PROTOTYPE FOR THE DATA MANAGEMENT OF CHEMICAL CLASSIFICATION OF FOODS AND DIETARY GUIDANCE GUIDE FOR TYPE 2 DIABETICS

Larissa de Sousa Miranda[1], Débora Gonçalves de Oliveira[2], Gabriel Vieira Lima[3], Vinicius Schineider Januário Viana[4], Pedro Fernandes Bahury[5], Simone Azevedo Bandeira de Melo Aquino[6], Daniel Duarte Costa[7], Sheila Elke Araújo Nunes[8] and Elizabeth Nunes Fernandes[9].

[1] Undergraduate student of the Medicine Course
at the State University of the Tocantina Region of Maranhão – UEMASUL
E-mail: larissamiranda.20200009980@uemasul.edu.br
ORCID: https://orcid.org/0009-0005-0027-1884
Lattes: http://lattes.cnpq.br/4906088706566412
[2] Undergraduate student of the Medicine Course
at the State University of the Tocantina Region of Maranhão – UEMASUL
E-mail: deboraoliveira.20200005229@uemasul.edu.br
ORCID: https://orcid.org/0009-0008-8301-6951
Lattes: http://lattes.cnpq.br/0400511399079509
[3] Graduating from the Computer Science Course
at the Federal Institute of Education, Science and Technology of Maranhão – IFMA
E-mail: gabrielvieira@acad.ifma.edu.br
ORCID: https://orcid.org/0009-0000-1637-7070
Lattes: http://lattes.cnpq.br/1443425994725803
[4] Graduating from the Computer Science Course
at the Federal Institute of Education, Science and Technology of Maranhão – IFMA
E-mail: viniciusschineider@acad.ifma.edu.br
ORCID: https://orcid.org/0009-0000-1637-7070
Lattes: http://lattes.cnpq.br/7622953449815962
[5] Graduating from the Computer Science Course
at the Federal Institute of Education, Science and Technology of Maranhão – IFMA
E-mail: pedro.f@acad.ifma.edu.br
ORCID: https://orcid.org/0009-0004-7010-4857
Lattes: http://lattes.cnpq.br/6458837107453041
[6] Master in Electrical Engineering Computer Science Federal
Institute of Education, Science and Technology of Maranhão – IFMA
E-mail: simonebandeira@ifma.edu.br
ORCID: https://orcid.org/0009-0001-9454-9410
Lattes: http://lattes.cnpq.br/9830160298104531
[7] Dr. in Biotechnology
Federal University of Maranhão – UFMA
Email: daniel.dc@ufma.br
ORCID: https://orcid.org/0009-0000-0714-7062
Lattes: http://lattes.cnpq.br/5830574741456955
[8] Dr. in Tropical Medicine and Public Health
State University of the Tocantina Region of Maranhão – UEMASUL
Email: sheilanunes@uemasul.edu.br
ORCID: https://orcid.org/0000-0002-2309-7314
Lattes: http://lattes.cnpq.br/2570242039075491
[9] Dr. in Analytical Chemistry
State University of the Tocantina Region of Maranhão – UEMASUL
E-mail: bethfernandes@uemasul.edu.br
ORCID: https://orcid.org/0000-0001-8279-0509
Lattes: http://lattes.cnpq.br/8745472290896502

ABSTRACT

Diabetes mellitus (DM) is an endocrine syndrome, of multiple origin, characterized by an abnormal increase in blood glucose due to the absence or reduction of insulin action. Nutritional control is essential and challenging in the treatment of DM, as it contributes to the prevention and management of the disease and its complications. Studies that have investigated the difficulties of type 2 diabetic patients in glycemic control indicate that diet is a crucial aspect for the control of the pathology, with many patients reporting doubts about what and how much to ingest. Uncertainties about what can or cannot be consumed represent a great challenge for patients and their families. In this context, the present study aimed to develop a prototype of the application, aimed at diabetic patients and family members, to help in the choice and recognition of foods, the 'DICUMÊ', which favor glycemic control. The prototype was developed in stages, including defining features, designing the interface, and creating an interactive menu. The initial version of the app has been completed, allowing future evaluations of its practical applicability, perception analysis, and impacts on disease management. This work represents an initial step in the use of digital technologies to improve the quality of life of patients with type 2 diabetes mellitus (T2DM).

Keywords: Application. Diabetes Mellitus. Food Diary. Prototype.

INTRODUCTION

Diabetes mellitus (DM) is an endocrine syndrome of diverse origin characterized by hyperglycemia, which occurs due to insufficient insulin secretion by the beta cells of the pancreas, peripheral resistance to insulin action, or both. The two main causes are type 2 DM (DM2), which accounts for 90 to 95% of cases, and type 1 DM (DM1), which accounts for 5 to 10% of cases. In type 1 diabetes mellitus (DM1), the body begins to attack the cells of the pancreas that produce insulin, eliminating their ability to produce the hormone, and in type 2 diabetes mellitus (DM2) the body's cells develop a resistance to the action of insulin (ADA, 2020; SBD, 2019).

Chronic hyperglycemia associated with diabetes often results in damage, dysfunction, and insufficiencies in various organs, especially in the eyes, kidneys, heart, and blood vessels (Vilar, 2020).

Nutritional care in DM is one of the most challenging parts of treatment and lifestyle change strategies. The relevance of nutritional therapy in the treatment of DM has been emphasized since its discovery, as well as its challenging role in the prevention, management of the disease, and prevention of the development of complications resulting from the pathology.

The *American Association of Diabetes Educators* (AADE) reports that building healthy behaviors is appropriate for a health self-management program, serving as a basis for individuals with the disease to include healthy eating in their lifestyle as part of self-care. This construct supports dietary changes and the practice of physical activity, with the aim of promoting weight loss or maintenance. Making patients aware of the importance of a balanced meal plan should be a priority in all programs aimed at individuals with DM (SBD, 2019; Pereira and Frizon, 2017; Santos *et al.*, 2002).

Nutritional therapy is a challenge in the treatment of DM and plays a crucial role in achieving and maintaining glycemic control. Regardless of the time of diagnosis, nutritional therapy must be integrated into the treatment of diabetes in all its phases. It is responsible for helping to avoid complications of the disease through effective glycemic control, in addition to being essential for the success of pharmacological therapy, addressing lifestyle changes, food education, and weight control, especially through healthy eating (SBD, 2019).

In general, nutritional guidance for T2DM should be based on a varied and balanced diet. In addition to food prescription, nutritional management should include a behavioral

assessment, placing the patient at the center of care. It is essential to consider the individual's disposition, physical and financial limitations, and local resources, adapting the recommendations to their personal preferences through a joint decision (Martins, Duarte, and Pinho, 2021).

Thus, it is possible to intuit that the key to good diabetes management is the involvement of the patient and family members as an active part of the entire process, in order to develop self-knowledge and assist in decision-making (SBD, 2019).

In the daily routine of care in health units, the lack of information about an adequate diet is evident, as many patients report restricting sweet foods and/or sugar, but often do not pay attention to other foods, such as carbohydrates in general and other sources of lipids, proteins, fibers and minerals. This can occur both due to lack of knowledge and difficulty in following a diet. Thus, in the nutritional context, it is essential to consider the quality of food, the composition of meals, and the pleasure that the act of eating provides, in addition to ensuring that access to information on how to eat correctly is easy and accessible for both the patient and their families.

Based on patients treated in Basic Health Units, there is a need for tools that are culturally appropriate, with uncomplicated access and that simplify the understanding of information. It is crucial that these tools address the nature of food and the correct way to consume it to achieve better glycemic outcomes. Thus, in order to address the need for care for diabetic patients and their families, it is proposed to create a tool that informs about appropriate foods for DM patients. Any effective solution that addresses the challenge of diabetes and improves patients' quality of life represents an important and valuable initiative (Martins; Duarte; Pinho, 2021)

Recognizing technological advancement, the World Health Organization (WHO) began to use the term Mobile Health (mHealth) to encompass all medical and public health practices that use communication technologies. In this context, this work used mobile technologies (mHealth) to develop a prototype of a mobile application to support diabetic patients and their families in choosing and identifying appropriate foods, in addition to providing guidance on food combinations that favor or impair glycemic control.

METHODOLOGY

MATERIAL AND METHOD

Education focused on DM self-management is the process of facilitating knowledge, skills and capacities necessary for self-care of the disease. The global objectives of DM education, in relation to the individual, are to support decision-making, guide self-management and problem solving, prevention, treatment and management of this disease. In this sense, helping to know the classification of foods, how they interfere with the diet and the knowledge of the adequacy of their diet will allow better results in the self-care of the diet of type II diabetic patients.

To feed the list of allowed and non-allowed foods, whether it is a carbohydrate recommended in the diet or not, whether it is a low, medium or high glycemic level carbohydrate, consultations were carried out on the information provided by the Food and Nutrition Surveillance System - SISVAN - of the Ministry of Health of Brazil (BRASIL, 2008), data from the Brazilian Diabetes Society and other national and international Associations and Nutritional Guidelines.

With the development process concluded, validation tests were carried out in the laboratory, prototype validation and then with the patients inserted in the scientific initiation research that has been carried out at UEMASUL, which has been approved by the Research Ethics Committee – CEP of the State University of Maranhão – UEMA, via Plataforma Brasil, through opinion No. 5,360,789 and CAAE: 55572722.8.0000.8907.

In a technical-scientific partnership with the Innovation Factory, with professors and students of the Computer Science course of the Federal Institute of Education, Science and Technology of Maranhão - IFMA/Imperatriz-MA, appropriate language and tools were selected for the development of the application, together with the executing team.
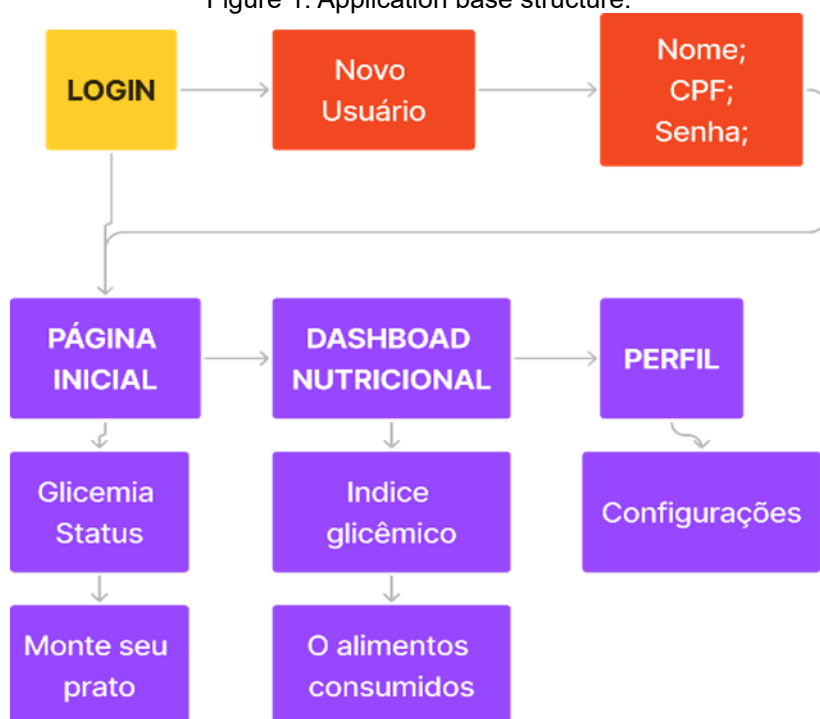
APPLICATION STRUCTURE

The development of the prototype of the application, named 'DICUMÊ', aimed at helping with glycemic control in diabetic patients, was a process that required a multidisciplinary approach, involving close collaboration between experts in health, technology and design.

The first key step in this process was to hold a *brainstorming* session with the project team members. The main objective of this meeting was to define the structure of the application, the pages and the sections that would make up the final interface. Through

this dynamic of exchange of ideas, it was possible to align the app's functionalities with the specific needs of patients, ensuring that all project objectives were met effectively. The structure is shown in Figure 1.

Brainstorming allowed for a broad and creative exploration of the possibilities for the app, considering the needs of end users, which include patients with different levels of literacy and familiarity with technology. During this phase, the main functionalities that the app should have to promote effective self-care in the context of DM2 were discussed. Emphasis was placed on developing an interface that was not only technically efficient, but also provided an intuitive and accessible user experience. Thus, the design of the prototype was oriented to be inclusive, considering the challenges faced by diabetic patients, such as understanding glycemic levels and the need for strict diet management.

Figure 1: Application base structure.

Source: Authors, 2024.

The structure of the application was designed to specifically meet the demands of 'DICUMÊ'. First of all, the login page was designed, which plays a key role in personalizing the user experience. Considering that the target audience includes patients with different levels of literacy and familiarity with technology, the team chose to simplify the login process. The home sign-in page offers two main options: the first for already registered users, allowing them to log in with their credentials, and the second for new users.

The process for new users is designed in a simplified way, so that anyone, regardless of their reading level, can create an account without any difficulties. To ensure the security and individuality of access, identification by CPF was chosen as the main method, providing a direct and reliable means for the identification of patients.

After logging in, users are directed to the app's homepage, which serves as a central dashboard for daily diabetes monitoring and management. This homepage is designed to be clear and to the point, with two main sections: the 'blood glucose status' and the 'build your plate'. The first section, 'blood glucose status', is an essential feature that allows users to monitor their blood glucose levels, from the food registrations already made, in a quick and intuitive way. This section is designed for patients to access their blood glucose readings immediately, without the need for complex navigation. This is particularly important for patients who need to constantly monitor their blood sugar levels and make quick decisions based on this information.

The second section of the *home page*, 'build your plate', is an interactive tool that helps users compose balanced meals according to their specific dietary needs. This functionality not only guides patients on which foods are suitable for consumption, but also how to combine them in a way that favors glycemic control. The idea behind this section is to educate users about the importance of a balanced diet and how food choices can directly influence diabetes management. 'Assemble Your Plate' is designed to be visually appealing and easy to use, making the process of choosing food an educational and engaging experience.

In addition to the *home page*, the 'DICUMÊ' app includes a detailed section called 'nutritional *dashboard*', which provides comprehensive information on diet and diabetes management. This nutrition dashboard is made up of three main subsections: 'nutrition facts', 'glycemic index', and 'foods consumed'. The 'nutritional information' subsection gives users a detailed view of the foods they consume on a given day or period. This subsection is designed to provide patients with in-depth knowledge about the composition of foods and how these components can impact their glycemic control. Nutrition education is a key element in diabetes management, and this app functionality is designed to empower users to make more informed food choices.

The 'glycemic index' subsection is another crucial functionality within the nutrition dashboard. This section educates users about the glycemic index (GI) of foods, a critical factor in diabetes management. The GI measures the speed at which carbohydrates from a

specific food raise blood glucose levels after being consumed. Foods with a high GI cause rapid and significant increases in glucose levels, while foods with a low GI result in slower, more gradual elevations. For diabetics, understanding the GI is critical to keeping glucose levels within a healthy range. Through this subsection, users can look up the GI of foods and learn how to choose those that help maintain their glycemic control more effectively. This functionality is designed to be easy to access and understand, with an interface that makes it easy to navigate and consult quickly.

The third subsection of the *nutrition dashboard*, 'food consumed', works as a food diary, where users can record what they have eaten throughout the day. This functionality allows patients to track their dietary history and identify patterns or foods that may be negatively affecting their glycemic control. By offering this registration tool, the app aims not only to facilitate self-control, but also to encourage greater reflection on food choices. Continuous tracking of the food consumed can provide valuable insights, both for patients and the healthcare providers accompanying them, helping to adjust diets more accurately and effectively.

Together, these functionalities create a robust platform for T2D management, providing patients with not only monitoring tools, but also education and support for effective self-management. The prototype design was developed with a strong emphasis on usability and accessibility, recognizing that users may have different skill levels in handling technology. Each section and subsection of the app is designed to be intuitive, with a clear interface that allows for fluid navigation. The integration of educational tools, such as the 'build your plate' and the 'glycemic index', within an interactive context, aims to transform the process of learning about diabetes into an engaging and empowering experience.

RESULTS

Frugal Innovation can be defined as that which meets the needs of customers with low purchasing power, commonly located in low-income emerging markets (Simula; Hossain; Halme, 2015). This type of innovation takes into account the scarcity of resources, simplification, and accessibility of the developed product, which is why the developed application can be classified as a frugal innovation.

In relation to the level of technological maturity, the TRL (Technology Readiness Level) scale was developed by the North American Space Agency (NASA) to assess the

technical maturity of a given technology. In Brazil, this scale is present in the NBR ISO 16290:2015 standard and ranges from 1 to 9, based on the deliverables/results related to each level (ABNT, 2022). The application, as it is in the experimental research phase in the laboratory and for having the functionality of its basic technological components validated in a controlled/laboratory environment, is classified as TRL 4.

In addition, the application will mainly serve the tertiary sector of the economy, providing services. As it is a technology aimed at the health area, it will help both users, with regard to the control of the pathology itself, and health professionals, with regard to the monitoring and adequacy of patient treatment, when accessing the information recorded in the application by the individuals who use it.

As for the results obtained in its features, the application has been divided into a few tabs:

1. Assemble Your Plate

The home page of the DICUMÊ application is characterized by its "Assemble your plate" functionality, represented in Figure 2. This design choice reflects the priority given to the practical and immediate aspect of diet management for diabetics. When opening the application, the user is directly taken to this page, avoiding unnecessary steps that could demotivate or confuse the patient. The interface was developed with a focus on accessibility, particularly for patients who may have a low level of literacy or little familiarity with technology, ensuring that anyone can use the app without difficulties.

In the 'Build your plate' section, the patient finds a virtual plate, which visually and intuitively represents the meals he is composing throughout the day. This visualization is essential as it allows the patient to not only add food, but also to visualize the impact of these choices on their glycemic control in a practical and straightforward way. Below the plate, there is a list of foods consumed, which is updated as the user adds new items to their meal.

In addition to offering a tool for meal composition, the home page also prominently displays the status of the patient's glycemic index. This data is presented in a clear way, allowing the user to have an immediate view of how their blood glucose levels are behaving throughout the day. Integrating this functionality with dish assembly is crucial, as it educates the patient about the direct relationship between what they consume and their glycemic fluctuations. Reading the glycemic index, therefore, not only informs but also serves as a guide for more conscious and informed food selection.

The glycemic index monitoring functionality is in line with the app's larger goal of promoting diabetes self-management. By educating the patient about the immediate effects of their food choices, the app encourages the adoption of healthier habits and favors self-care. This continuous monitoring is essential for diabetic patients, who need to be constantly aware of how different foods and combinations can affect their glucose level.

Once the patient identifies the food they want to add to their meal, they can easily select it from the interface. This selection is followed by choosing the amount consumed. How this choice was implemented at DICUMÊ demonstrates a deep understanding of the needs of diabetic patients. The quantity selectors are designed to be intuitive and represent portions in a way that any patient can easily understand.

Figure 2: 'Assemble your plate' function.
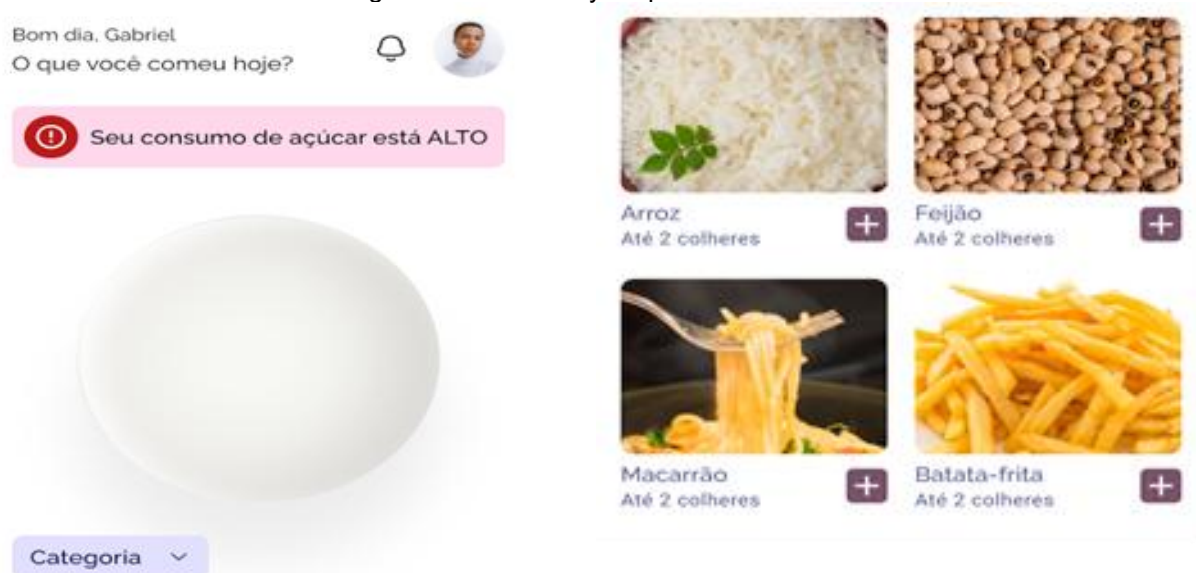
Source: Authors, 2024.

2. Quantity Selectors

The selectors include options such as ladles, spoons, dessert spoons, and other common portions that patients can easily identify. Rather than requiring the user to enter precise numerical values, which could be cumbersome and discouraging for some, the app offers these practical and familiar measures, making the food registration process easier. For example, a patient can select '2 tablespoons of rice' or '1 ladle of beans' with just a few taps on the screen, making the registration process quick and hassle-free, as shown in Figure 3.

Figure 3: "Quantity selectors" function.

Source: Authors, 2024.

As the patient adds food to the virtual plate, the app stores and presents it in an illustrative way. This visualization not only helps the patient to have a clear idea of their food choices, but also makes it easier to keep track of what has already been consumed throughout the day. The food list located below the plate is a complementary feature that serves as a textual record of what has been consumed, reinforcing the user's visual memory and helping them to keep track of their meals more effectively.

The combination of the illustrative view with the textual list is a smart strategy to reinforce the user's retention of information. Many patients may have difficulty remembering all of their food choices throughout the day, especially in a condition like diabetes, where the eating routine can be rigorous and demanding. By offering two forms of follow-up – visual and textual – the app maximizes the chances that the patient will keep an accurate and detailed record of their diet.

In addition, the list of foods consumed is designed to be easy to edit. If the patient realizes that he has made a mistake when registering a food or that he wants to adjust the amount consumed, he can do so directly through this list. This flexibility is critical to ensure that food records accurately reflect daily meals, allowing for better monitoring of glycemic control. As shown in Figure 4, the state of the dish after adding the food is observed.

Figure 4: Editing layout of food consumed.
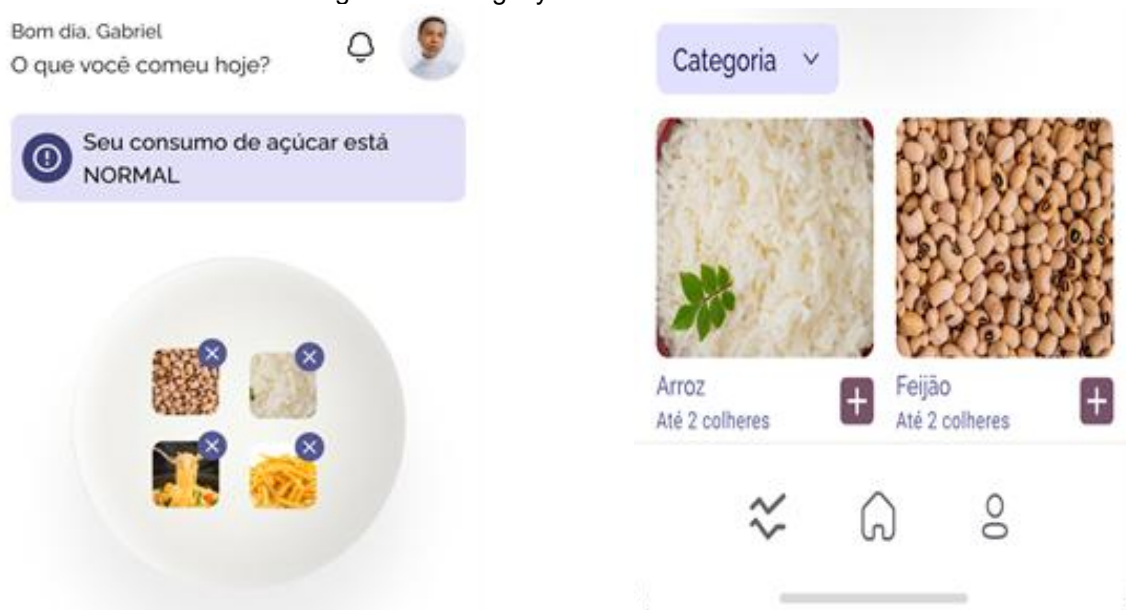
Source: Authors, 2024.

3. Nutritional Information

One of the key features of the "Nutrition Facts" section is the day selector, which allows the patient to choose a specific day to review their meals (Figure 5). This selector is extremely useful, as patients can easily access information about their past diets and compare their food choices over different days. The possibility of reviewing specific days helps the patient to identify patterns in their eating behavior, allowing a deeper reflection on what may be contributing to variations in glycemic levels, as shown in the figure on the side.

For example, a patient can use the day selector to review what they consumed on a day when their blood glucose level was higher than usual. By analyzing in detail the foods consumed and the amounts recorded, the patient may realize that certain foods or combinations of foods may have contributed to this increase. This analysis allows the patient to make adjustments to their future diet, avoiding foods that can cause blood glucose spikes.

In addition, the day selector also serves as a valuable resource for diabetes educators and dietitians who are monitoring patient progress. During appointments, these professionals can use the app to review with the patient their food choices on specific days, offering personalized feedback and guidance based on concrete and individual data.

Another essential feature within the "Nutrition Facts" section is the simplified blood glucose graph. This chart was designed with a clear focus on accessibility and ease of

understanding, especially for patients who may have difficulty interpreting more complex charts or who do not have a deep technical understanding of glycemic monitoring.

The graph uses colors and alert icons to immediately indicate the patient's status in terms of glycemic control. The colors were chosen to represent different ranges of blood glucose levels: green for levels within the ideal range, yellow for levels that are approaching an alert threshold, and red for levels that indicate risk or lack of control. This color coding allows the patient, with a simple glance, to understand their current condition and take the necessary steps to correct any deviation.

Alert icons are another critical feature of the simplified blood glucose graph. They serve as visual indicators that alert the patient when their glycemic readings are outside the desired parameters. For example, an alert icon may appear on days when the glucose level has been consistently high, signaling the need for immediate attention and perhaps adjustments to diet or medications. This functionality not only alerts the patient to potential problems, but also reinforces the importance of corrective actions, promoting greater awareness of health and well-being.

Figure 5: Simplified blood glucose graph and selector of days with respective food consumption.
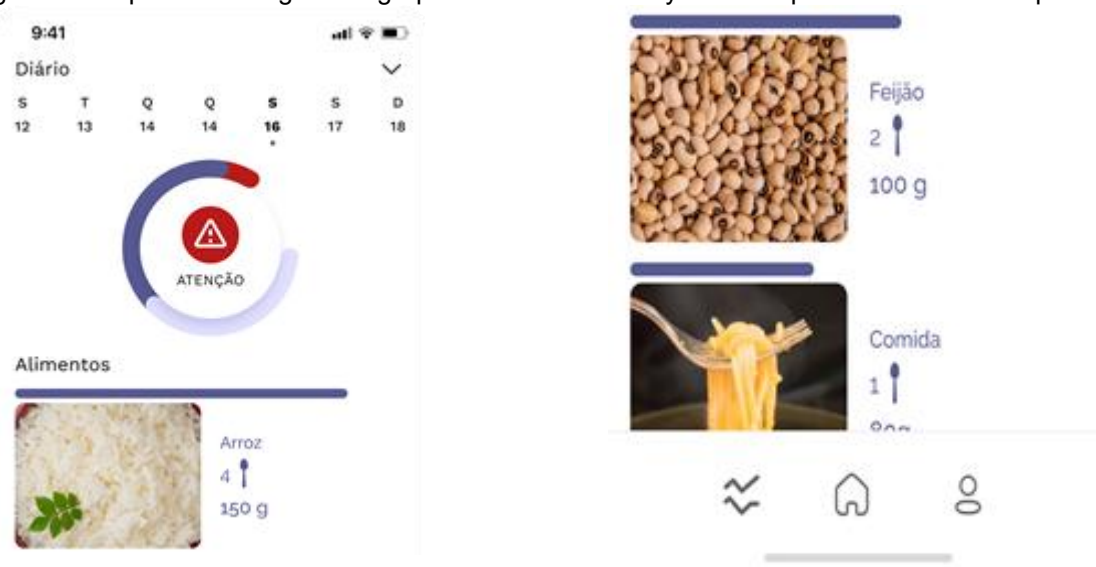
Source: Authors, 2024.

DISCUSSION

Prior to the formulation of the application, a prior art search was carried out in national databases with the objective of identifying technologies in the health area to serve as a basis for the development of this project. When performing this stage, a technological shortage was found regarding the basic objective of the application, which encompasses diabetes mellitus and its glycemic and nutritional monitoring. Therefore, based on other mobile technologies present in the health area, the interface and technology that would be used in the innovation were designed.

The product prototype remained in the testing phase in a controlled environment, so possible improvements in the design and structuring of the application would be evaluated after validation tests simulating the operating environment in which the technology will be employed. However, it is already possible to observe differentials in the developed product, even in its laboratory testing phase of the prototype: it is visually adapted to meet even individuals with low literacy and low technological knowledge; it allows you to have access to what you have consumed throughout the days and also use it in medical and/or nutritional consultations, in order to improve the treatment by professionals; It also monitors the glycemic index in order to alert the user to the effectiveness of their diet in controlling the desired parameters in a person with diabetes mellitus.

For the creation of the product, a partnership was made with the Computer Science course of the Federal Institute of Education, Science and Technology of Maranhão - IFMA/Imperatriz to develop all the software and technological technical part of the application. In addition to this partnership, which proved to be necessary to originate an efficient product that met the initial proposal of the project, partnerships with the public health network are potentially viable if the prototype continues with good applicability. That said, partnerships with companies in the field of communication technology are also potential partnerships, providing technical and structural support for the improvement of this health tool that shows promise in the social context of the city of Imperatriz-MA and, consequently, in the Brazilian context.

Thus, the creation of this innovative application, aimed at glycemic and nutritional monitoring of people with diabetes mellitus, fills a technological gap identified during preliminary research. Even in its initial phase, the application already demonstrates differentiated characteristics that make it accessible to different user profiles and useful in the context of medical treatments. The success in the controlled environment tests paves

the way for future collaborations, aimed at continuous improvement and the expansion of the social impact of the application.

FINAL CONSIDERATIONS

The development of the 'DICUMÊ' application, aimed at recording food and glycemic control, has enormous potential to positively impact the lives of individuals with diabetes mellitus, especially socioeconomically vulnerable citizens. Considering the importance of glycemic control for the health of these patients, the tool was designed to be not only functional, but also intuitive and accessible, with an interface that facilitates daily use. The prototype was developed in order to prioritize simplicity of use, data security and the customization of user support. In this way, a well-designed app can be a powerful tool to help people better control their pathology, be healthier, and live healthier and more balanced lives.

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