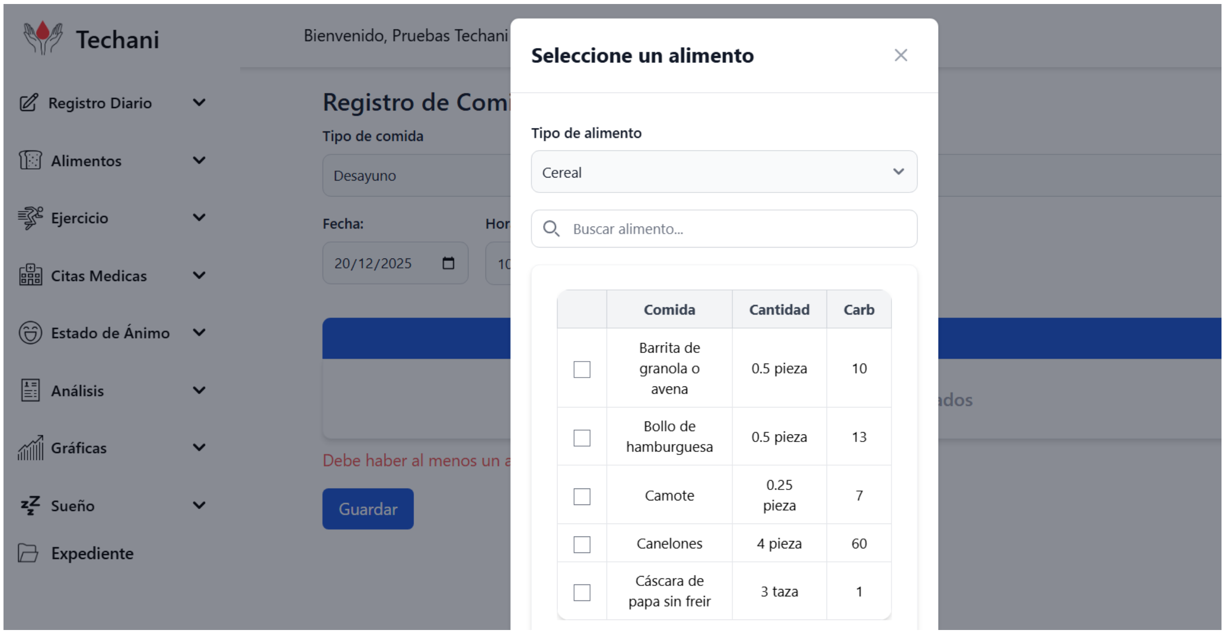


Figure 7. Food capture

Figure 8. Carbohydrate calculation

tion of the system

Source: Own elaboration with the results of the SUS evaluation.

4.2 Comparative analysis with existing M-Health tools

There are usability studies in the literature on mobile apps for diabetes, as well as evaluations of existing mobile apps [30][31], and others on patients' needs, such as photo recognition, insulin calculation, and personalized bolus calculation [32]. Table 4 shows the comparison of the functionalities of Techani with other apps, to see the contribution of this project:

Source: Own elaboration based on the descriptions and functionalities of the applications published on Google Play app stores, the vendor pages, articles from journals, and the applications pages themselves, accessed April-Nov 2025.

5. Analysis and Discussion

This study presents the development and preliminary evaluation of Techani, a web page and a mobile solution designed to expand the scope of diabetes self-monitoring, particularly in low-resource settings. Compared with commercial systems, Techani incorporates a broader set of clinical, behavioral, nutritional, and lifestyle variables, including culturally adapted carbohydrate estimation using SMAE. This offers an advantage in contexts such as Mexico, where diet patterns differ substantially from those used by Western food databases.

Compared with widely used applications such as SocialDiabetes, mySugr, or LibreLink, Techani emphasizes the integration of data relevant to clinical decision-making (e.g., insulin bolus and basal dosages, meal composition, mood, hydration, and sleep). While commercial systems frequently rely on CGM integration or automated data ingestion, many lack support for multi-domain tracking or culturally localized nutritional databases, both of which are necessary for individualized

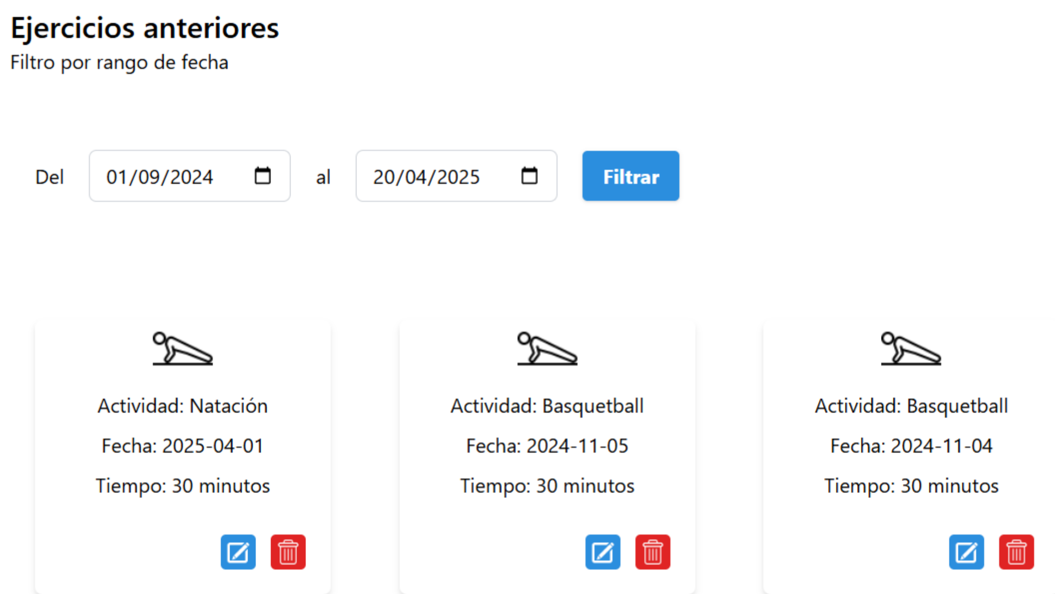


Figure 9. Exercise log history

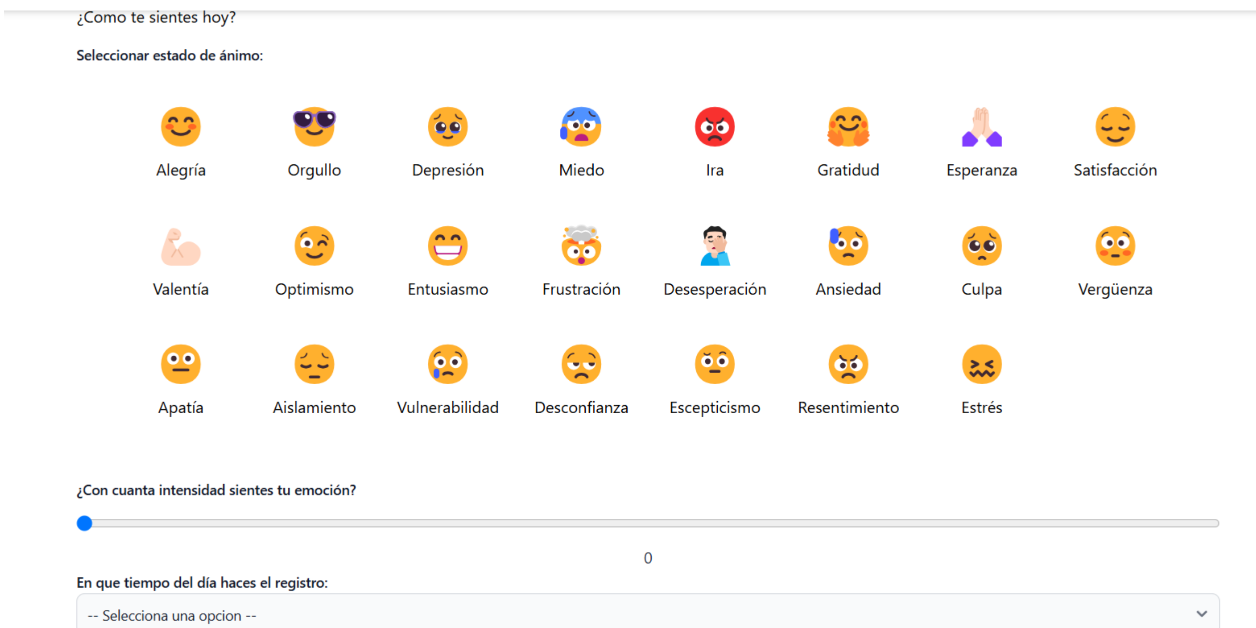


Figure 10. Mood log

carbohydrate estimation across populations.

However, Techani currently relies primarily on manual data entry, which increases user burden and may limit long-term adoption. Likewise, the system has not yet undergone clinical validation in patients to measure its effect on glycemic outcomes such as HbA1c or time-in-range. These aspects represent the necessary next steps in the system's roadmap.

Results from the SUS evaluation suggest that the system is perceived as clinically relevant and easy to interpret, supporting its further development and evaluation. Nevertheless, pilot sampling was limited to convenience sampling, and future studies should incorporate a broader range of professional profiles and direct testing with T1DM patients in real-world care settings.

In summary, Techani advances the field by offering a low-cost, locally adaptable digital solution that integrates multiple domains of diabetes management, but further development is required to automate data acquisition, evaluate real-world effectiveness, and align with regulatory and interoperability standards for medical software.

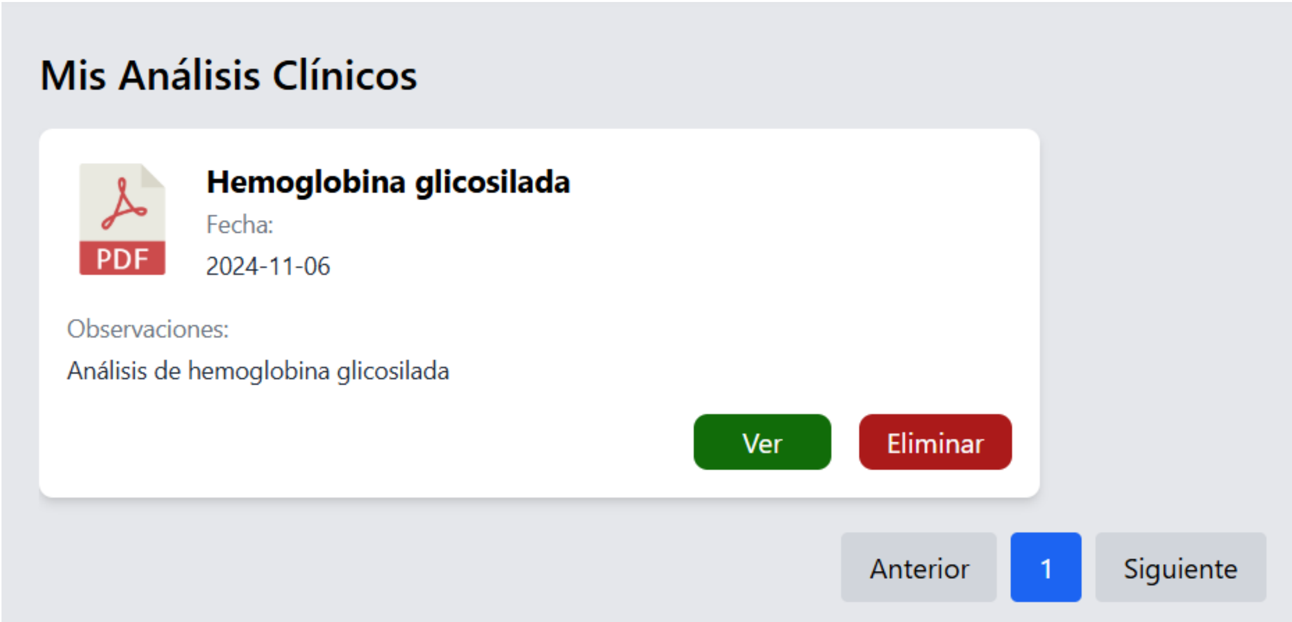
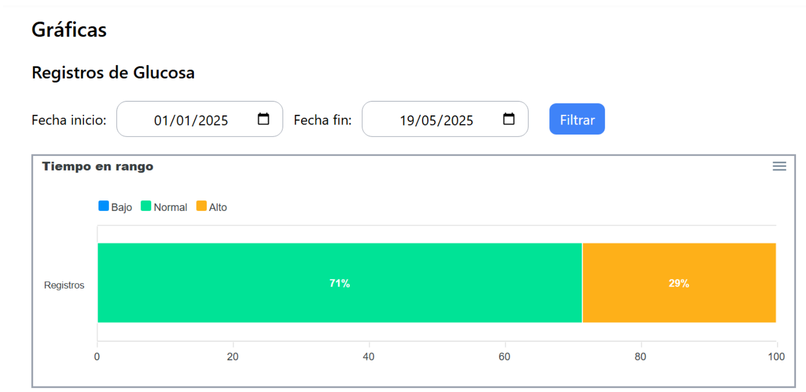
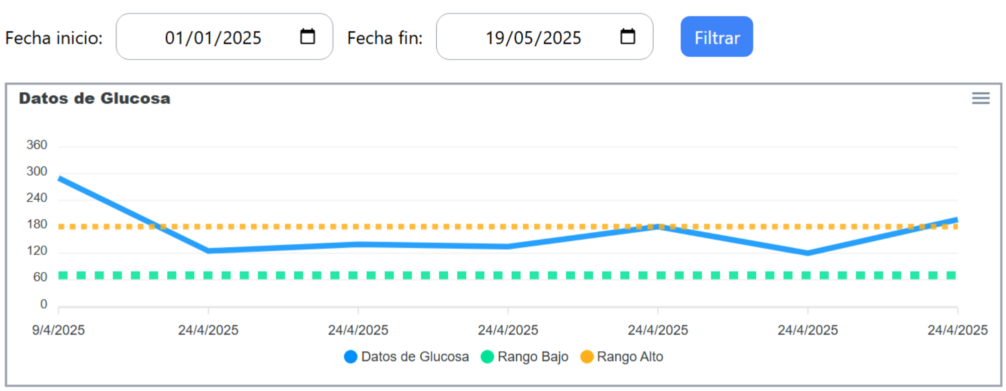


Figure 11. My clinical analysis



(a)



(b)

Figure 12. Graphs

6. Conclusions

This study presented Techani, a system that integrates clinical, behavioral, and emotional variables for managing Type 1 Diabetes. The system is functional, intuitive, and culturally adapted, facilitating personalized data tracking for patients and healthcare professionals.

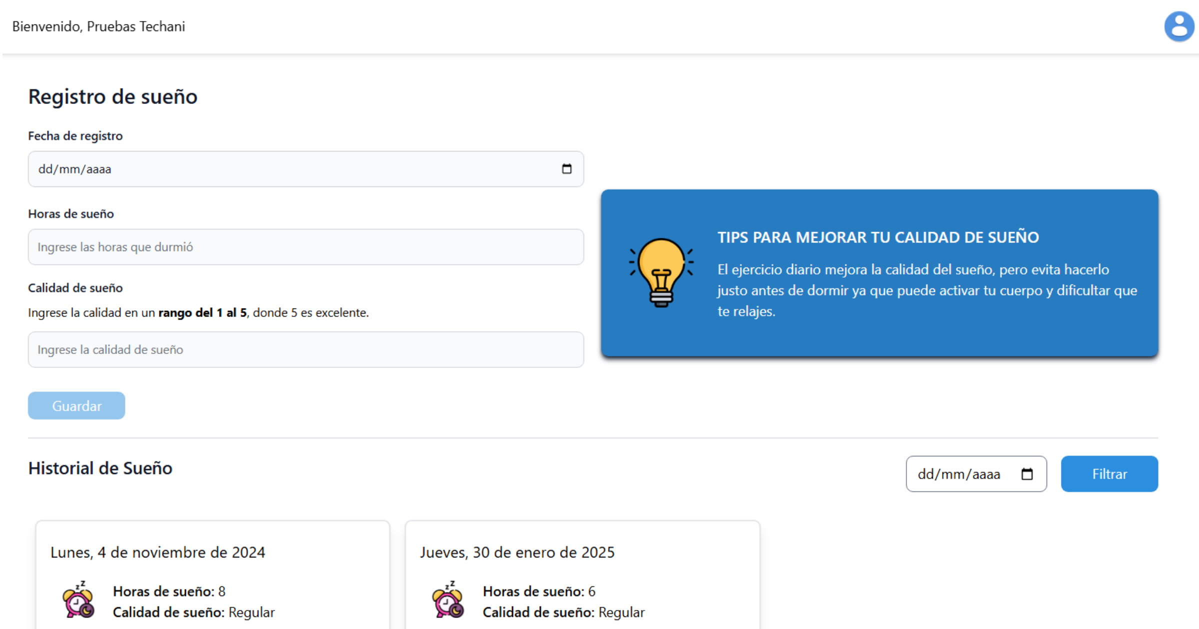


Figure 13. Sleep log.

Table 3. Results of the System Usability Scale questionnaire survey

Questions	Average
1. I think I would want to use this website frequently if I had the condition it tracks (Type 1 Diabetes Mellitus).	3.7 Neutral with a tendency to agree
2. I found the site unnecessarily complex.	2.5 Disagree
3. I think the site is easy to use.	3.5 Neutral
4. I think I would need technical support to be able to use the site.	2.8 Disagree with a tendency toward neutral
5. I found the features to be well integrated.	3.6 Neutral with a tendency to agree
6. I felt there was too much inconsistency on the site.	2.1 Disagree
7. I imagine most people would learn to use the site quickly.	3.6 Neutral with a tendency to agree
8. I found the site very complicated to use.	2.3 Disagree
9. I felt confident using the site.	3.4 Neutral
10. I would need to learn many things before I could use the site.	2.6 Disagree

Techani's main contribution is the combination of technological innovation, cultural adaptation, and clinical relevance. It extends the range of monitored variables, automates carbohydrate counting through SMAE, and enables OCR-based glucose entry. As a scalable biomedical engineering framework, it supports data-driven, AI-based insulin optimization, promoting treatment adherence and patient empowerment.

Current limitations include reliance on manual data entry and a limited initial sample. Future research will expand clinical validation and integrate CGM and wearable data. A second-phase usability and clinical pilot is planned with N=12 T1DM patients, focusing on time-in-range and HbA1c (Glycosylated hemoglobin) pre and post 3 months, and user-centered metrics (SUS, task completion time, error rates), and the third phase implementing the Glucose Insulin Optimized (GIO) subsystem for predictive insulin modeling and glycemic trend analysis with the application of AI models. Another limitation at this moment is that most SUS respondents had a software development background, which may introduce usability bias and limit generalizability to real-world T1DM patients. This is planned to be resolved in the next phase of clinical evaluation with real patients.

Finally, Techani represents an innovative, culturally adapted, and clinically relevant solution for diabetes management in Mexico. By bridging patient self-management with clinical supervision, it advances digital health integration and improves adherence, reduces complications, and enhances quality of life for individuals with Type 1 Diabetes.

Next steps include clinical testing in patients with T1DM, integration with CGM data streams, and assessment of clinical outcomes, such as time-in-range and HbA1c.

Table 4. Table of Diabetes Management Apps' main functionalities.

App	Carbohydrate calculation	Food catalogue based on the SMAE	Works with different glucometers and CMGs	Mood	Glucose	Food	Insuline	Exercise	Hydration	Sleep	Atypical day	Medical record	Graphs	ppointment schedule	Patient Alerts	Family alerts	Pedometer	Motivational messages or tips	Bolus calculation help
Social Diabetes. [17]	Y	N	Y	Y	Y	Y	Y	Y	N	N	N	N	Y	Y	Y	N	N	N	Y
SERGAS Diabetes [18]	N	N	Y	N	Y	Y	Y	Y	N	N	N	Y	Y	Y	Y	N	Y	N	Y
DIABTREND: Diario de Diabetes [20]	Y	N	Y	N	Y	Y	Y	Y	N	Y	Some	N	Y	Y	Y	N	N	Y	Y
mySugr: App Diario de diabetes [21] and [33]	N	N	Some	N	Y	Y	Y	N	N	N	N	N	Y	N	N	N	N	Y	Y
Diabetes: M Blood Sugar diary [22] and [23]	Y	N	Y	N	Y	Y	Y	Y	N	N	N	N	Y	Y	Y	N	N	N	Y
Freestyle LibreLink [34]	N	N	N	N	Y	Y	Y	N	N	N	N	N	Y	N	Y	Y	N	N	N
Contour Diabetes [25] and [35]	N	N	N	N	Y	Y	Y	Y	N	N	Some	N	N	Y	Y	Y	N	N	N
Techani	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	GIO

Note: Y = Yes, the app proportionates the functionality, N = No, the app doesn't proportionate the functionality, Some = Partial feature is proportionate to the final user, see references.

7. Funding

The authors thank Institution Tecnológico Nacional de México, as this project has been funded, with support provided through project Number 21636.25-P, and the students José Alfonso Gallardo Magaña, Andrés Arroyo Cervantes, Fernando Joel Uribe Martínez, Fidel Villegas Hernández, Andrea Jeanette Camacho Alvarez, Omar García Lara, Oscar Kuricaveri Zamudio Damián, Martínez Ambriz Eladio, Andrea López Flores and Santiago González Lara that participates in this project.

8. Acknowledgements

The authors thank to the Ministry of Public Education, through the National Technological Institute of Mexico, for the authorization of the project's financing and for the Scholarship-Commission License for Postgraduate Studies. The authors also thank the medical staff of the Mexican Social Security Institute (IMSS) in Michoacán for answering the survey, as well as the endocrinologist Dr. Israel Fernando Ruíz Tablada for his advice and support in reviewing the developed system. To date, this study has not involved human or animal participants. Therefore, informed consent was not required. The research protocol was duly registered with the Institute's ethics committee. However, for future acceptance testing with volunteer patients, the informed consent form has already been designed and approved by the relevant ethics committee. This does not imply any modification to their medical treatment or any risk to their health.

9. Author Contributions (CRediT)

Conceptualization, R.C.J. and J.C.O.-R.; methodology, R.C.J. and A.C.T.A.; software, R.C.J., J.A.G.M., O.K.Z.D., O.G.L. and E.M.A; validation, R.C.J., J.A.G.G. and J.C.O.R.; formal analysis, R.C.J., J.A.G.M., O.G.L. and E.R.A.; investigation, R.C.J. and J.C.O.R.; resources, R.C.J. and E.R.A.; data curation, R.C.J. and J.C.O.R.; writing—original draft preparation, R.C.J. and J.C.O.R.; writing—review and editing, A.C.T.A., J.A.G.G., E.R.A.; visualization, R.C.J. and J.A.G.M.; supervision, J.C.O.R., A.C.T.A., J.A.G.G. and E.R.A.; project administration, J.C.O.R. and A.C.T.A.; funding acquisition, J.C.O.R. AND R.C.J.; All authors have read and agreed to the published version of the manuscript.

10. Conflict of Interest

Likewise, the authors declare that there is no conflict of interest in this research.

11. Data Availability Statement

The data are available from the corresponding author upon reasonable request.

12. Artificial Intelligence Use Disclosure

The authors declare that no generative AI tools were used in the preparation of this manuscript.

13. References

[1] Clinica Endi, "Recursos impresos," [Online]. Available: https://clinicaendi.mx/recursos-impresos/ [Accessed 23 04 2025].

[2] The Institute for family health, "Registro de azúcar en la sangre," [Online]. Available: https://institute.org/wp-content/uploads/Blood-Glucose-Log_SPA.pdf [Accessed 20 04 2025].

[3] NORMA Oficial Mexicana NOM-015-SSA2-2010, Para la prevención, tratamiento y control de la diabetes mellitus," [Online]. Available: https://www.dof.gob.mx/normasOficiales/4215/salud/salud.htm [Accessed 20 04 2025].

[4] Alfonsi JE, Choi EEY, Arshad T, Sammott SAS, Pais V, Nguyen C, Maguire BR, Stinson JN, Palmert MR Carbohydrate Counting App Using Image Recognition for Youth With Type 1 Diabetes: Pilot Randomized Control Trial JMIR Mhealth Uhealth 2020;8(10):e22074, doi: 10.2196/22074PMID: 33112249PMCID: 7657721 [Accessed 20 04 2025].

[5] A. Brazeau, H. Mircescu, K. Desjardins, C. Leroux, I. Strychar, J. Ekoé and R. Rabasa-Lhoret, "Carbohydrate counting accuracy and blood glucose variability in adults with type 1 diabetes," Diabetes Research and Clinical Practice, vol. 99, no. 1, pp. 19-23, 2013. Available https://www.diabetesresearchclinicalpractice.com/article/S0168-8227(12)00391-9/abstract https://doi.org/10.1016/j.diabres.2012.10.024 [Accessed 20 04 2025].

[6] Wyche, S., Olson, J., Karanu, M., Omondi, E., & Olonyo, M. (2024). Limitations of Using Mobile Phones for Managing Type 1 Diabetes (T1D) Among Youth in Low and Middle-Income Countries: Implications for mHealth. Proceedings of the ACM on human-computer interaction, 8(CSCW2), 506. https://doi.org/10.1145/3687045 [Accessed 20 04 2025].

[7] Fu HN, Adam TJ, Konstan JA, Wolfson JA, Clancy TR, Wyman JF Influence of Patient Characteristics and Psychological Needs on Diabetes Mobile App Usability in Adults With Type 1 or Type 2 Diabetes: Crossover Randomized Trial JMIR Diabetes 2019;4(2):e11462 doi: 10.2196/11462 PMID: 31038468 PMCID: 6660121 [Accessed 20 04 2025]

[8] Diabetes Teaching Center at the University of California, San Francisco, "Diabetes Education Online," 2023. [Online]. Available: https://diabetesteachingcenter.ucsf.edu/insulin-basics-type-1-diabetes [Accessed 20 04 2025].

[9] A. Brown, "42 Factors That Affect Blood Glucose?! A Surprising Update," diatribe.org, 22 09 2022. [Online]. Available: https://diatribe.org/diabetes-management/42-factors-affect-blood-glucose-surprising-update [Accessed 20 04 2025].

[10] Sakane, N., Domichi, M. & Suganuma, A. Efficacy of carbohydrate counting in people with type 1 and type 2 diabetes mellitus: a systematic review and meta-analysis. Diabetol Int 16, 546–558 (2025). https://doi.org/10.1007/s13340-025-00810-4 [Accessed 20 04 2025].

[11] Fu, S., Li, L., Deng, S. et al. Effectiveness of advanced carbohydrate counting in type 1 diabetes mellitus: a systematic review and meta-analysis. Sci Rep 6, 37067 (2016). https://doi.org/10.1038/srep37067 [Accessed 20 04 2025]

[12] Organización Mundial de la Salud WHO, "Report of the third global survey on eHealth," 2016. [Online]. Available: https://apps.who.int/iris/bitstream/handle/10665/252529/9789241511780-eng.pdf?sequence=1#page=31 [Accessed 20 04 2025].

[13] Van Rhoon L, Byrne M, Morrissey E, Murphy J, McSharry J. A systematic review of the behaviour change techniques and digital features in technology-driven type 2 diabetes prevention interventions. DIGITAL HEALTH. 2020;6. doi: 10.1177/2055207620914427 [Accessed 20 04 2025].

[14] F. Ahmed and W. Yunglong, "Health Behaviour Change Techniques in Diabetes Management Applications: A Systematic Review," 19 04 2019. [Online]. Available: arXiv: 1904.09884v1 [Accessed 12 11 2025].

[15] SANOFI, "¿Cuáles son las mejores apps para controlar la diabetes?," 31 08 2020. [Online]. Available: https://pro.campus.sanofi/es/otras-tematicas-diabetes/articulos/apps-control-diabetes [Accessed 20 04 2025].

[16] I. Grau, B. Kostov, J.A. Gallego, F. Grajales III, L. Fernández-Luque, A. Sisó-Almirall, Método de valoración de aplicaciones móviles de salud en español: el índice iSYScore, SEMERGEN - Medicina de Familia, Volume 42, Issue 8, 2016, Pages 575-583, ISSN 1138-3593, https://doi.org/10.1016/j.semerg.2015.12.001 https://www.sciencedirect.com/science/article/pii/S1138359315004281 [Accessed 12 11 2025]

[17] Google play, "Social Diabetes," Google Play, [Online]. Available: https://play.google.com/store/apps/details?id=com.socialdiabetes.android&hl=es&pli=1 [Accessed 27 04 2025].

[18] Google play, "Sergas Diabetes," Google play, [Online]. Available: https://play.google.com/store/search?q=sergas+movil+app&c=apps&hl=es [Accessed 27 04 2025].

[19] Osborn CY, Hirsch A, Sears LE, Heyman M, Raymond J, Huddleston B, Dachis J One Drop App With an Activity Tracker for Adults With Type 1 Diabetes: Randomized Controlled Trial JMIR Mhealth Uhealth 2020;8(9):e16745 doi: 10.2196/16745 PMID: 32540842 PMCID: 7530691 . [Accessed 12 11 2025]

[20] Google play, "Diabtrend," Google play, [Online]. Available: https://play.google.com/store/apps/details?id=com.diabtrend&hl=es_MX [Accessed 27 04 2025].

[21] MySUGR, "MySUGR," MySUGR.com, [Online]. Available: https://www.mysugr.com/en [Accessed 27 04 2025].

[22] Google play, "Diabetes-M Blood Sugar Diary," Google play, [Online]. Available: https://play.google.com/store/apps/details?id=com.mydiabetes&hl=es [Accessed 27

04 2025].

[23] diabetes-m.com, "Diabetes:M," diabetes-m.com, [Online]. Available: https://diabetes-m.com/ [Accessed 27 04 2025].

[24] Freestyle Librelink MX, "Freestyle Librelink MX," Freestyle libre, [Online]. Available: https://play.google.com/store/apps/details?id=com.freestylelibre.app.mx&hl=es_MX [Accessed 27 04 2025].

[25] ascencia.com, "Aplicación Contour: Diabetes," [Online]. Available: https://www.ascensia.com.mx/products/contour-diabetes-app/#:~{}:text=El%20emparejamiento%20de%20un%20gluc%C3%B3metro,poner%20en%20contexto%20tus%20resultados [Accessed 27 04 2025].

[26] Fundación iSYS, "Catálogo de aplicaciones de la salud | iSYScore," Fundación iSYS.org, 2024. [Online]. Available: https://www.fundacionisys.org/es/apps-de-salud/todas-las-apps?gad_source=1&gbraid=0AAAAADNkwj8sqHPlnd1DxREqmVr-yvKMe&gclid=CjwKCAjwwqfABhBcEiwAZJjC3gqrBkt6x1SreYMrVUWUj5gPX0JCLQDnVCRlw-5iPJ69thBzPZkslRoCuSwQAvD_BwE [Accessed 20 04 2025].

[27] P. E. Romero, "Nuevas Apps predictoras de glucosa," Diabetes, pp. 30-33, 2021. Available: https://www.revistadiabetes.org/wp-content/uploads/Art.-3.-Rev_69_Tecnologi%CC%81a_Apps-predictoras-de-glucosa-Dra.-Enes-OK.pdf [Accessed 12 11 2025]

[28] Federación Mexicana de Diabetes, "Los costos de la diabetes," 09 01 2019. [Online]. Available: https://fmdiabetes.org/los-costos-la-diabetes/ [Accessed 20 04 2025].

[29] Rhyner D, Loher H, Dehais J, Anthimopoulos M, Shevchik S, Botwey RH, Duke D, Stettler C, Diem P, Mougiakakou S Carbohydrate Estimation by a Mobile Phone-Based System Versus Self-Estimations of Individuals With Type 1 Diabetes Mellitus: A Comparative Study " Journal of medical Internet research, vol. 18, no. 5, 2016 doi: 10.2196/jmir.5567 PMID: 27170498 PMCID: 4880742 [Accessed 20 04 2025]

[30] F. J. Represas-Carrera, Á. A. Martínez-Ques, A. Clavería, Effectiveness of mobile applications in diabetic patients' healthy lifestyles: A review of systematic reviews, Primary Care Diabetes, Volume 15, Issue 5, 2021, Pages 751-760, ISSN 1751-9918, https://doi.org/10.1016/j.pcd.2021.07.004 https://www.sciencedirect.com/science/article/pii/S1751991821001212 [Accessed 12 11 2025]

[31] Islam SMS, Mishra V, Siddiqui MU, Moses JC, Adibi S, Nguyen L, Wickramasinghe N Smartphone Apps for Diabetes Medication Adherence: Systematic Review JMIR Diabetes 2022, Vol 7, No 2, Doi: 10.2196/33264 PMID: 35727613 PMCID: 9257622 [Accessed 12 11 2025]

[32] Housni A, Katz A, Bergeron LJ, Simard A, Finkel A, Roy-Fleming A, Nakhla M, Brazeau AS Bridging the Gap in Carbohydrate Counting With a Mobile App: Needs Assessment Survey J Med Internet Res 2025, Vol. 27 Doi: 10.2196/63278 PMID: 40153793 PMCID: 11992487 [Accessed 12 11 2025]

[33] Cuixart, G., Corcoy, R. & González, C. Can a mobile application improve glucose-related and patient-reported outcome measures (PROMs) in people with type 1 diabetes mellitus? A randomized controlled trial using the mySugr® app. Hormones Vol. 24, pp 137–147, 2025. https://doi.org/10.1007/s42000-024-00609-z [Accessed 12 11 2025]

[34] A. Nguyen, J. R. White, FreeStyle Libre 3, Clinical Diabetes 2 January 2023, Vol. 41 (1) p.p. 127 - 128 https://doi.org/10.2337/cd22-0102 [Accessed 12 11 2025]

[35] D. Fernández-García, E. Aguilera, A. Martín, J. Alfonso, B. González, B. Jauregui et al, "Contour Next One Used with the Smartphone Application Contour Diabetes App Improved Self-Management and Adherence without Reducing Quality of Life in Patients with Diabetes," Diabetes, vol. 69, no. Issue Suplement, 2020. https://doi.org/10.2337/db20-71-LB [Accessed 12 11 2025]