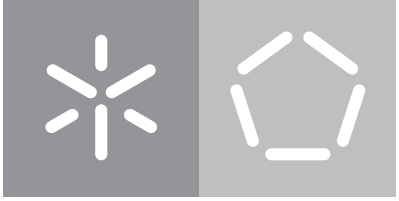
Universidade do Minho
Escola de Engenharia
Departamento de Informática

Sandro Emanuel Machado Cruz

Chatbot Assistant For Diabetic Patients

October, 2021



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Sandro Emanuel Machado Cruz

Chatbot Assistant For Diabetic Patients

Master's Dissertation
Master's in Informatics Engineering

Work supervised by
Rui Manuel Ribeiro de Castro Mendes
Sílvia da Silva Rêgo

October, 2021

STATEMENT OF INTEGRITY

I hereby declare having conducted this academic work with integrity. I confirm that I have not used plagiarism or any form of undue use of information or falsification of results along the process leading to its elaboration.

I further declare that I have fully acknowledged the Code of Ethical Conduct of the Universidade do Minho.

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Abstract

Nowadays, with the existence of several chronic health conditions, Diabetes Mellitus (DM) being one of the main ones, there is a great burden that patients must have in order to be able to take care of themselves. Thus, in addition to seeking to resolve their needs by obtaining information from health professionals, they increasingly seek information and advices in forums, communities and groups. The use of dialogue systems has become essential in people's lives. The development of conversational agents is still an unresolved research problem that poses many challenges in the Artificial Intelligence (AI) community.

This work aims to build an AI chatbot that is based on the principles and techniques of AI directed to Natural Language Processing (NLP) and Deep Learning to help people newly diagnosed with DM in the self management of the disease.

A literature search of DM education and information for people newly diagnosed with DM was conducted. Additionally, the main topics in which patients ask for support were retrieved from a search of several online support groups of DM, as well as questionnaires with 8 patients and interviews with 3 health professionals. The application were developed through the back-end side in Python and the front-end side in React Native and its communication was made through WebSockets. Furthermore, an interaction and interface design are developed in this work using Human-Centered Design (HCD) methodology. For that purpose, iterative usability test sessions were conducted with 12 users using Think Aloud methods and the System Usability Scale (SUS).

The chatbot developed is Information Retrieval (IR) type and answered questions asked by users in a human-like way. The result of the usability tests of the final version of the application was satisfactory (with a System Usability Scale (SUS) score of 88) and users found the application quite intuitive and robust. Further studies should concentrate on customizing the chatbot to each user by collecting information from prior interactions and verifying the impact of using this chatbot for newly diagnosed Portuguese users with DM.

Keywords: DM; Chatbot; AI; Deep Learning; NLP; HCD;

Resumo

Atualmente, com a existência de várias condições crónicas de saúde sendo uma das principais a Diabetes Mellitus (DM), há um grande fardo que os pacientes devem ter para poderem cuidar de si mesmos. Assim, para além dos pacientes buscarem procurar resolver as suas necessidades por meio da obtenção de informações junto aos profissionais de saúde, cada vez mais buscam informações e conselhos em fóruns, comunidades e grupos. O uso de sistemas de diálogo tornou-se essencial na vida das pessoas. O desenvolvimento de agentes conversacionais é ainda um problema de pesquisa não resolvido que apresenta muitos desafios na comunidade da Inteligência Artificial (IA).

Este trabalho visa construir um IA chatbot que é baseado nos princípios e técnicas de Inteligência Artificial (IA) direcionado a Processamento de Linguagem Natural (PLN) e Aprendizagem Profunda para ajudar pessoas recém-diagnosticadas com DM no autocuidado desta doença.

Neste trabalho, foi acompanhada uma pesquisa bibliográfica sobre a educação e informações da DM para pessoas recém-diagnosticadas com DM. Além disso, foram abordados em vários grupos de apoio online relacionados com a DM os principais tópicos que os pacientes pedem apoio, a utilização de um questionário com 8 pacientes e entrevistas com 3 profissionais de saúde. A aplicação foi desenvolvida através do back-end em Python e front-end em React Native e a sua comunicação foi feita através de WebSockets. Foi também desenvolvido um design de interação e interface através da metodologia Human-Centered Design (HCD). Para tal, foram realizadas sessões de testes iterativos de usabilidade com 12 participantes seguindo os métodos Think Aloud e System Usability Scale (SUS).

O chatbot desenvolvido é do tipo Information Retrieval (IR) e responde às perguntas feitas pelos utilizadores de forma humana. O resultado dos testes de usabilidade da versão final da aplicação foram satisfatórios (SUS de 88) e os utilizadores acharam a aplicação bastante intuitiva e robusta. Os estudos futuros devem concentrar-se na personalização do chatbot para cada utilizador, com a coleção de informações e de interações anteriores e na verificação do impacto da utilização deste chatbot para utilizadores portugueses recém-diagnosticados com DM.

Palavras-chave: DM; Chatbot; IA; Aprendizagem Profunda; PLN; HCD;

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Acronyms

ADA	American Diabetes Association
AI	Artificial Intelligence
AIML	Artificial Intelligence Markup Language
AMI	Amazon Machine Image
ANN	Artificial Neural Network
APDP	Associação Protectora dos Diabéticos de Portugal
AR	Augmented Reality
AWS	Amazon Web Services
BOW	Bag of Words
CPU	Central Processing Unit
CRUD	Create, Read, Update and Delete
DM	Diabetes Mellitus
EC2	Amazon Elastic Compute Cloud
EHR	Electronic Health Records
EU	European Union
FAQ	Frequently Asked Questions
GB	Gigabyte
GUI	Graphical User Interface
HCD	Human-Centered Design
HIT	Healthcare Information Technology
HTTP	Hypertext Transfer Protocol
HTTPS	Hypertext Transfer Protocol Secure

I-CVI Content Validity Index per item
IA Inteligência Artificial
IBM International Business Machines
IE Information Extraction
IP Internet Protocol
IPv4 Internet Protocol version 4
IPv6 Internet Protocol version 6
IR Information Retrieval
ISO International Organization for Standardization

JSON JavaScript Object Notation

ML Machine Learning
MLF Multi-layer feed-forward
MLPs Multi-Layer Perceptrons

NIHR National Institute for Health Research
NLG Natural Language Generation
NLP Natural Language Processing
NLTK Natural Language Toolkit
NLU Natural Language Understanding
NoSQL Not Only Structured Query Language

OCDE Organização para a Cooperação e Desenvolvimento Económico

PE Processing Elements
PLN Processamento de Linguagem Natural
POS Part of Speech

RDP Remote Desktop Protocol
ReLU Rectified Linear Unit
REST Representational State Transfer

S-CVI Content Validity Index by scale level
SGD Stochastic Gradient Descent

SPD Sociedade Portuguesa de Diabetologia
SUS System Usability Scale

TCP Transmission Control Protocol

UA Universal Agreement
UI User Interface
UML Unified Modeling Language
USA United States of America
UX User Experience

VR Virtual Reality

Chapter 1

Introduction

The adoption of information technology in the healthcare system has increased dramatically in the past decade. Until 2009, the United States of America (USA) healthcare system largely relied on paper medical records, which limited patient's ability to share information efficiently with other care providers and made health outcomes research difficult [1]. Actually, Electronic Health Records (EHR) are a vital part of Healthcare Information Technology (HIT) and can contain a patient's medical history, diagnoses, medications, treatment plans, immunization dates, allergies, radiology images, and laboratory and test results; allow access to evidence-based tools that providers can use to make decisions about a patient's care; automate and streamline provider workflow [1].

The future of healthcare lies in working hand-in-hand with technology and healthcare workers have to embrace emerging healthcare technologies in order to stay relevant in the coming years [2]. This technology could help transform unsustainable healthcare systems into sustainable ones, equalize the relationship between medical professionals and patients, provide cheaper, faster and more effective solutions for diseases [2].

Potential improvements in population health include some applications on mobile devices that can help patients manage their mental state or fight mental disorders, empower patients to actively participate in their health care by taking advantage, encourage patients to lead a healthy lifestyle and help patients learn to take care of their health responsibly [3]. The ubiquity of mobile health technology is so pervasive that one could argue that mobile health is more impactful than health technology that is immobile. This is especially true in areas that are under served due to logistical considerations [3].

AI is the key for researching on this type of business because the use of NLP and Deep Learning techniques. NLP has the capability to capture unstructured data, analyze the grammatical structure, determine the meaning of the information and summarize the information [4]. As a result, NLP techniques can reduce cost and extract the relevant information. Hence, this computing field is being increasingly explored to provide a less complex way to solve these challenges. Deep learning provides the ability to

analyze data at exceptional speeds without compromising on accuracy [4].

Futhermore, in business, chatbots have become so common because they reduce service costs and can handle many customers simultaneously. They offer users comfortable and efficient assistance when communicating with them and provide them with more engaging answers, directly responding to their problems [4].

This chapter presents the problem statement and motivation for the realization of the dissertation, the challenges proposed and the objectives that must be met. Furthermore, a description of the document structure is displayed.

1.1 Problem statement

Diabetes Mellitus is a common condition that affects the way one's body uses food to obtain energy [5]. Treatment and management strategies include medication (and in some cases the use of insulin), diet and exercise [5]. When a patient is diagnosed with DM, he/she has many information and abilities to learn, such as blood sugar testing, medication management, meal planning, and how to balance exercise and rest so that blood sugar level remains under control. Additionally, patients should adopt some self-care behaviors, for example, foot care, stress management, and monitor blood pressure and cholesterol [6].

About 422 million people worldwide have DM, the majority living in low-and middle-income countries, and 1.6 million deaths are directly attributed to DM each year [7]. Both the number of cases and the prevalence of DM have been steadily increasing over the past few decades [7]. Age is a major risk factor for DM. Continued monitoring of the prevalence of type 1 and type 2 DM among adults is particularly important because both have increased substantially over time among children and adolescents [7].

Over the past decade, there has been a substantial increase in the use of social media in healthcare [8]. A variety of studies have established that patients appreciate social media mainly for informational and emotional support. When seeking advice online about health concerns, forums dedicated to medical themes are increasingly becoming an appreciated source of information for many patients [8]. These forums are typically hosted by non-profit organizations that serve or advocate for people with DM or their families [8]. Examples include Associação Protectora dos Diabéticos de Portugal (APDP) and Sociedade Portuguesa de Diabetologia (SPD) [9, 10]. Common features include discussion threads, chat boards, links to recent research, advocacy opportunities, surveys and polls, calendars of online and in-person events, and photo albums documenting DM-related activities and community events [11].

Theoretically, in some instances, chatbots may be better suited to help patient needs than a human physician because they have no biological gender, age, or race and elicit no bias toward patient demographics. Chatbots do not get tired, fatigued, or sick, and they do not need to sleep [12]. They are cost-effective to operate and can run 24 hours a day, which is especially useful for patients who may have medical concerns outside of their doctor's operating hours [12]. Chatbots can also communicate in multiple different languages to better suit the needs of individual patients [12].

1.2 Motivation

Besides patient education is provided by healthcare professionals, such as medical doctors, nurses and nutritionists, the patient still needs to integrate all those treatments and lifestyle rules in their daily living, which is very challenging [13]. Many patients look for advice from other patients or caregivers of patients who have had the disease for a long time. They usually use the internet to contact other patients, through internet blogs and forums [13]. These are positive facilitators of DM management. However, blogs and forums members are not available anytime [13].

The growing number of healthcare chatbots, partly due to the democratization of chatbot development, motivates a closer look at how the systems address aspects concerning user experience, adoption and trust in automation, and healthcare provision [14]. Chatbot applications can provide immediate support to the user in natural language [14]. These applications present standardized information with the advantage of being customized to each patient, as Machine Learning (ML) enable chats to learn from prior interactions with the user, creating personalized advice [14].

People who are diagnosed with DM in the next few years are on the *Millenial Generation* - people who were born in or after the 1980s and who entered the labour market in the 2000s [15]. With that being said, there is a research that aimed to analyse the relationship between motives for using a chatbot and satisfaction with chatbot characteristics in the Portuguese *Millennial* population [15]. The majority of the respondents (54%) reported having already had experienced interaction with a chatbot [15]. The curiosity about this topic is present and research indicates it might be increasing [16]. There are three new dimensions that can be used to capture motives for using a chatbot: convenience, exploring and social [16]. The reason to use chatbots for convenience purposes thereby displays the highest value [16].

This dissertation consists in the design and development of a chatbot application for patients with DM, applying natural language and deep learning techniques. The design of the chatbot will be informed by user-centered research.

1.3 Aims

The main work that is made with the Associação Fraunhofer is aligned with the design and development of a chatbot application for patients newly diagnosed with DM, applying NLP and ML techniques. The design of the chatbot will be informed by user-centred research.

That being said, the main goals for this dissertation are:

1. Development of a model for the creation of a chatbot.
2. Development of a mobile application with the approached concepts.
3. Test and analyze the application.

1.4 Document outline

This document is organised in four chapters.

The first chapter presents a brief contextualization on the motivation for this study, identifying the objectives that are intended to be achieved and the main challenges to be addressed.

The second chapter describes the state of the art with regards to the concepts that are related to the main objective of this case study, where they are addressed as the main techniques for carrying out the work and its problems.

The third chapter explores the full details on the scope of this dissertation work, characterization of the problem, its challenges and the development plan.

The fourth chapter describes some studies already developed.

Chapter 2

State of Art

2.1 Chatbot overview

Over the last few years, along with the attractiveness of instant messaging, chatbots and pedagogical agents have motivated educators to integrate messaging tools in teaching and learning [17]. Chatbots are computer programs designed to carry on a dialogue with people, assisting them via text messages, applications, or instant messaging [17]. Therefore, the definition of a chatbot adopted for this dissertation is a computer program communicating by text in a humanly manner and who provides services to human users in order to accomplish a well-defined goal [17].

Essentially, instead of having a conversation with a person, the user talks with a bot that's powered by basic rules or AI [18]. Chatbots are already widely used to support, expedite, and improve processes in other industries, and now, the technology is gaining traction in health care, where it is helping patients and providers perform myriad tasks [18].

Developments in AI enhance the abilities of chatbots to mimic human agents in conversation. However, human–chatbot communication has notice able differences in the content and quality in comparison to the human–human discussion [4]. The duration of a human–chatbot conversation is long. People often use concise language with poor vocabulary or even lousy language. The crucial difference among chatbots and humans is the perception of empathy, as chatbots are less capable of conversational understanding than humans are [4]. However, progress is being made, and chatbots are gradually becoming more fully aware of their interlocutor's feelings. The common problem is that the subjective human perception makes people consider disclosed chatbots less informed and emotionally intelligent [4].

The major growth factors of the use of chatbots in healthcare include the rising urge for help patients in order to reduce risks and improve significant health concerns and growing demand for improving data usability to enhance patient care [19]. The following graphic exhibits the prediction of the evolution on chatbots investment. By it, it is possible to verify that in a near future the investment though chatbots will

increase in various areas as Healthcare, E-commmerce and Banking Financial Services and Insurance (Figure 2.1) [19].

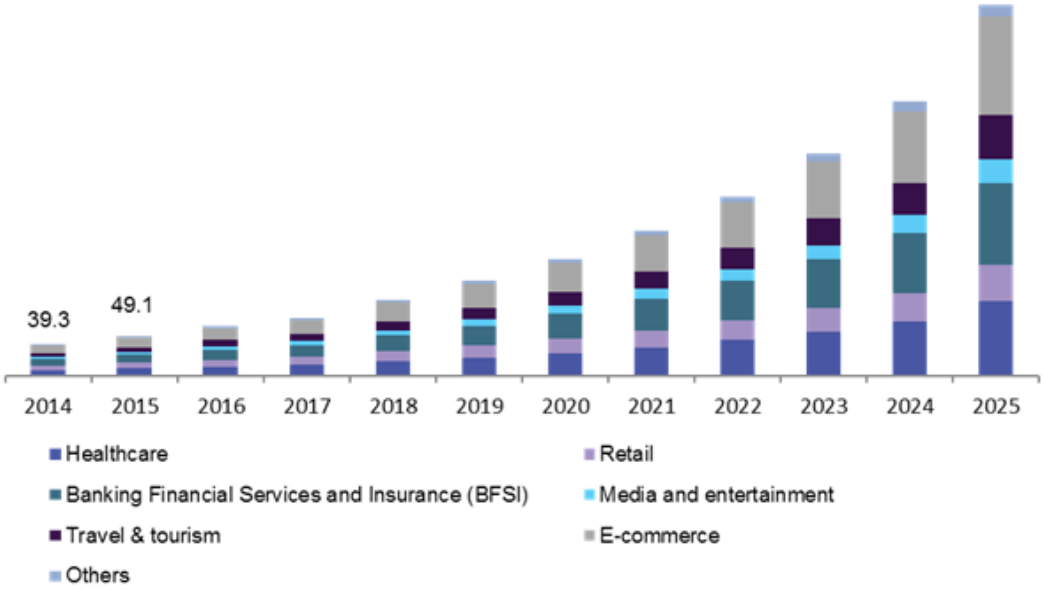

Figure 2.1: Prediction of the evolution of chatbots investment in healthcare and other areas. [19]

In order to be able to make an appropriate and deeper study, the chatbots that were created over time and the many types that exist will be addressed. After choosing the most suitable type of chatbot, it is essential to consider the use of NLP and Deep Learning. After studying the essential components for the development of the mobile application, the study of its content will be addressed, as it is intended for newly diagnosed patients with DM. After linking all these studies, the application development will be well planned.

2.2 A brief history of chatbots

In 1950, Alan Turing wondered if a computer program could talk to a group of people without realizing that their interlocutor was artificial [4]. This question, named Turing test, is considered by many to be the generative idea of chatbots. A chatbot is an AI program that simulates interactive human conversation by using key pre-calculated user phrases and auditory or text-based signals [4].

The first chatbot created was named ELIZA which marked a significant development in both the machine intelligence and human–computer interaction [4]. ELIZA operates by recognizing key words or phrases from the input to reproduce a response using those keywords from pre-programmed responses [4].

The next advancement involved the use of NLP and it was developed the project ALICE in 1995 by Richard Wallace. The production of ALICE allowed for more sophisticated conversation and it was revolutionary, though, for being open-source. Developers could use Artificial Intelligence Markup Language (AIML) to create their own chatbots powered by ALICE [4].

In the last years, the development of chatbots evolved with the creation of smart personal voice assistants such as *Apple Siri*, *International Business Machines (IBM) Watson*, *Google Assistant*, *Microsoft Cortana* and *Amazon Alexa* [4]. They connect to the internet and, in contrast to their predecessors, they create quickly meaningful responses [4].

As shown in this brief summary of the field of conversational agents, a lot of progress has been made since the early days of NLP.

2.3 Chatbots in medicine

Nowadays, medical chatbots reduce healthcare professional's workload by reducing hospital visits, reducing unnecessary treatments and procedures, and decreasing hospital admissions and readmissions as treatment compliance and knowledge about their symptoms improve [20]. For patients, this comes with a lot of benefits. Furthermore, hospitals and private clinics use medical Chatbots to triage and clerk patients even before they come into the consulting room [20]. These bots ask relevant questions about the patient's symptoms, with automated responses that aim to produce a sufficient history for the doctor [20].

Patients will not get in touch with physicians or nurses or any medical professional with every one of their health questions but will turn to chatbots first [20]. If the little medical helper cannot comfortably respond to the raised issues, it will transfer the case to a real-life doctor [20].

Chatbots may play a beneficial role in healthcare. However, this work has developed significantly on that research with the primary finding from this study indicating that, with greater experience, mental healthcare professionals have greater belief in the use of chatbots to better manage their client's own mental health [20]. The truth is chatbots cannot replace a doctor's expertise, neither can they take over patient care. However, combining the best of both worlds improves the efficiency of patient care delivery, simplifying and fast-tracking care without compromising quality [21].

Furthermore, chatbots can be used as virtual assistants helping their users by playing many different roles, for example as symptom checkers, medication reminders or personal data gatherers [22]. Physicians agree with the idea that chatbots can help in most of the automatic simple tasks in healthcare scenarios [22]. Chatbots are the perfect tools to make possible this turn around, being aligned with chronic patients' needs, interacting with them in the same way that patients communicate with their friends and relatives through their favorite messaging platforms [22].

The majority of existing applications focus on only a few needs of a patient with DM (e.g., nutrition guidance or glucose monitoring), and few focus on addressing the behavioral or psychological barriers to successful disease management [23]. Consequently, there is an evidence that showed promise in using mobile phones to help people with DM manage their condition effectively [24].

Although healthcare was not the first sector in which experiments with chatbots have been carried out, since the beginning of 2018 we have seen the emergence of and experimentation with many different use cases in this field [23]. The chatbots thus try to handle several needs, such as personalized medical

follow-up, communication and transmission of test results, dissemination of information, or even advice to patients or preliminary diagnosis. Below are some examples of chatbots that contribute to medicine [23].

2.3.1 Florence

Florence (Figure 2.2) reminds users to take their medication or birth control pills, motivates them to be adherent with their regimens, and is also able to present medicine specific information [25]. This application keeps track of patient health and helps him to reach his goals. There are additional features such as the explanation about a certain disease or finds a special location for the patient, like a doctor or a pharmacy [25].

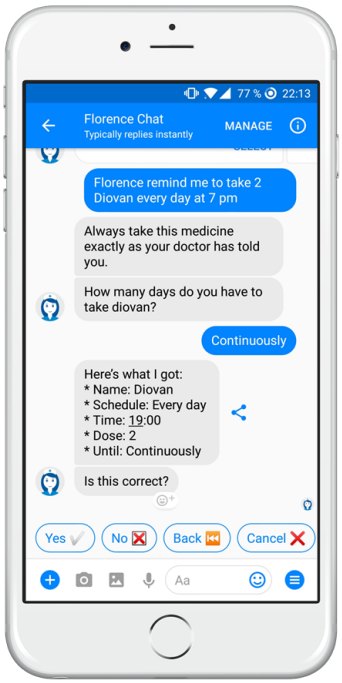

Figure 2.2: *Florence* Application.

2.3.2 Safedrugbot

SafedrugBot (Figure 2.3) is a chatbot messaging service that offers assistant-like support via the *Telegram* messaging application to the health professionals for example, doctors who need appropriate information about the use of drugs during breastfeeding [26]. SafedrugBot offers readily accessible drug information guides for health professionals who work with pregnant and breastfeeding women, it is a virtual assistant that can perform a variety of task. This application can perform different types of searches to find important informations on active ingredient or brand name drugs [26].

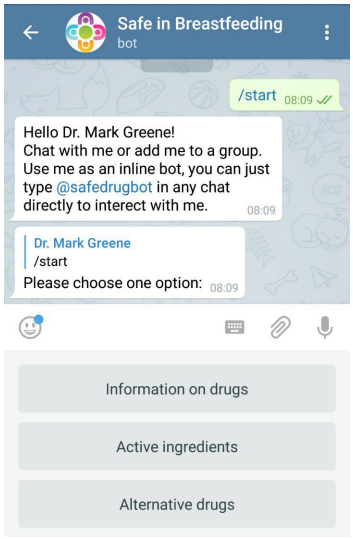

Figure 2.3: *Safedrugbot* Application.

2.3.3 GYANT

GYANT (Figure 2.4) is a health chatbot that asks patients to understand their symptoms and then sends the data to doctors, who provide diagnoses and prescribe medicine in real time [27].

The service is available on *Facebook Messenger* or *Alexa*, but the team plans to release it on every messaging platform soon. In addition, they not only provide help for English-speaking patients, but *GYANT* can speak to users in Spanish, Portuguese or German [27].

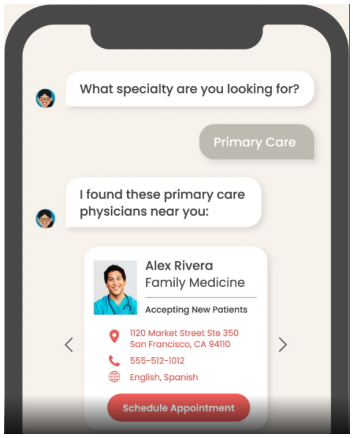

Figure 2.4: *GYANT* Application.

2.3.4 CancerChatbot

CancerChatbot (Figure 2.5) is a helpful resource for cancer patients, caregivers, friends and family on *Facebook Messenger* [28]. This chatbot offers plenty of resources for patients from chemo tips and tricks to free services [28]. It provides resources for caregivers to ease the burden of caring and making their lives easier. Furthermore, it offers friends and families advice on what to say and how to help cancer patients best. It is a sophisticated and well-thought-out solution [28].

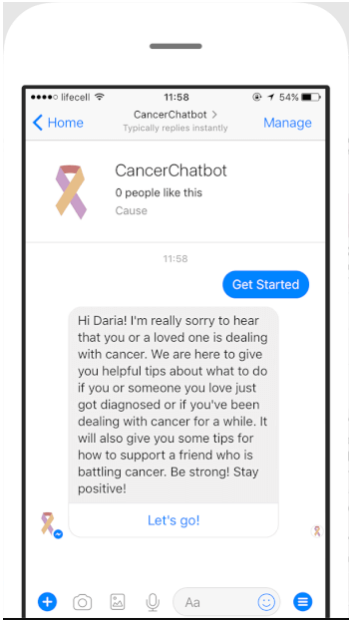

Figure 2.5: *CancerChatbot* Application.

2.3.5 Buoy Health

Buoy (Figure 2.6) exists to help the patient figure out what to do when he/she is sick [20]. This application checks the symptoms in combination with the latest medical information to offer personalized information about possible causes and treatments for the patient's illness, and proactive next steps to seek care [20].

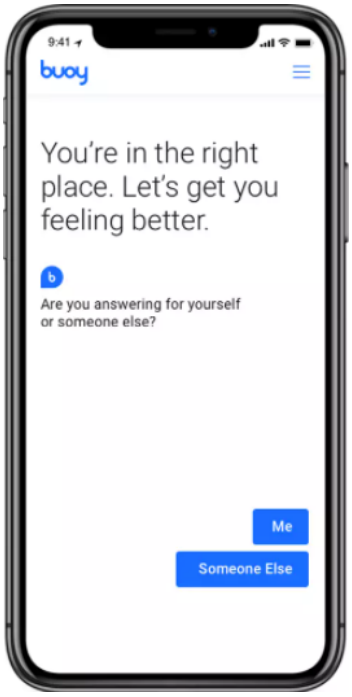

Figure 2.6: *Buoy Health* Application.

2.3.6 Aurora

In Portugal, the production of chatbots has not yet made much progress towards the contribution to medicine [29]. In 2018 it was produced the chatbot named *Aurora* (Figure 2.7) which is an online web chat program available on *Facebook Messenger* that automatically tracks parents looking for practical solutions to help improve their children's sleep [29].

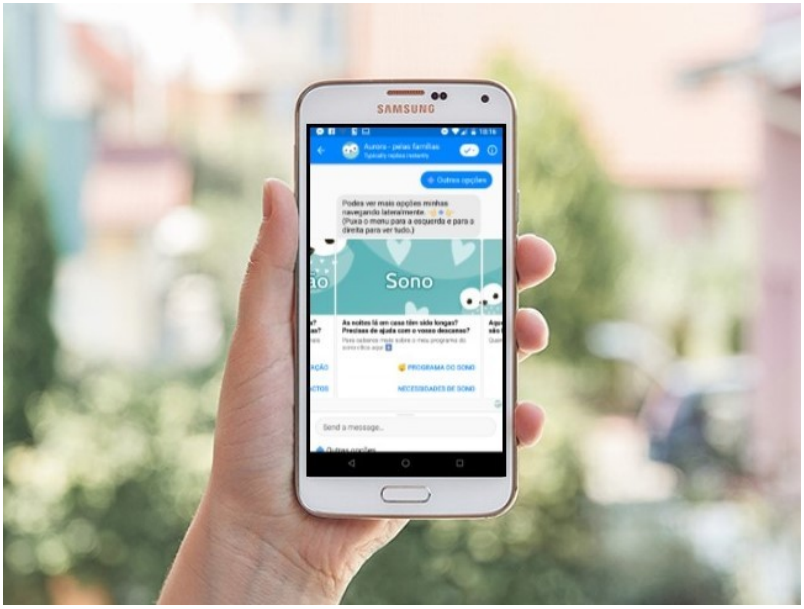

Figure 2.7: *Aurora* Chatbot.

2.3.7 AVA

In 2020, a web virtual cancer support assistant, *AVA* (Figure 2.8), capable of answering the main doubts about the disease, which concern patients and family members became available [30].

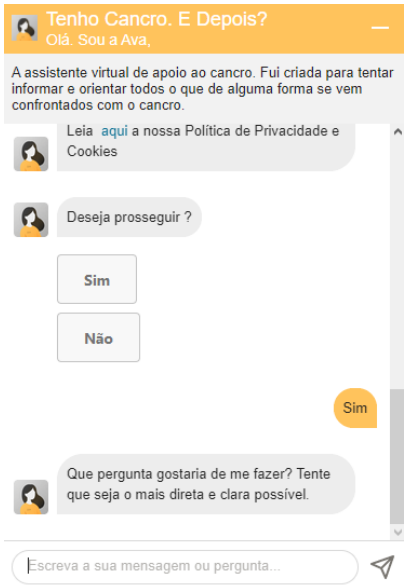

Figure 2.8: *AVA* Chatbot.

Next, a table is presented that contains a summary of some examples of chatbot applications for medicine that were analyzed above.

Table 2.1: Summary of some chatbots in healthcare.

Chatbot Application	Type of Application	Purpose	Supported Languages
Florence	Facebook Messenger App	Reminds the medication, gives medicine information	English
Safedrugbot	Telegram Messenger App	Gives information about drugs	English
GYANT	Facebook Messenger App	Concerns about the symptoms of the patients	English, Spanish, Portuguese, German
CancerChatbot	Facebook Messenger App	Helpful resource for cancer patients	English
Buoy Health	Web App	Helps patients who are sick	English
Aurora	Facebook Messenger App	Improves children sleep	Portuguese
AVA	Web App	Helps people with cancer daily	Portuguese

2.3.8 Chatbots for patients with DM

As described above, there are several chatbots around the world in order to be able to help people in the medical field. Very recently, there have been some productions of chatbots that can help people with DM and they have several different approaches.

After more appropriate research, it is possible to deduce that chatbots produced with the objective of helping patients with DM are always produced with the collaboration of the same company called *Novo Nordisk* which is a global healthcare company, founded in 1923 and headquartered just outside Copenhagen, Denmark [31]. The purpose of this company is to drive change to defeat DM and other serious chronic diseases such as obesity, and rare blood and rare endocrine diseases [31].

The first chatbot produced by them was a web chat application developed in 2018 [32]. It was called *Sophia* (Figure 2.9) and it is available online at the website *Cornerstones4Care* [32]. *Sophia* answers questions and addresses concerns (forwards or redirects when it does not know the answer) but also learns through human interactions and will consistently improve over time at addressing questions and needs. This chatbot was designed for people that can talk in English or Spanish [32].

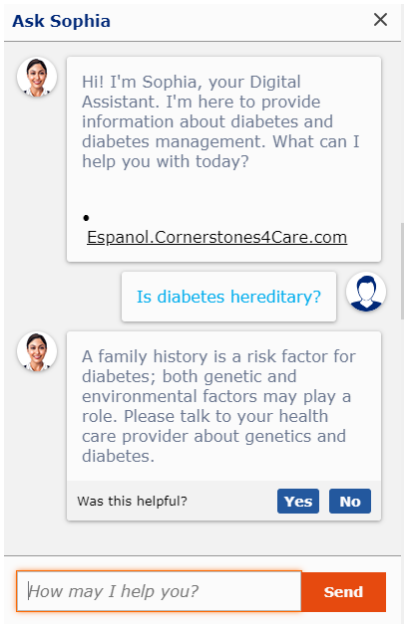

Figure 2.9: *Sophia* Chatbot.

Since 2020, this same company has been creating chatbots but for people who understand other languages. In 2020, with the collaboration of *H-FARM* and *CELI* companies it was created an Italian chatbot named *AIDA* (Figure 2.10) which is a digital personal assistant that helps users to get scientifically-based answers and it is a web chat appplication available at *aidachatbot.it* [33]. The chatbot analyses the questions also from an emotional point of view and tries to respond appropriately where it recognizes fear or stress in the users' words [33].

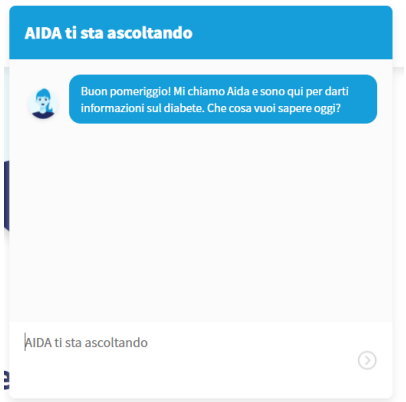

Figure 2.10: *AIDA* Chatbot.

In 2021, *Novo Nordisk* planned to develop a Chinese-speaking chatbot for the same purpose with the assistance of *Microsoft's Azure cloud* platform [34]. They are setting a new benchmark in AI-powered chronic disease management, driving critical advancements in healthcare [34].

In addition to *Novo Nordisk*, there is one more company, National Institute for Health Research (NIHR), that is doing a study on a possible chatbot in order to support young people with type DM using IBM Watson as the AI platform [35].

Lastly, there is an application which is called *Eddii* (Figure 2.11) and it is a virtual in-app (chatbot included in the application) character designed to engage people living with DM to track and record their health [36]. This application was made for *Android* and *iOS* mobile phones and it will come out in the present year in the USA [36].

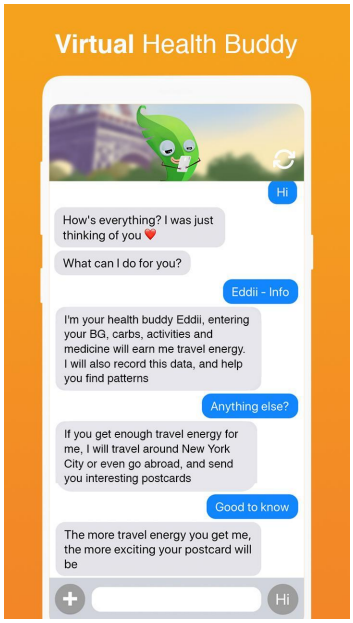

Figure 2.11: *Eddii* Application.

So far, there is no idea or elaboration of a chatbot to help people with DM in the Portuguese language and that uses guidelines from Portuguese associations or a study with Portuguese people who have DM.

Below is presented a table that indicates the chatbots that help people with DM existing up to now.

Table 2.2: Summary of chatbots for patients with DM.

Chatbot Application	Medicine Area	Type of Application	Purpose	Supported Languages
Sophia	Yes	Web App	Helps people with DM daily	English, Spanish
AIDA	Yes	Web App	Helps people with DM daily	Italian
eddii	Yes	Android/iOS App	Helps people with DM through interactive games (Chatbot included)	English

2.4 Patient-Centered Care

In patient-centered care, an individual's specific health needs and desired health outcomes are the driving force behind all health care decisions and quality measurements [37]. Patients are partners with their health care providers, and providers treat patients not only from a clinical perspective, but also from

an emotional, mental, spiritual, social, and financial perspective [37]. AI has the potential to both reduce physician burnout and improve the patient experience.

The primary goal and benefit of patient-centered care is to improve individual health outcomes, not just population health outcomes, although population outcomes may also improve [38]. To preserve this ideal of patient-centred care, AI systems should be built in a way that allows for value-plurality, meaning the possibility that different patients might hold different values and have different priorities related to their care [38]. In this way, the ethical ideal of shared decision-making can be maintained and not be replaced by another form of paternalism, one practised not by doctors, but by AI algorithms [38].

2.4.1 Automated Care

At the moment, patients find themselves relying on a digital-first approach to healthcare — an arrangement that, at first, might not involve a human on the other end of the exchange [39].

It is not realistic to expect every patient to be on board with digital-care solutions beyond their current use. Having multiple points of entry for care —chatbots, telehealth visits, in-person consultations — provides patients with the valuable choice of how they want to receive it, ultimately boosting their confidence in and loyalty to their care provider [39].

AI-powered chatbots work well beyond helping frightened patients assess their symptoms and determine next steps. The technology has the ability to recommend treatments and schedule visits, among other things [39].

2.4.2 Intelligent, Empathetic and Supportive Care

Chatbots provide instant conversational responses and make connecting simple for patients. And when implemented properly, they can help care providers to surpass patient expectations and improve patient outcomes [39]. However, AI solutions sometimes lack the most important quality to good care delivery: a human touch [39]. However, *Characteristic* dimensions like *Emotion* or *Personality* do not seem to have any relevance to Portuguese *Millennials*. Instead the sample group valued *Efficiency* related *Characteristics* as important [16].

Despite all the potential benefits, like any other technology enabled services, chatbots will help only if people use them and follow their advice. There three main factors that influences the use of chatbots in the matter of trust:

- Competence: The application must have the knowledge and skills needed to answer the questions [40].
- Integrity: The application must do what it says it will do [40].
- Benevolence: The application must have the patient's best interests in mind, and not be guided by ulterior motives [40].

The underlying trust factors of competence, integrity, and benevolence play important roles in the use of technology, and technology providing recommendations in particular [40]. Ability and integrity are typically more important for instrumental outcomes associated with transactions (such as purchasing) because users are most concerned with whether the technology will work as intended to complete the transaction [40]. Affect and other perceptual outcomes (such as satisfaction) are often influenced more by benevolence as these are based more on relationship aspects of technology use [40].

In healthcare, chatbots are deemed most helpful when the chatbot's ability, patient compliance, integrity and benevolence match that of a human agent.

2.5 User Experience

User Experience (UX) has become an important aspect of interactive system evaluations in the last two decades [41]. According to International Organization for Standardization (ISO), User Experience (UX) is a *person's perceptions and responses resulting from the use and/or anticipated use of a product, system or service* [41].

UX is important because it tries to fulfill the user's needs. It aims to provide positive experiences that keep a user loyal to the product or brand. It's important to note that the UX encompasses much more than how a user feels about a product or service [41]. It incorporates a strategic understanding of the product's business model and the processes clients use [41]. It also consists of understanding the broader context in which users interact and engage [41].

A successful UX design creates solutions that meet the needs of the client, users and ultimately works within the bounds of the technological platforms [41].

2.5.1 User Interface

There is substantial interest and engagement concerning conversational users' interfaces for customer service [42]. Given the relative importance of customer service in users everyday lives, a broad uptake of chatbots for this purpose may be important in advancing users' overall acceptance of conversational user interfaces in general [42].

However, attaining a broad uptake of chatbots for customer service will depend on whether customers perceive these as valuable and useful [42]. Chatbots for customer service will only enjoy sustained relevance and interest if they generate good user experience and represent value propositions that motivate users to engage in repeated interactions [42].

While the UX is not as visible to the user, the interface design is the first thing they will see, immediately influencing their perception of an application [43]. It is the responsibility of the User Interface (UI) Designer to enhance the brand within the interface. UI Design ultimately helps guide users through the interface using visual aids [43]. For a greater UI, it is needed to consider the following aspects:

- Clarity: The interface avoids confusion and ambiguity by making everything clear through language and visuals. Mobile applications with good UI usually do not need extensive onboarding to show the user how the application works [43].
- Familiarity: Many users like to see familiar features, buttons, or call-to-action. Familiarity includes commons symbols, icons, or colors, to convey a message such as red to exit or delete. Even if someone uses an interface for the first time, certain elements can be familiar [43].
- Responsiveness: This includes speed as an excellent user interface should not lag or feel slow. Providing feedback when a screen is loading will also enhance the UI by keeping the user informed on what is happening, for example, informing them of purchase confirmation or data processing [43].
- Consistency: Keeping your interface consistent across your application is important because it allows users to recognize usage patterns. Once your users learn how certain parts of the interface work, they can apply this knowledge to new areas and features [43].
- Aesthetics: While it is not necessary to make a UI attractive for it to function correctly, making something look attractive will make the application more enjoyable [43].

2.5.2 User Experience in healthcare chatbots

In general, there is a general lack of familiarity and understanding of health chatbots [44]. Quality, trustworthiness and accuracy of the health information provided by chatbots are the main aspects that people care. The use of chatbots is very accessible if it is targeted to minor health concerns that would not require a physical examination [44]. They must be perceived as a convenient tool that could facilitate the seeking of health information online. Thus, if free at the point of access, chatbots were seen as time-saving and useful platforms for triaging users to appropriate healthcare services [44].

To encourage people to adopt and use medical chatbots, both content quality and expertise of the chatbots should be first considered in the development process [44]. From the perspective of utilitarian and hedonic value, content quality has strongly positive effects on perceived usefulness and enjoyment, both of which influence users' usage intention [44]. Perceived expertise of the medical chatbots can increase the users' trust in the chatbots, which in turn affects their continuance intention to use the service agents [44]. In addition to the effort to improve a chatbot's content quality and expertise, it is also important to iteratively evaluate its usability and UX, both in the development process and after the completion of its development [44].

It is necessary to study user-centred and theory-based approaches addressing patients' concerns and optimising UX in order to achieve the best uptake and utilisation [45]. Patients' perspectives, motivation and capabilities need to be taken into account when developing and assessing the effectiveness of health chatbots [45].

2.5.3 Usability Testing

Usability evaluation is one way of ensuring that interactive systems are adapted to the users, their tasks and that there are no negative outcomes of their usage [46]. Usability evaluation is a fundamental step in the user centered design process of any interactive system be it a software, a web site or any information and communication technology or service [46]. The goal of a usability evaluation is to assess the degree to which a system is effective, efficient, and favors positive attitudes and responses from the intended users [46].

Think Aloud method

Thinking Aloud is a method that requires subjects to talk aloud while solving a problem or performing a task [47]. This method traditionally had applications in psychological and educational research on cognitive processes, but also for the knowledge acquisition in the context of building knowledge based on computer systems [47]. In many cases the *Think Aloud* method is a unique source of information on cognitive processes: it generates direct data on the ongoing thought processes during task performance [47]. Thus, the *Think Aloud* method is a very direct method to gain insight in the way humans solve problems [47].

2.6 Chatbot Approaches

There are two main chatbot building architectures: rule-based approches and data-driven approaches [48]. The rule-based systems were exploited earlier and they rely on pattern-action rules. On the other side, the data-driven relies on large conversations corpora [48].

2.6.1 Rule-based chatbots

Rule-based chatbots are designed to answer questions based on prefixed rules. During the dialogue, the bot follows specific rules to chat with the user [48]. Rule-based chatbots are very popular in today's market as they are easy to build and performing for simple tasks. However, performing complex tasks requires writing many rules which can be time consuming [48]. Despite their simplicity, the first proposed rule-based chatbots in history are impressing. Basically, with rule-based chatbots hand-crafted rules are used to produce answers or even questions [48].

2.6.2 Data-driven chatbots

Data-driven chatbots are the newest approaches and the most used ones [48]. The availability of text datasets, in general, and conversational datasets, in particular, allowed to apply data-driven approaches to text [48]. Data-driven approaches use existing human-human or bot-human conversations and/or narrative documents to create the bot utterances. In order to leverage the existing conversational data, one can use whether Information Retrieval (IR) or Machine Learning (ML) [48].

2.6.2.1 IR based chatbots

Information retrieval chatbot models work as a search engine where the query is the user turn and the search result is the chatbot answer [48]. With the pairs dataset and question, the IR based conversational model will look in the dataset for the best matches. It is widely used in the industry to make goal-oriented chatbots where the chatbot can be customized on the tone and flow in order to drive the customers with the best experience [48].

The IR chatbots use techniques like keywords matching, ML or deep learning to identify the most appropriate response [48]. Regardless of the technique, these chatbots provide only predefined responses and do not generate new output [48].

2.6.2.2 ML based chatbots

The problem of generating human-like conversations has been modeled, lately, as the problem of mapping a human turn to a machine turn which is the target to be predicted [48]. Most recent works focused on applying deep learning models but each of these formulates the problem in a particular way and uses a different set of features. Most used ML models are sequence to sequence learning and reinforcement learning [48].

2.7 Applications and Techniques of NLP

NLP has recently gained much attention for representing and analysing human language computationally [49]. This came into existence to ease the user's work and to satisfy the wish to communicate with the computer in natural language [49]. Since all the users may not be well-versed in machine specific language, NLP caters those users who do not have enough time to learn new languages or get perfection in it [49].

This field is related with different theories and techniques that deal with the problem of natural language of communicating with the computers [49]. Ambiguity is one of the major problems of natural language which is usually faced in syntactic level as well as it has sub task as lexical and morphology which are concerned with the study of words and word formation [49]. Each of these levels can produce ambiguities that can be solved by the knowledge of the complete sentence [49].

The goal of NLP is to accommodate one or more specialities of an algorithm or system. The metric of NLP assess on an algorithmic system allows for the integration of language understanding and language generation [49].

2.7.1 Natural Language Understanding

A Natural Language Understanding (NLU) system is a machine that produces an action as the result of an input sentence (speech or text). There are examples of systems that are able of modeling and learning the relationship between the input sentence and the action in a direct way [50].

NLU is post-processing because starts to reveal to the computer the true meanings of text and not just surface understanding [50]. However, NLU is a huge problem and an ongoing research area because the ability of computers to recognize and process human language at human-like accuracy has an enormous possibility [50]. Computers could finally stand in for low paid customer service agents, capable of understanding human speech and its intent [50].

The biggest draw for NLU is a computer's ability to interact with humans unsupervised [50]. The algorithms classify speech into a structured ontology, but AI takes over to organize the intent behind the words [50]. This method of deep learning allows computers to learn context and create rules based on more substantial amounts of input through training [50].

2.7.2 Natural Language Generation

Natural Language Generation (NLG) is the subfield of AI and computational linguistics that focuses on computer systems that can produce understandable texts in human languages [51]. Typically starting from some non-linguistic representation of information as input, NLG use knowledge about language and the application domain to automatically produce documents, reports, explanations, help messages, and other kinds of texts [51].

As a research area, NLG brings a unique perspective on fundamental issues in AI, cognitive science and human-computer interaction [51]. These include questions such as how linguistic and domain knowledge should be represented and reasoned with, what it means for a text to be well written, and how information is best communicated between machine and human [51].

2.7.3 Text Preprocessing Techniques

There are a lot of many processes involved in the pipeline of NLP. At the syntactic level, statements are segmented into words, punctuation (i.e. tokens) and each token is assigned with its label in the form of noun, verb, adjective, adverb and so on (Part of Speech (POS) Tagging) [52]. On the semantic level, each word is analyzed to get the meaningful representation of the sentence. Hence, the basic task of NLP is to process the unstructured text and to produce a representation of its meaning [52].

Information Extraction (IE) refers to the use of computational methods to identify relevant pieces of information in documents generated for human use and convert this information into a representation suitable for computer based storage, processing and retrieval [52].

Next, it is presented the architecture for the preprocessing of the messages (Figure 2.12). Firstly, the user sends a message that will be divided into sentences through sentence segmentation. Then, each sentence will be divided into words through tokenization. After tokenization, one of two processes will be used to obtain the canonical word: lemmatization or stemming. Finally, a model called Bag of Words (BOW) is implemented in order to prepare the using of ML techniques.

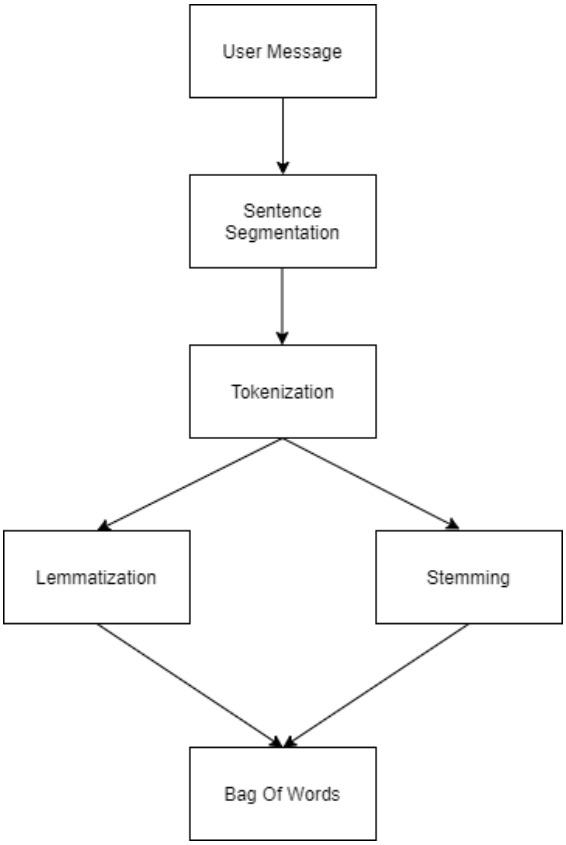

Figure 2.12: Pipeline Architecture for a Preprocessing System.

2.7.3.1 Sentence Segmentation

Sentence Segmentation is the problem of dividing a string of written language into its component sentences. Fortunately, this process is not that complex. The sentences can be split whenever it is seen a punctuation mark [52].

2.7.3.2 Tokenization

Tokenization is the problem of dividing a sentence (string) of written language into its component words. Generally, the better resolution for this type of data is dividing the word whenever it is seen a space [52].

For grammatical reasons, documents can contain different forms of a word or related words with a similar meaning. In order to solve these problems, it can be used two processes: lemmatization or stemming [52]. The main goal for these processes is to to reduce inflectional forms and sometimes derivationally related forms of a word to a common base form [52].

Lemmatization

Lemmatization usually refers to doing things properly with the use of a vocabulary and morphological analysis of words, normally aiming to remove inflectional endings only and to return the base or canonical form of a word, which is known as lemma [53].

The utilization of this process can be very useful for a better accuracy. However, in some cases, its use is not recommended because it is very consuming. Most of lemmatization algorithms are slow, with a computation overhead [53].

Stemming

Stemming refers to a crude heuristic process that chops off the ends of words in the hope of achieving this goal correctly most of the time, and often includes the removal of derivational affixes [53].

Unlike lemmatization, a stemmer is easier to implement and usually runs fast [53]. Addictionally, the reduced accuracy may not matter for some applications. The bad side of its use is that the algorithms do not actually know the meaning of the word in the language it belongs to [53].

2.7.3.3 Bag of Words

Humans can understand the language easily in a fraction of seconds. But, machines cannot understand the language [54]. For that, it will be needed to convert the text into a numerical form that is easily understandable by the machine. Most of the ML and statistical model work with numeric data hence. So, it is important to convert all the texts into numbers [54].

For that it is used the Bag of Words (BOW) which acts as a baseline model and thus can be treated as a basic model to test the results and know more about the data that is being fed to a model [54]. After that, one can proceed further with deep learning approaches. This process is often referred to as vectorization. With all this, a BOW also turns out to play well when the data is small and domain specific [54].

The result is a numerical vector which can be utilized as inputs in the various ML algorithms to classify documents into topics, to be used in chatbots or for many other ML applications where text is the initial input [54]. Although this is a simple model, it has proven to be effective in various scenarios [54].

2.8 Deep Learning

Deep learning is a type of ML that trains a computer to perform human-like tasks, such as recognizing speech, identifying images or making predictions [55]. Instead of organizing data to run through predefined equations, deep learning sets up basic parameters about the data and trains the computer to learn on its own by recognizing patterns using many layers of processing [55].

In recent years, *Deep Learning* has garnered tremendous success in a variety of application domains [56]. Learning is a procedure consisting of estimating the model parameters so that the learned model (algorithm) can perform a specific task [56]. Different methods have been proposed based on different categories of learning, including supervised, semi-supervised, and unsupervised learning [56]:

- Supervised learning is a learning technique that uses labeled data [56]. In the case of supervised *Deep Learning* approaches, the environment has a set of inputs and corresponding outputs $(x_t, y_t) \sim \rho$ [56]. For example, if for input xt, the intelligent agent predicts $\hat{y}_t = f(x_t)$, the agent

will receive a loss value $l(y_t, \hat{y}_t)$. The agent will then iteratively modify the network parameters for a better approximation of the desired outputs [56]. After successful training, the agent will be able to get the correct answers to questions from the environment;

- Semi-supervised learning is learning that occurs based on partially labeled datasets [56].
- Unsupervised learning systems are ones that can without the presence of data labels. In this case, the agent learns the internal representation or important features to discover unknown relationships or structure within the input data. Often clustering, dimensionality reduction, and generative techniques are considered as unsupervised learning approaches [56].

This new field of ML has been growing rapidly and has been applied to most traditional application domains, as well as some new areas that present more opportunities [57]. Experimental results show state of the art performance using *Deep Learning* when compared to traditional ML approaches in multiple fields [57].

2.8.1 Artificial Neural Network

An Artificial Neural Network (ANN) is a biologically inspired computational model formed from hundreds of single units, artificial neurons, connected with coefficients (weights) which constitute the neural structure [58]. They are also known as Processing Elements (PE) as they process information. Each PE has weighted inputs, transfer function and one output [58]. PE is essentially an equation which balance inputs and outputs. ANN is also called connectionist model as the connection weights represent the memory of the system [58].

Artificial networks comparable to a human brain in complexity are thus still far beyond the creative capacity of the human brain [59]. The human brain is much more complex and, unfortunately, many of its intellectual functions are still not well known. ANNs are capable of processing extensive amounts of data, however, and making predictions that are sometimes surprisingly accurate [59].

ANN Supervised Learning

Supervised learning is the most common technique in the classification problems, since the goal is often to get the machine to learn a classification system that it is created [59].

Most commonly, supervised learning leaves the probability for input undefined, such as an input where the expected output is known. This process provides dataset consisting of features and labels [59]. The main task is to construct an estimator that is able to predict the label of an object given by the set of features as inputs along with the correct outputs, and it learns by comparing its actual output with corrected outputs to find errors [59]. It then modifies the model accordingly. The model that is created is not needed as long as the inputs are available, but if some of the input values are missing, it's not possible to infer anything about the outputs [59].

This category is the most common technique for training neural networks and decision trees [59]. Both of these depend on the information given by the pre-determined classification. Also, this learning is used in applications where historical data predicts likely future events [59].

In context of neural networks, that means that the desired output is known and adjusting of weight coefficients is done in such way, that the calculated and desired outputs are as close as possible [59]. Back propagation, illustrated in Figure 2.13, is the most widely used method for neural network training because it is the easiest to implement and to understand and it works reasonably well for most linear and nonlinear problems [59].

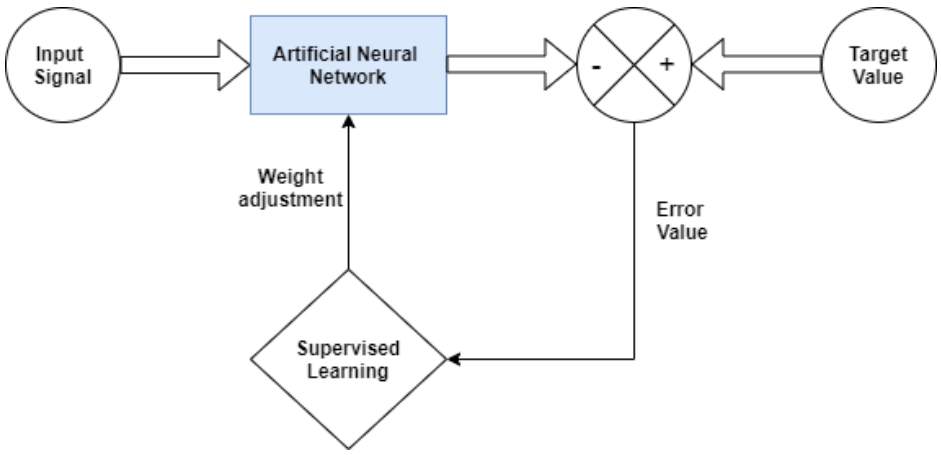

Figure 2.13: ANN Supervised Learning process. [60]

2.8.2 Feed-Forward Neural Network

Feed-forward networks are among the simplest deep learning models for text representation [61]. Yet, they have achieved high accuracy on many text classification benchmarks. These models view a text as a BOW. For each word, they learn a vector representation using an embedding model, take the vector sum or average of the embeddings as the representation of the text, pass it through one or more feed-forward layers, known as Multi-Layer Perceptrons (MLPs) or Multi-layer feed-forward (MLF), and then perform classification on the final layer's representation using a classifier [61].

A MLF neural network consists of neurons, that are ordered into layers [61]. The first layer is called the input layer, the last layer is called the output layer, and the layers between are hidden layers [61]. For the formal description of the neurons it is usually used the mapping function γ, that assigns for each neuron a subset ($\gamma(i) \subseteq V$ for each neuron i) which consists of all ancestors of the given neuron [61]. So, it is possible to get all predecessors with the inverse mapping function ($\gamma(i)^{-1} \subseteq V$). Each neuron in a particular layer is connected with all neurons in the next layer [61]. The connection between the ith and jth neuron is characterized by the weight coefficient $\omega_{i,j}$ and the neuron by the threshold coefficient θ_i or θ_j [61]. The weight coefficient reflects the degree of importance of the given connection in the neural network. The output value of the ith neuron x_i is determined by the following equations [61]:

$$x_i = f(\xi_i) \tag{2.1}$$

where ξ_i is the potential of the ith neuron and $f(\xi_i)$ is the transfer function.

$$\xi_i = \theta_i + \sum_{j \in \gamma_i^{-1}} \omega_{ij} x_j \tag{2.2}$$

where θ_i is the threshold coefficient and the summation is carried out over all neurons j transfering the signal to the ith neuron. The transfer function is calculated by [61]:

$$f(\xi_i) = \frac{1}{1 + exp(-\xi)} \tag{2.3}$$

The supervised adaptation process varies the threshold coefficients ξ_i and weight coefficients ω_{ij} to minimise the sum of the squared differences between the computed and required output values [61]. This is accomplished by minimisation of the objective function E:

$$E = \sum_n \frac{1}{2}(x_n - \hat{x}_n)^2 \tag{2.4}$$

where x_n and $\hat{x}_n$ are vectors composed of the computed and required activities of the output neurons and summation runs over all the output neurons n [61].

The network is configured to output n values, one for each class in the classification task, and the function used is the softmax one in order to normalize the outputs, converting them from weighted sum values into probabilities that sum to one [62]. Each value in the output of the softmax function is interpreted as the probability of membership for each class [62]. Softmax is a mathematical function that converts a vector of numbers into a vector of probabilities, where the probabilities of each value are proportional to the relative scale of each value in the vector [62]. Adding a softmax layer to the above outputs, the ith output of the network after the softmax layer may be represented as [62]:

$$softmax(f(x))_i = \frac{exp(f_i(x))}{\sum_{i=1}^{j} exp(f_i(x))} \tag{2.5}$$

where $g_i(x)$ is one of outputs of network before adding a softmax layer and $\forall_i = 1, ..., j$.

After computing the derivative with respect to all of the weights in the network using the back-propagation through time algorithm, the weights can be updated in order to get closer to an optimum with optimization techniques such as Stochastic Gradient Descent (SGD) [57].

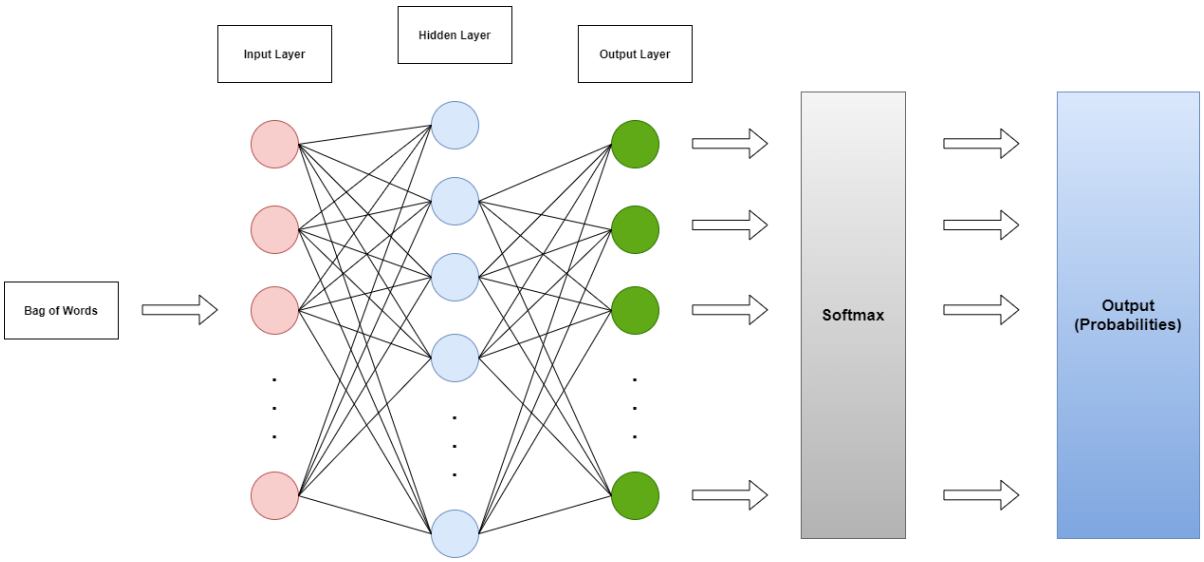

Figure 2.14: Multi-layer feed-forward model.

A series of matching methods can be applied to short-text conversations for retrieval-based systems such as these methods model sentences using MLFs to construct abstractive representations [57]. Although not all of these methods are originally designed for conversation, they are effective for short-text matching tasks and are included as strong baselines for retrieval-based conversational studies [57].

Training Data

The MLF neural network operates in two modes which are the training and the prediction mode. In order to accomplish the operations on the two modes two data sets are defined: the training set and the set that will be used to predict (test set) [61].

The training mode begins with arbitrary values of the weights with random numbers and proceeds iteratively [61]. Each iteration of the complete training set is called an epoch. In each epoch the network adjusts the weights in the direction that reduces the error [61]. As the iterative process of incremental adjustment continues, the weights gradually converge to the locally optimal set of values. Many epochs are usually required before training is completed [61].

On other hand, the prediction mode consists on the information flowing forward through the network, from inputs to outputs [61]. The network processes one example at a time, producing an estimate of the output values based on the input values. The resulting error is used as an estimate of the quality of prediction of the trained network [61].

2.9 Case Study of Diabetes Mellitus

2.9.1 Impact

Diabetes Mellitus (DM) is a frequent chronic disease that requires continuous medical treatment and teaching self-care to the patient [63]. DM can be properly managed in order for patients to have a healthy

and active life. There are three major components in managing diabetes: monitoring blood glucose level, follow a proper diet (by following dietitian advice) and exercise [63]. Additionally, patients' motivation (to motivate individuals with DM to have the urge of managing their disease) is also important [63].

DM is considered by some authors to be a global epidemic. In 2003 it was estimated that around 194 million people worldwide had DM, and 5.1% was in the age group of 20-79 years [63]. This estimate predicted an increase to about 333 million, by 2025, with 6.3% in the adult population [63]. The largest absolute and proportional increase in cases can be focused on developing countries, where prevalence is expected to increase from 4.2% to 5.6% [63]. According to the World Health Organization, it is estimated that there are more than 180 million individuals with DM worldwide and that number is likely to exceed the double of cases in 2030 [63]. It was estimated that in 2005, about 1.1 million people died from DM [63].

The impact of DM on population implies high social and financial costs resulting from the occurrence over time of many microvascular and macrovascular complications with progression of the natural history of the disease [63]. This will result in a high comorbidity that will lead to very high mortality rates in the population affected [63].

2.9.2 Prevalence in Portugal

In Portugal, in recent decades, diabetes has increasing attention on the part of technicians and health institutions [64]. According to Organização para a Cooperação e Desenvolvimento Económico (OCDE), Portugal is the second country in the European Union (EU) with the highest prevalence rate of DM. In 2019, Portugal had 9.8% of adults (between 20 and 79 years) with type 1 and 2 DM, rising behind Germany (10.4%), that is the worst country in the EU in statistics [64].

In addiction, the last report from Portugal named Relatório Anual do Observatório Nacional da Diabetes (Edição de 2019), concluded that the prevalence of DM in 2018 was about 13.6% where 7.7% of that was diagnosed and 5.9% was not [10, 65].

There is a statistically significant difference in the prevalence of DM among men (15.9%) and women (10.9%) [10, 65]. According to Sociedade Portuguesa de Diabetologia (SPD) (Figure 2.15), there are more than a quarter (about 27%) of people between 60-79 years old have DM, while in the middle age (40-59 years) there is about 12.7% of cases [10, 65]. In the 20-39 age group, it is possible to conclude that there are more positive results, with only 1.9% of cases existing [10, 65].

Therefore, it is possible to verify that in Portugal, the highest incidence of people with diagnosed DM is in the age group of 40 years and over. It is precisely in this age group that people mostly have to learn to manage DM and there are many concepts and skills to learn.

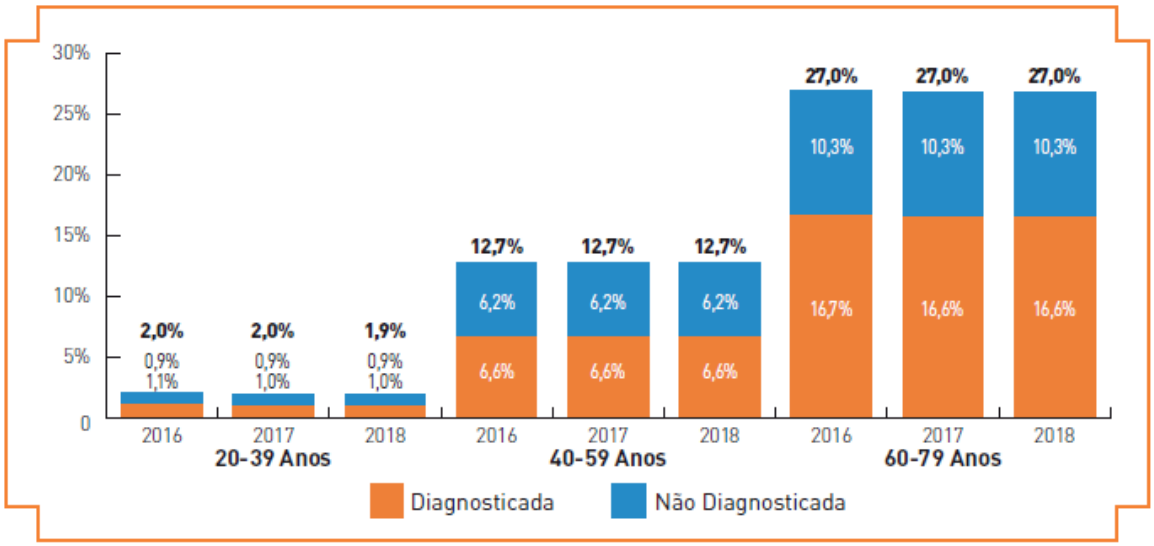

Figure 2.15: Prevalence of DM in Portugal order by age group. [65]

2.9.3 Types of Diabetes Mellitus

2.9.3.1 Type 1 Diabetes Mellitus

Type 1 DM can affect people of any age, but it usually occurs in children or young adults. The patients need insulin injections daily to control the blood glucose levels blood [65]. Without insulin, they cannot survive. Type 1 DM is less common than type 2 DM, but its incidence is increasing most likely due to changes in environmental risk factors such as the increase of height, weight and maternal age at childbirth, the change on food, and the exposure to certain viral infections [65].

Treatment

In practical terms, food increases blood sugar (blood glucose), while insulin and exercise decrease it. Good control of diabetes results from the balance between these three factors [65]. Daily tests (self-monitoring) inform people with DM if the blood sugar is high, low or normal and allow the self-control to the adjustment of insulin dose, diet and physical activity [65].

2.9.3.2 Type 2 Diabetes Mellitus

The diagnosis of type 2 DM usually occurs after the age of 40, but due to obesity problems can occur in an earlier stage [65]. Meanwhile, children has been increasing on the develop of Type 2 DM. This type can be asymptomatic and has a strong component of heredity [65].

Unlike type 1 DM, patients with type 2 DM are not dependent on exogenous insulin and they are not prone to ketosis [65]. They may need insulin to control hyperglycemia if they are unable to do so through the diet associated with oral medications, which are non-insulinic antidiabetics [65].

The increase in the prevalence of type 2 DM is associated with rapid changes of cultural and social conditions, an aging population, growing urbanization, dietary changes, reduced physical activity and unhealthy lifestyles, as well as other behavioral patterns [65].

Treatment

The treatment of type 2 DM is thus multifactorial and covers major modifiable risk factors, such as obesity, physical inactivity or low level of physical activity, tobacco smoke, blood pressure elevated and dyslipidemia [65]. The treatment implies interventions to change lifestyles (eating habits and physical activity) and approach pharmacological assessment with continuous assessment of the onset of complications [65].

The normal treatment of type 2 DM consists on the adaptation to new habits such as the change on the food and physical activity that must be performed daily (regular exercise in order to allow a better circulation of sugar). Additionally, if the patient has excessive weight part of that will be lost [65].

In normal situations, the patient follows the stated treatment. However, complications may occur [65]. If the patient cannot control the DM with that, it is necessary to proceed to a new treatment with medication and, in certain cases, the use of insulin. It is still common the need to use medicines to control cholesterol and blood pressure [65].

Recently, there have been new therapeutic classes that emerged for the treatment of this type of DM, namely GLP-1 receptor agonists, inhibitors for DDP-4 and inhibitors for SGLT2 [66].

2.9.3.3 Gestational Diabetes Mellitus

Gestational DM is the one that occurs during pregnancy [65]. This form of DM arises in pregnant women who did not have DM before pregnancy and usually disappears when it ends. However, almost half of these pregnant women with DM will later be people with type 2 DM if no preventive measures are taken [65].

Treatment

The treatment consists on lifestyle changes where the patient needs to be restrictive to healthy diet, regular physical activity, make the typical blood sugar monitoring and, in some cases, medication is needed [65].

2.9.4 Nutrition

The idea of being on a diet for a chronic lifelong condition such as DM is enough to put many people off as knowing what to eat and maintaining an optimal eating pattern are challenging [67]. Medical nutrition therapy was introduced to guide a systematic and evidence based approach to the management of diabetes through diet, and its effectiveness has been demonstrated, but difficulties remain [67].

Most physicians are not trained in nutrition interventions and this is a barrier to counselling patients [67]. Moreover, talking to patients about nutrition is time consuming. In many settings, outside of specialised DM centres where trained nutritionists/educators are available, advice on nutrition for DM is, at best, a printed menu given to the patient [67].

Guideline for healthy eating

In order to have a balance of food, it is necessary to follow basic advices. The APDP has made these advices available to help patients in their treatment (Figure 2.16) [9].

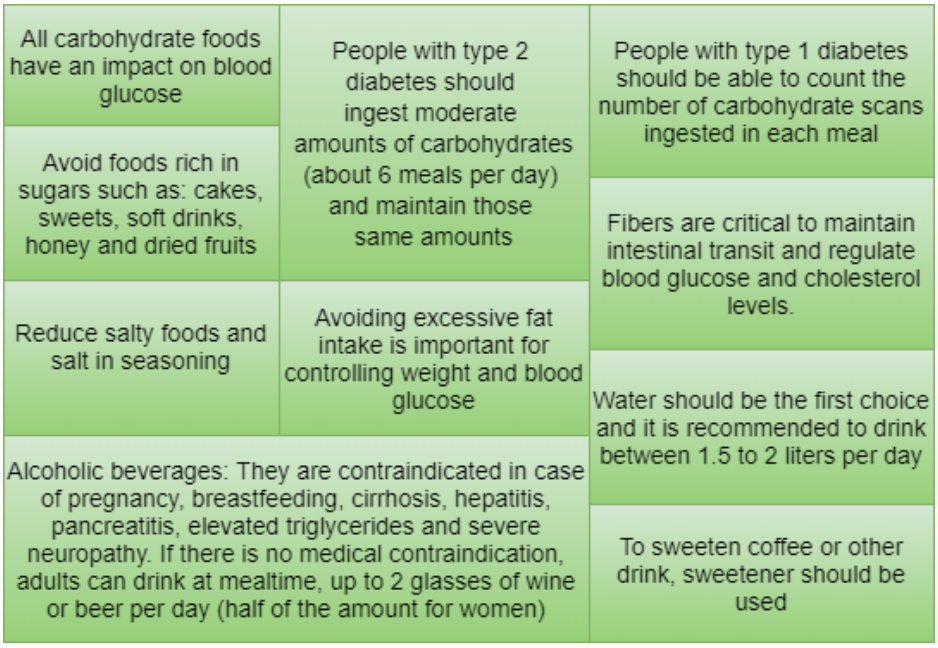

Figure 2.16: Guideline for Healthy Eating by APDP [9]. [9]

Foods to avoid

Consensus exists on reducing or avoiding the intake of processed red meats, refined grains and sugars (especially sugar sweetened drinks) both for prevention and management of DM [9]. Furthermore, many guidelines also highlight the importance of reducing the intake of foods high in sodium and trans fat because of the relevance of these specifically for cardiovascular health [9]. It can be generalized that the foods to avoid in the diet for DM are those high in sugar or simple carbohydrates [9].

- Sugar and sweets in general
- Honey, fruit jelly, jams, marmalade, confectionery and pastries
- Sweets in general like chocolates and goodies
- Sugary drinks such as soft drinks, industrialized juices, chocolate milk
- Alcohol

Healthy Balanced Diet

An important part of managing DM is to eat a healthy balanced diet [9]. Cooking from scratch gives the control over what the patient eats. The concept of healthy eating is abstract and, at the moment with the dietary patterns that may be constituted, there is no healthy diet that can be considered for a person with DM because there is no recommended diet [9]. There will be adequate food for each person, and this food has to minimally guarantee the satisfaction of nutrients with a greater or lesser amount of carbohydrates and protein that the minimum needs are met [9]. So, the following items presented (Table 2.3) are the meals recommended by APDP and the same amount must be taken every day.

Table 2.3: Recommended food recipes. [9]

Soups	Cream of red cabbage, Gazpacho soup, Vegetable soup, Cream of peas with coriander, Coriander soup, Pumpkin soup with watercress, Green soup with cauliflower and carrot, Pumpkin cream with mint, Beet soup
Fishes	Stuffed tomatoes, Fish pudding, Sardine pate, Fillets in the oven, Horse mackerel in escabeche, Baked cod, Hake with spinach, Hake in a pot, Hake fillets with vegetables and potatoes punching
Salads	Tomato-rich salad, Fresh lettuce salad, Tropical fruit salad, Peas with poached eggs, Country lunch, Arugula and lettuce salad, Mimosa lentils, Stuffed courgettes, Summer salad, Cold grain salad
Pastas/Rice	Special pasta, Rice pudding with tuna, Spiral pasta with roasted vegetables, Spaghetti with monkfish, Cotovelinhos with alinho, Special bean rice
Meats	Chicken with tomatoes and peppers, Roastturkey leg with orange sauce, Turkey breast in the pan, Turkey crown with tomato sauce, Rabbit in garlic vineyard, Rabbit to saloia, Turkey breast stuffed with cabbage and bread, Stewed rabbit, Pork loin with milk and plums
Desserts	Fruit with lemon and cinnamon, Tropical fruit salad, Apple with yoghurt and walnut crumb, Fruit salad, Mango mousse, Cream milk, Golden slices, Farophyas, Blackberries with yoghurt

2.9.5 Complications

The management of DM in a primary care setting in Portugal can and should be improved, since 9.8% of patients are not treated and 48.3% are not controlled [68]. DM has a considerable clinical impact due to its strong association with the complications that a patient may have [68]. Below the most worrying complications are addressed (Table 2.4). Some complications are related to the others so, some of that do not need a proper explanation because they are on the same group.

Table 2.4: List of complications.

Group	Complications
Microvascular	1) Retinopathy 2) Nephropathy 3) Neuropathy
Macrovascular	3) Coronary Heart Disease 4) Brain Disease 5) Lower Limb Arterial Disease 6) High Blood Pressure
Neuro, macro and microvascular	8) Diabetic Foot
Others	10) Sexual Dysfunction 11) Infections

2.9.5.1 Retinopathy

Retinopathy is an ophthalmological manifestation of DM and one of the main causes of vision loss worldwide. The frequency of retinopathy depends on the years of DM duration [9]. After 20 years of evolution, more than 90% of people with type 1 DM and more than 60% of people with type 2 DM develop retinopathy. Poor metabolic control (blood glucose) is also a risk factor for the onset of retinopathy [9]. There are other risk factors such as blood pressure, dyslipidemia, smoking and DM duration [69].

2.9.5.2 Nephropathy

The nephron is the functional unit of the kidney [9]. There are millions of nephron and each one works in the filtration of the blood and in the formation of the urine [9]. When, over the years, arteries are subjected to elevated blood glucose levels, they start to be damaged, this damage is even more serious if high blood pressure coexists [9].

In more serious situations, nephropathy can culminate in renal failure, that is, the kidney is no longer able to perform its purification function and it is necessary to resort to hemodialysis for the blood to be purified [9]. It is extremely important to prevent this situation through effective glycemic control. The glomerular filtration rate should be evaluated annually in people with DM, it is a value that varies according to sex, age and body surface. Nephropathy is more common in type 1 and type 2 DM when it is poorly controlled [9].

2.9.5.3 Neuropathy

Diabetic neuropathy is a nervous disorder caused by DM [9]. The onset of neuropathy can be so slow that in the early stages it may show no symptoms or signs but symptoms may vary according to the type of damage to the affected nerve fibers [9]. Patients may experience some symptoms, such as numbness or pain, especially in the extremities of the limbs, at the level of the legs and feet [9]. It can also cause changes in motor function and sensitivity. The extremities of the hands can also be reached, giving rise to changes similar to those of the feet [9].

The increase in blood glucose (hyperglycemia) is one of the most important causes of this complication, but there are other causes [9]. It is possible to prevent neuropathy or delay its development, thanks to a good control of DM, through a healthy lifestyle (food and physical activity, not smoking and avoiding alcoholic beverages) and complying with the appropriate pharmacological treatment [9].

2.9.5.4 Coronary Heart Disease

Cardiovascular risk factors such as obesity, hypertension and dyslipidemia are common in patients with DM, placing them at increased risk for cardiac events [70]. Therefore, targeting cardiovascular risk factors in patients with DM is critical to minimize the long-term cardiovascular complications of the disease [70].

DM generally confers twice the risk of vascular events, regardless of the risk factors, and the risk is also higher in women [70]. This risk is increased in those associated with long-standing DM and microvascular complications [70]. In cases of early onset of type 1 DM, between 1-10 years of age, there is a loss 17.7 years of life in women and 14.2 years in men [70]. In type 2 DM poor glycemic and renal complications were the main determinants of cardiovascular events. These results highlight the need for intensive control of risk factors in both groups [70].

2.9.5.5 Brain Disease

DM is associated with moderate cognitive deficits and neurophysiological and structural changes in the brain, a condition that may be referred to as diabetic encephalopathy [71]. DM increases the risk of dementia, particularly in the elderly. Due to the ageing of the western population,the prevalence of diabetes and the combination of DM and advanced age dementia is expected to increase considerably [71].

2.9.5.6 High Blood Pressure

Hypertension aggravates the problems in the smaller arteries (microangiopathy), especially diabetic nephropathy (damage to the kidney arteries), for which it is a major risk factor. High blood pressure is twice as common in people with DM and increases with age [9].

Hypertension already exists in about 40% of people when they are diagnosed with DM, which suggests a relationship between the obesity and insulin resistance leading to high blood pressure and it worsens glucose (sugar) intolerance [9]. In most cases there is no cause for high blood pressure, so it is called essential, this is particularly the case in type 2 DM [9].

2.9.5.7 Diabetic Foot

Diabetic foot is one of the most frequent complications in DM and 25% of people with DM have conditions that increase the risk of diabetic foot [9]. This complication is responsible for the majority of amputations in Portugal. To avoid this complication it is important a good control of DM and foot care [9]. Additionally, patients with DM should have an annual foot evaluation with their doctor in which a low risk, medium risk or high risk rating will be assigned [9].

2.9.6 Information Availability

Over the past two decades, the internet has become a widely available source of information, as well as a key component in clinical informatics, a rapidly growing field aimed at exploring and updating the potential of information and communication technology to improve health outcomes [72]. One prominent example is the use of patient web portals that enable patients to access their health records, exchange emails with providers, complete administrative forms, receive appointment reminders, and manage medications [72].

The association between healthcare access barriers and online health information seeking suggests that when healthcare needs are not met, people may have a high demand for online health information [72]. Therefore, providing reliable health-related information online may help to meet the demand for such information, which is a potentially important self-care resource for those facing barriers to care access [72].

2.9.6.1 Support in Portugal

Currently, in Portugal, when a person needs help, he/she turns to the medical unit mainly to solve his/her problems [73]. Initially, a patient with DM has too many questions regarding the treatment and its conditions. In order to solve this problem, the patients are starting to use reliable consumer-level information on the *internet* when they face a daunting task [73]. An enormous quantity of content is dispersed among an ever-increasing number of *websites* [73].

Therefore, to help patients turn to reputable and trustworthy portals that provide information in the form of educational guides, to groups or forums where there are several people addressing the subject. Another not very reliable but quite common way is to do a search in a search engine for any doubt the patient may have. That being said, recent studies have raised concerns about the accuracy and organization of disease-specific information on the *internet*.

APDP

Associação Protectora dos Diabéticos de Portugal (APDP) is a Portuguese institution and the oldest DM association in the world having more than 15 thousand members. This institution maintains the flag of respect for people with DM and the defense of their autonomy and social integration. APDP works to improve the quality of life and well-being of people with DM, so that this disease does not constitute a barrier in their daily lives. The educational material available is divided into the various existing themes

about DM and this is where a person with DM can explore a lot of information to help in self-care related to DM. [9].

SPD

Sociedade Portuguesa de Diabetologia (SPD) is a scientific society with a strong component in supporting research and dissemination of knowledge in the area of DM. It also has the role of disease advocacy with messages that reach the general population [10].

SPD is also responsible for the *National Diabetes Observatory*, for the quarterly periodical publication of a scientific journal, the *Revista Portuguesa de Diabetes* and for the annual holding of the *Portuguese Diabetes Congress* [10].

Diabetes 365º

Diabetes 365º is a *web* platform dedicated to the dissemination of DM from three main angles: knowing, preventing and caring [74]. It has partnerships with magazines and websites specialized in health, such as those mentioned above, as well as the support of organizations for DM education and prevention, from Medical Associations, Patient Associations, Pharmaceutical Industry, among others [74].

Diab(r)etes

Diab(r)etes is a group that was created on *Facebook* and emerged from the need for people with the same problems, in this case with a chronic disease such as DM, to share their experiences, help each other and learn from each other [75].

The main objectives of this group are to demystify DM, help people with DM who are in need and psychological support through the sharing of experiences, either online in the *Facebook* group, or through meetings that are promoted nationwide [75].

Diabet1cos

Diabet1cos is another *Facebook* group that has similar objectives to the group mentioned above: sharing experiences in matters related to any type of DM, whether for the self or for family members of people with DM, a place to vent to those who understand the situation, to have someone who listens to the patient and gives him a word of comfort [76].

2.9.6.2 Limitations

Online health information presents some inherent difficulties and it is difficult to regulate, meaning quality control is a challenge, and, further, patients vary widely in their health information literacy [77]. Bad health information used in an improper way can be highly detrimental [77]. Patients might trust misleading

information or might make important health decisions based on sensationalized or emotionally charged stories that are not relevant to their health context [77].

Patients are often in a vulnerable position, and many are willing to accept information that provides a sense of hope and control [77]. Owing to a lack of technical knowledge, some patients are also unable to critically assess or might misinterpret health information [77]. These factors can lead to a false sense of knowledge and security, and potentially noncompliance if the patient adopts beliefs that conflict with appropriate medical practices [77].

Chapter 3

Implementation

This chapter is intended to expose the decisions made in order to achieve the main objectives. Then the problems that arose during the preparation of the work will be exposed as well as the strategies to solve them.

3.1 Application Content

In order to achieve one of the main goals of this work which is approaching the content to be introduced into the application, it was necessary to make a research about the application content that is related to the questions that individuals newly diagnosed with DM search. This research was performed into two ways:

- The first way was achieved by search on Portuguese websites or guidelines that are reliable. Most of the guidelines presented are composed of relevant and important information for any individuals with DM who does not have much experience on a daily basis. Thus, much of the information can be systematized for the application due to the fact that they are responses of high need and that they are arranged in several easy-to-understand steps. In the context of this research, a study was also carried out where the main issues that people with DM had during an earlier phase were observed.
- The second way was made through some interviews made to experienced healthcare professionals such as nutritionists and physicians where they clarified several doubts that patients newly diagnosed with DM often have, and in which they worry. The various responses obtained during the interviews were able to clarify several doubts that existed during the investigation of the first method. In addition to complementing these researches, it also served to obtain a new perspective of the patients with DM since the research is based on work made by specialists of the area.

After a careful and more structured analysis of all the methods carried out to obtain the best possible content, a document (Appendix A) was completed that contained all the information regarding the pair of questions/answers that were available for the application. Bellow, all the methods that were approached will be discussed and explored.

3.1.1 Online Communities

In order to be able to carry out a study in relation to a potential user of the application, it was possible to obtain various information about individuals with DM in groups that exist on *Facebook*. These groups are communities that contain people who understand and clarify various issues related to DM and others who are new to some subjects and have some doubts.

Thus, the idea was to create a form (Appendix B) where people from these groups could annotate the questions they had when they were diagnosed with DM. Invitees were sent by a post on the group inviting them to complete the form, accessible via an embedded *web link*.

A total of 8 people completed this form and all participants gave informed consent to complete it. Overall, the findings demonstrated that patients have varied questions and DM is a topic that contains tons of questions. Many of the questions corresponded to some that had already been implemented (the more general questions).

Frequently Asked Questions

- Can I eat sweets? / What can I eat?
- What are carbohydrates and how can I count them?
- What are ketones?
- What is basal and rapid insulin?
- What is the glycemic index?
- Is diabetes curable?
- Can I have diabetic children?
- What are the risks of having high blood glucose?
- Can I travel?
- What physical exercise should I do?

3.1.2 Interviews

3.1.2.1 Nutritionist

The nutritionist signed an informed consent prior to participating in the interview (Appendix C). He was asked about the questions that newly diagnosed patients with DM often have. The interview approached many questions that can be applied on the context of the application (Appendix D). So, in order to complement the application and meet what the user wants, it was necessary to assimilate the most important data.

Firstly, the questions that most individuals newly diagnosed with DM ask are:

- What foods are prohibited?
- What foods can I eat?
- What did I do wrong?

The nutritionist also provided insights about the answer to those questions. For the first two questions it is appropriate to answer that there are no prohibited foods or foods that the patients with DM can eat. Instead, they should follow a dietary pattern that can be considered appropriate for people with DM or for anyone else who does not have DM. The point is that in people with DM it has to be personalized according to their needs which means that the patients with type 1 DM have to follow the intensive therapy through measuring the amount of foods that provide carbohydrates and consequently determine the amount of carbohydrates that they will eat; individuals with type 2 DM should generally ingest an identical amount every day due to the drugs that will be pre-calculated taking into account the methods used.

One of the most common problem is that the body is not prepared to metabolize the amount of carbohydrates that the patient ingest. It is normal to have some foods that are not recommended but it is possible for the person to consume. The same is applied to some type of drinks.

Regarding the last question, it is possible to say that individuals with DM in the first phase are very frightened because there will have to be a huge change in habits and behaviors from now on. This means that there is a radical change in the paradigm about what it was like to be normal because someone who had nothing will start insulin therapy that will have to be with several injections throughout the day, have a device for 24 hours that will have to do the monitoring of blood glucose, worrying about high/low blood sugar, and thinking what they are going to eat.

Furthermore, issues faced by individuals with DM at job were also addressed. The employer and the conditions should allow the individuals with DM to have the opportunity to take care of themselves as long as they have the mechanisms for measuring blood glucose. As long as the job itself provides the conditions for the employees to treat their DM, it is possible to work at any job.

Relatively to newly diagnosed pregnant women with gestational DM, the past is a very important factor and it is not just during pregnancy that women may have the risk of developing a type of DM: age of the woman, obesity before pregnancy, if during pregnancy the woman gains more weight, and if the woman

has had another previous pregnancy are risk factors to consider as well. They should eat about at least 175g of carbohydrates per day. Gestational DM is a warning if in case the woman doesn't care she may become a person with DM sooner than she would like.

Lastly, the nutritionist provided a list of the best *web* pages that can have useful guidelines such as SPD, APDP, American Diabetes Association (ADA), and *Academy of Nutrition and Dietetics*. The table of food composition indicated is the Portuguese Food Composition Table of the *Instituto Nacional Ricardo Jorge*.

3.1.2.2 Individuals with Diabetes Mellitus

The sessions that were held with people with DM addressed the content of the application. Before participating in this session, participants signed an informed consent (Appendix F). This step was very important because the main target audience is people newly diagnosed with DM and, with people who already have DM, it was possible to clarify some doubts such as what questions they had when they were diagnosed as well as review the content that was developed. These sessions were conducted through a semi-structured guide presented in the appendix G.

Regarding the question "Why do I have diabetes?", initially it only addressed a target audience, which in this case would be people with type 2 DM. Through conversations with people who got DM it was possible to notice that the answer was still incomplete because it did not mention a reason for people with type 1 DM.

Other corrections were pointed out in the way the questions are asked. With the help of individuals with DM, it was possible to clarify more correctly how they would do this issue. From the user's point of view, it is an important way to customize content to make it easier to stay clear. Regarding the rest, in a way it was evaluated positively, and the patient with DM easily understood what the message of the answer to each question intended to convey.

In the end, the participants indicated some questions that they had in the diabetes diagnosis phase that were not present in the content already presented. The questions that were pointed out to add included the most basic definitions of terms related to DM, such as the following questions:

- What is insulin?
- What are carbohydrates?
- What is hyperglycemia?
- What is hypoglycemia?

3.1.2.3 Doctors

General practitioner doctors are typically the primary point of care for a DM–related health issues, so these participants were targeted for the evaluation of the content of the mobile application that will serve

to meet the daily needs of patients newly diagnosed with DM. A total of two doctors who have experience in the area participated after signing an informed consent (Appendix C).

The content already developed and added to the application was based on guidelines that were developed by the diabetic communities in Portugal and on the interview that was approached with the nutritionist. In order for this interview to have some structure, a semi-structured guide was created with questions that were asked (Appendix E).

What can I eat for breakfast/lunch/snack/dinner?

A very important aspect is that a person with type 2 DM, in the last stage can behave like a person with type 1 DM. When it comes to the treatment of type 1 DM in relation to what the person with DM should eat for breakfast, lunch, dinner varies a little. Some people do not undergo intensive care and, especially in the beginning, a person with DM still does not know how to count carbohydrates. It is something that the patients learn but there are those who never manage to do it.

When can I travel?

In this question a correction regarding the use of *Glucagen®* was advised: it is a hormone produced by the alpha cells of the pancreas. Increases blood glucose causing it to return to normal values. It has a very fast action [78]. Normally, *Glucagen®* is used as a treatment for hypoglycaemia in a person with type 1 DM as it is not used in most individuals with DM. With that being said, it should be noted that *Glucagen®* must be prescribed by the health unit.

The information regarding the European Health Card was incomplete as it is explained in general. Therefore, in addition, it should be noted that in Portugal, the European Health Card must be requested online on *Segurança Social Direta* if the patient is a beneficiary of *Segurança Social*, at a *Segurança Social* service desk or at a shop/citizen's space.

Another important aspect that was not presented in the answer to this question is the fact that it is necessary to assess the level of healthcare in the country to be visited.

What are the precautions before getting pregnant?

In this question, it is necessary to indicate to the patient that they must inform the medical unit as they send the person to a specific consultation in order to be able to clarify all questions before the pregnancy.

A woman can develop gestational pregnancy when it is diagnosed in the period of pregnancy but from certain values because if the blood glucose or glycated hemoglobin is too high after a certain value, she has DM. There is a spectrum of values and the diagnosis of gestational DM is different from diabetes mellitus.

People with DM who become pregnant or who contract some form of DM during pregnancy will always be followed up with specific consultations with an endocrinologist.

Rapid acting insulin vs Long acting insulin

There are another medication beyond pills or insulin for individuals with type 2 DM: at this moment there is also medication that is injectable/subcutaneous that is not insulin. There is a lot of fear in taking insulin (especially in older people).

Another information that was added to the bot application was about the two types of insulin which are rapid acting insulin and long acting insulin: the long one usually works very well for individuals with type 2 DM and covers the whole day; the fast one is usually given before meals. In a person counting carbohydrates, rapid insulin units can be given according to the count. If the person does not know how to do it (or has not yet learned how to do it) the counting can be done depending on the value of the blood glucose spike that the person has before the meal.

Glycated Hemoglobin

Glycated Hemoglobin is a blood test that shows what is the average blood sugar level that has been in the patient for the past 2 to 3 months. This test is important to check if the DM treatment is working the right way. This term was indicated in both interviews because patients take the test and often do not know what they actually do in the preliminary sessions. Accordingly, this information was added to the bot.

Diabetic Foot

Among all the complications, the one that was clearly addressed by the patients was the diabetic foot. Older people usually ask at diagnosis if they will ever lose foot/leg and what they can do to prevent it. Therefore, the introduction of foot care was recommended as it is something that gives concern.

Vaccines

Another of the topics that was discussed and did not exist in the content already made was the introduction of vaccines. This issue is, in fact, something that patients also ask.

As individuals with DM are at greater risk of complications, they should be vaccinated with:

- *Streptococcus pneumoniae*: Vaccination against the infections. Period should be clarified with the medical unit.
- *Flu vaccination*: Vaccination that the patient must get every year.

Diabetes MODY

Diabetes MODY is basically clinical research diagnoses, so it is irrelevant to be in the application's content. In this case, it was advised to remove any questions regarding this topic as it will not help the patient at all.

Stress and depression

These sessions addressed the issue of stress and depression in people who have DM. It is a very interesting topic that people face during their lifetime, being associated with life events such as mourning, conflicts with important people, bad news, difficult changes and adaptations. The frequency of depression in people with DM is almost double that of people without DM [9]. Then, its is important to include this topic in the bot.

3.2 Application Development

3.2.1 Chatbot adopted

Deciding on a technical approach is only the first step to building a successful chatbot. Since this work will have a structured data for responses and the chatbot will be used for the patients resolve their issues, the chatbot adopted was the IR based one. The other reason is that more novel approach (ML based chatbots) will be limited by the research capabilities, since these are less proven directions and many chatbots with advanced algorithms still have failures with user experience.

Given that there are not many chatbots in Portugal that can help in the field of medicine, this is a good context for the development of one for people newly diagnosed with DM. The goal in creating this chatbot is to be able to have a pedagogical effect that can help people by exchanging important information. There are already chatbots that generally help a person with DM, but it does not exist in Portuguese and they are mostly web applications. The context of this dissertation is part of the creation of something to be able to help people who can communicate in Portuguese following the available guidelines of the Portuguese associations.

Furthermore, the strategy was planned to make an application that could be as simple as possible (considering the age group) and for smartphones since more people of this age group are starting to use these devices, and the communication is easier.

3.2.2 Application Requirements

For the elaboration of the requirements it is necessary to analyze for which age group this application will be destined. Since DM affects the age group from 40 years old and up, it is necessary to create a mobile application completely suitable for this type of users. Therefore, the main objective is to create a simple and intuitive mobile application in which the user can access this chatbot very easily. So, one of the main requirements that can be identified initially is the fact that the user may have some knowledge regarding the use of chats, otherwise he/she will experience some difficulties since he/she has never used something like this.

3.2.2.1 Functional

1. The user must authenticate himself/herself in the application using his/her name.
2. After the authentication, the user will receive a message on the main screen of the application (generic chat interface) from the bot that explains the existence of the chatbot and the functionalities in the main menu.
3. On the main screen of the application (generic chat interface), the user will be able to access the following features:
    a) View all conversation
    b) Send message
    c) Copy message
    d) Delete message
    e) Exit the application
4. On the generic chat interface, the user will be able to have access to the help screen where he can ask a question that the bot was unable to answer
5. The user can send any message to the bot. Bot will eventually receive all answers.
6. After the first authentication, the screen of authentication will never appear again. When the user starts up the application it opens a load screen and then the main screen of application with the old messages loaded.
7. When the user faces connection problems in the chat interface or in help screen a warning screen appears.
8. In the help screen, the user only has to put the question in a text box and proceed. Later, the bot will reply in the chat interface.
9. The user can see the old messages by sliding up on the chat interface.
10. Each message has the date and time identified.

3.2.2.2 Non-Functional

1. The system should be developed for use in smartphone devices and be careful with regard to ease of use, so that interacting with it is easy and intuitive.
2. The application needs *Wi-Fi* or mobile data for its use.
3. The system must have high availability, be able to maintain the confidentiality and integrity of users data, against other users or external entities, in accidental or purposeful cases.

4. Users who have already had experience with a chat, will use the system without difficulty.

5. The system should have high availability.

3.2.3 System Architecture

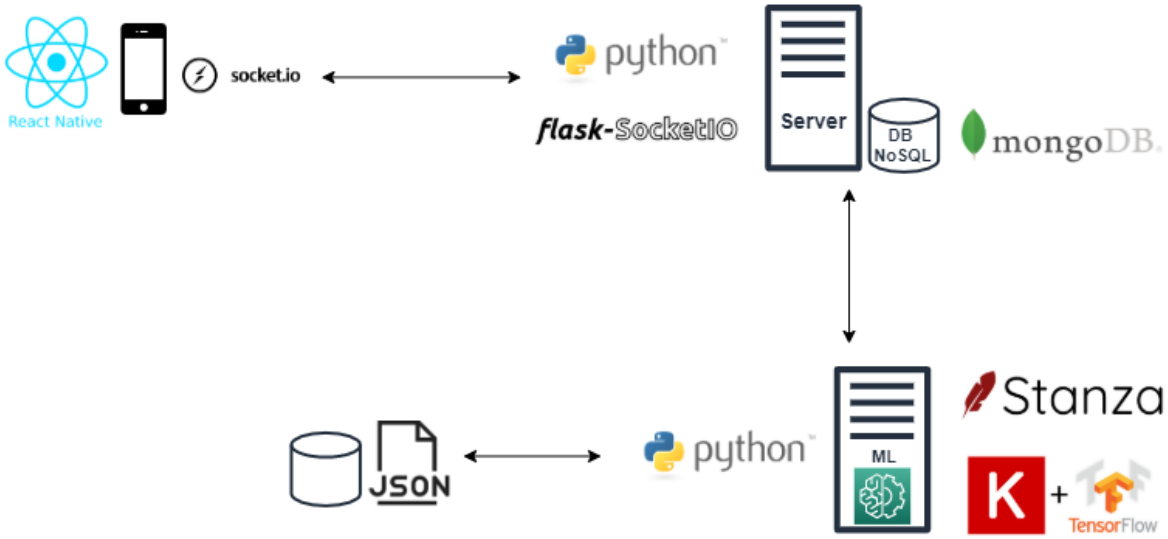

Figure 3.1: System Architecture of the project.

The system architecture is composed of three parts as illustrated in Figure 3.1: the front-end, the back-end and the bot response engine (ML). In order to achieve a proper environment it was made communications based on *WebSockets* between the front-end side and the back-end side, and the ML engine was integrated with the server located on back-end. Moreover, these three parts have different purposes in order to work together.

The front-end side refers to the client side where it is supplied the user interface that communicates to the back-end to get all information. In this case, the interface was developed for *Android* or *iOS* smartphones through the *React Native* framework.

The back-end side works with the calls that are made by the front-end. The main focus here is the work with the messages that are exchanged between the user and the bot (response engine). It was developed on *Flask* framework and uses a Not Only Structured Query Language (NoSQL) database, more precisely, *MongoDB* in order to store user informations, messages, and questions that the different users can have.

Furthermore, as the communication of front-end and back-end is through *WebSockets*, it is possible to deduce that front-end uses *Socket.IO* framework written in *Javascript* and back-end approaches are defined with *Flask-SocketIO* framework.

Lastly, the bot response engine or ML engine is where the ML is applied. It is a system that can receive any message from the user and then processes it accordingly with the trained data. The structured data with the questions and the answers is stored on a JSON file that is used for the training process. For preprocessing the messages using NLP it was necessary the *Stanza* package, and then in order to train

data the presence of *TensorFlow* and *Keras* frameworks working together were needed. In the end, the final response is generated and the communication works directly with the back-end side.

3.2.4 Decision Making

3.2.4.1 Front-end side deployment

With the objective to build the front-end side, the first concern was about to create one codebase that could work on both *Android* and *iOS*. The fact that there is no need for two different development for two platforms and to synchronize features and layouts solves many of the problems of building a front-end.

With that being said, it was chosen the framework *React Native* because it supports cross-platform development, which provides a consistent user experience across multiple platforms, it is more efficient and faster to launch, and there is no need to develop in the native languages of the devices.

3.2.4.2 Back-end side deployment

Since the communication is made with *WebSockets* and the client-side uses one of the *SocketIO* official clients libraries (in *Javascript*), it was used *Flask-SocketIO* framework. *Flask* is one of the robust frameworks which is known for its simplicity and flexibility. Furthermore, it is needed more control about which components to use such as database or the bot response engine system.

Then, it was necessary to plan which cloud should be used to the deployment. Among all those that were researched, the best type that had better characteristics and compatibility capability for use as a *Flask* wrapper in *Python* was the creation of a *Python* development environment capable of providing the developed framework.

The final solution consisted of using an Amazon Web Services (AWS) product: Amazon Elastic Compute Cloud (EC2). EC2 is a web service that provides secure, resizable compute capacity in the cloud. It is designed to make web-scale cloud computing easier for developers. It provides complete control of computing resources and runs on *Amazon's* proven computing environment. The selection of computational resources was limited to the free option and consisted of the creation of a virtual instance on the *Windows* platform.

3.2.4.3 Database for back-end

The most suitable option for the database was the creation of a non-relational database since the use of document databases are extremely flexible, allows variations in the structure of documents and allows storage of documents that is partially complete. So, it was chosen *MongoDB* that allows to build a clustered topology with replication and sharding. It means there will be horizontal scaling with no downtime even on the maintenance hours.

3.2.4.4 Communication between front-end and back-end

The main reason for choosing the type of communication is based on the application that is intended to be developed. Therefore, as the application will be a chatbot and there will be conversations in real time, the communication would have to be done with *WebSockets* and not by Representational State Transfer (REST). The best reasons are discussed below.

- *WebSocket* is a low-level protocol based on the concept of socket and port, which are the underlying transport mechanism, whereas REST is based on Create, Read, Update and Delete (CRUD) operation [79].
- *WebSocket* approach is ideal for real-time scalable application, whereas REST is better suited for the scenario with lots of getting request [79].
- *WebSocket* is bi-directional in nature, i.e. both way operation from client to server and vice versa is possible, whereas REST follows a uni-directional approach [79].
- *WebSocket* works better, where the client-server communicates over the same Transmission Control Protocol (TCP) connection for the life of web socket connection whereas, for an Hypertext Transfer Protocol (HTTP) request, a new TCP connection is initiated [79].
- *WebSocket* communication allows the client and server to talk independently of each other, whereas with the REST-based approach, either client is talking to the client or the server is talking to the client at any given time [79].

3.2.4.5 Bot response engine deployment

For the deployment of bot response engine *Python* was used because it is more stable, flexible, and has many tools available. This programming language is the best fit for ML and AI-based projects, since it includes simplicity and consistency, access to great libraries and frameworks for AI and ML, flexibility, platform independence, and a wide community. These add to the overall popularity of the language.

For preprocessing the data, *Stanza*, a *Python* NLP package was used. The choice of another package could be made, such as Natural Language Toolkit (NLTK). The adoption of *Stanza* is due to the language that will be used for preprocessing. The native language is Portuguese and, as NLTK is quite incomplete for this language, *Stanza* was chosen because it is a very recent and well updated package in relation to Portuguese.

Since it is needed a scikit-learn type for building Neural Networks, *Keras* was used as part of a *TensorFlow* workflow that is completely Python-based framework and supports almost all the models of a neural network. *Keras* layers and models are fully compatible with pure-*TensorFlow* tensors, and as a result, *Keras* makes a great model definition add-on for *TensorFlow*.

3.2.5 System Modeling

Before proceeding with the implementation of the application, it is necessary to develop a modeling of the system in order to understand how the application will be presented to the user experience.

The key to modeling was to think about the type of user who will use the application. Due to the age group, it was crucial to create something that has an easy usability and flexibility. Along with the modeling, it was necessary to plan how the features can be arranged so that the user has a simple and accessible experience.

Thus, a Unified Modeling Language (UML) activity diagram was implemented for capture the dynamic behavior of the system (execution and flow of the behavior of a system). This type of diagram consists of activities that are made up of actions that apply to behavioral modeling technology. Next, a diagram of this type will be presented, which consists of the activities and actions that the user can choose.

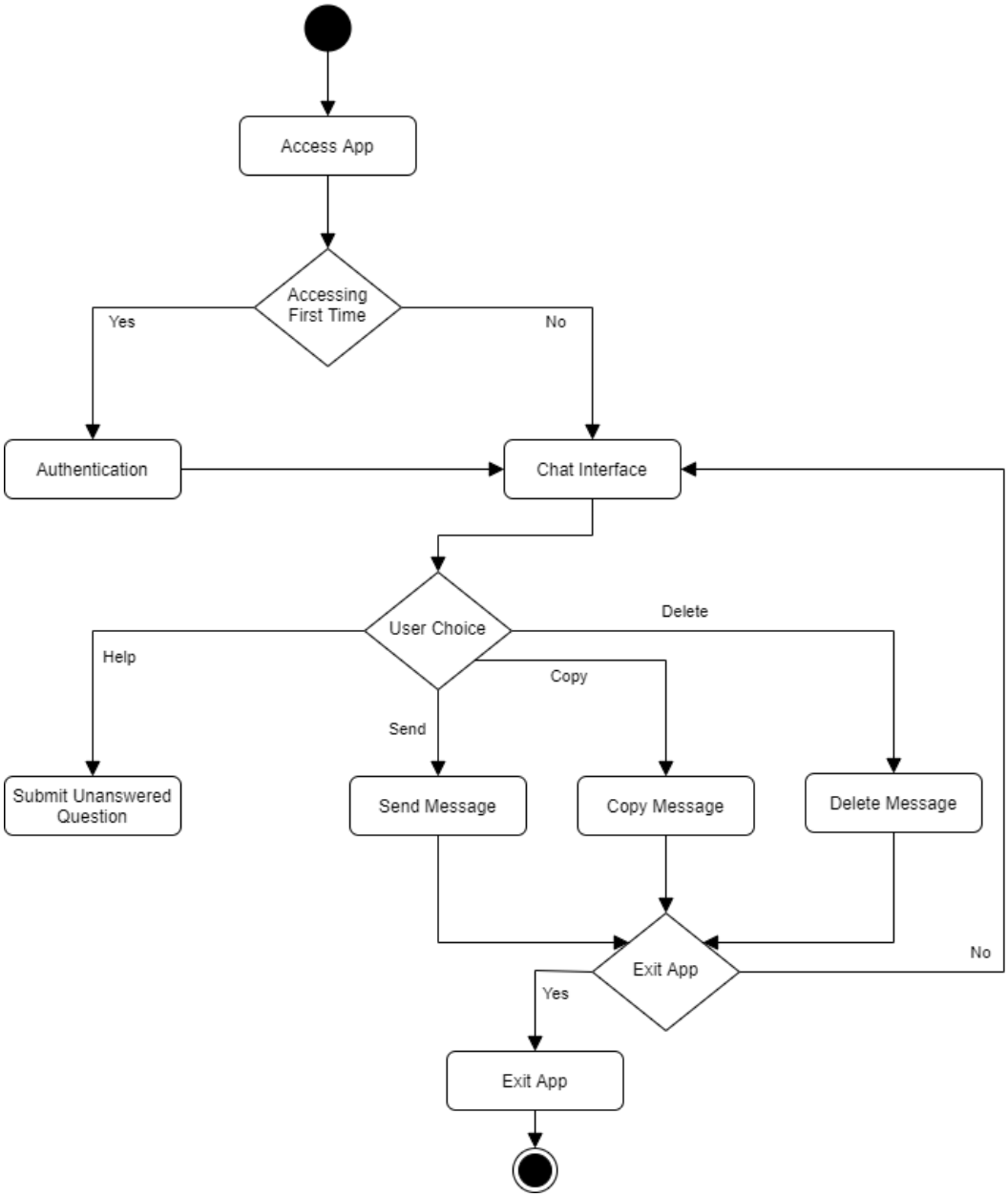

Figure 3.2: UML activity diagram of the application.

3.2.6 Implementation of the application

The main idea in implementing a chatbot application was to create a first version that was a local Graphical User Interface (GUI) (with terminal). In this way, it was possible to do several tests on the bot response engine in order to improve the bot. When the bot response engine was ready to use (with a few concepts of DM), it was necessary to proceed to the main GUI: *Android* and *iOS* smartphones. To accomplish that, it was created a second version that was a local running device or an emulator through *Expo*. At this stage, a lot of updates were made in relation to the front-end in order to make improvements in the quality and accessibility of the application for the user. Lastly, the final version was about to the deployment of the application through a *Cloud*. After that, the application was ready to use in order to make some tests.

3.2.6.1 Bot response engine

The bot response engine was made based on the use of the *Keras* as a part of a *TensorFlow's* library as it was said earlier and using the principles and concepts of ANN directed to Feed-Forward Neural Network. This is divided into two steps: the first one approaches the preprocessing and training of data; on the other hand, the second makes the prediction by loading the model created. As a final result, a limitation of the error was made in order to have an percentage of efficiency of the response on the bot side. The efficiency percentage refers to the degree of certainty that the bot has of an answer being set to 85%.

In short, based on the training that was done, the responses that the bot is giving are based on a confidence of 85% of being able to respond, and if it is below it will indicate that he did not understand the content of the message that the user sent.

Preprocessing data

The first phase involves the processing of all data in order to be trained. NLP is used here to remove punctuation marks, use tokenization and make the lemmatization of the sentences. To achieve this, *Stanza* was used. Firstly, a total of 4 sets were defined:

- Set of punctuation marks: This set contains the punctuation marks and it will remove all the punctuation on each sentence (question or answer).
- Set of words: It will contain all words of all sentences after the proccess of lemmatization and the exclusion of punctuation.
- Set of tags: The tags are intended to be the unique identifier for a given set of defined questions/answers. So, these tags will be added to this set.
- Set of documents: This set will be a set of pairs where the first value is precisely the set of words and the second is the tag referenced to the set of words which means that each pair refers to each sentence (question or answer).

In order to add some content to these sets, a JSON file with all the tags, questions and answers was created because it was more appropriate and simple to store and read content. Lastly, after the sets are complete they are serialized and saved into pickle files.

```
{
    "tag": "cumprimento",
    "patterns": ["Olá", "Boa tarde", "Bom dia", "Boa noite", "Ola"],
    "responses": ["Olá!", "Olá, como posso ajudar?", "Olá"]
}
```

Figure 3.3: Example of JSON file composition.

Training data

The second phase contains the conversion of all the sets approached above to a BOW and the creation of a proper model to be trained.

Firstly, it was necessary to convert the text into a numerical form (vectorization) to create the model. For that it was created a BOW. In order to accomplish this, the set of all words was used. For each sentence (pattern) it was created an array with the size of the words set. This array is filled with 0's or 1's: if the a word on the sentence is equal to the word on the words set it is filled with 1, otherwise it is filled with 0. This process is made for all the sentences (questions/answers) that were created at the start. Then, it was created to lists called *train_x* and *train_y*: *train_x* list refers to the vectorized result for the model creation; *train_y* which is made up of numbers that serve as unique identifiers for each tag.

The next step involves the creation of the model that will receive the two lists (*train_x*, *train_y*). The model has three layers: on the first one with 128 units, the input shape will be the length of *train_x* list and it is applied the Rectified Linear Unit (ReLU) activation function which means the element-wise maximum of 0 and the input tensor; the second one with 64 units will use again the ReLU activation; the third one with the size of the tags set as the unit number and it will use the *softmax* activation in order to be made the probability distribution. Between these layers, it is used a regulation layer which is called *Denser Layer* to prevent over fitting. Before creating the model, it was used the SGD.

After create the model it is necessary to train itself, over a number of epochs that can be defined with any number. In this case it was used 300 epochs. Finally, the model is saved locally.

Load model and predict

The prediction will work based on the sentence/question that is given as input. In the first step, it is made the preprocessing of the data on the sentence with NLP: remove punctuation marks, use tokenization and make the lemmatization of itself. Then, it is used the words set that contains all words that were trained in order to verify if any word of the sentence given is on this set. After that, and based on this verification it is made the prediction with the model that was created and loaded. Then, it is analysed through the probability distribution which answers are above the threshold error that is 85%. Lastly, it is verified if there are any results: if there are results, it is created a list with the final results ordered by the best percentage.

After the results are displayed, it is essential to get all the answers for the sentence/question that was given for the input. So, with the final results it is only needed to compare which tag is the same between the final results and the JSON file that contains all tags associated to all questions and answers. After that, and when the tag is found it is chosen a random answer of that and the final answer is presented for the user that asked the question.

3.2.6.2 Back-end

Before the implementation it was needed to create a new database to store all the messages between the user and the bot. For that it was created a new cluster on *MongoDB* available for all Internet Protocol

(IP) addresses which means that it was defined 0.0.0.0/0 where effectively specifies all networks. In this database there are two collections: the first one is called *questions* and stores all the questions that the user has sent when the bot failed to send a proper answer. This collection will help out through the adding of new sets of questions/answers; the second one is called *users* and contains the identifier of the user, name of the user and all the messages exchanged.

The communication between back-end and bot response engine is made locally. The back-end will call directly in order to use it. Then it is created a method that will make the prediction for a certain message/question. In order to accomplish the communication through *WebSockets* between the back-end and front-end it was used a *Socket.IO* integration for the *Flask* application. With *Flask-SocketIO* the server needs to register handlers for the events, similarly to how routes are handled by view functions. So, the server-side event handler is defined with the following events:

- **authentication**: this is the authentication from the user. He/She only needs to give a name that will be registered on the collection *users* with a pre-defined message from the bot explaining the application. Then, it is sent the identifier that was created for the user by a socket emit.
- **chat message**: this will handle the messages which means that it will receive the message from the user and then is made the prediction of the answer, the storage of the received message and the generated one on database, and the answer is sent back to the user by using a socket emit.
- **getname**: the front-end needs to request the name of the user that is using the application. It is just made a query to find the name and then it is sent by a socket emit.
- **load messages**: this will load all the messages exchanged between the user and the bot through a query to find the identifier of the user, get all messages and then the socket emit.
- **delete message**: as the name says, this will delete a message through the identifier of the user and the identifier of the message.
- **add question**: this is to add a question that the bot cannot answer. The user will have on the interface an option to make this type of questions that are stored on the collection *questions*. Basically it is made an insertion on this collection.

In an initial phase, this implementation was developed for a local environment which means that the back-end was run locally to test communication via *WebSockets* with more accessibility. When the back-end was complete, it was proceeded the placement into a cloud. As it was said before, the chosen one was EC2 with the creation of a virtual instance on *Windows*. The virtual instance created in the EC2 service uses an Amazon Machine Image (AMI) that is a template with a predefined software configuration. The actual configuration is defined for *Microsoft Windows Server 2019 Base 64-bit*. The instance type is a free version (*t2.micro*), which is thus limited: 1 Gigabyte (GB) of memory, 1 virtual Central Processing Unit

(CPU), moderate network performance, it has Internet Protocol version 6 (IPv6) support and a storage with the volume size defined to 30 GB.

After the creation of this instance, it was necessary to put the back-end to run globally, so that there are HTTP ports used to communicate with all smartphone devices that use the application. So, in order to accomplish that it was needed to define inbound rules on the security group rule. With these rules, it was possible to obtain a server connected to port 0.0.0.0:80 on the EC2 instance. Next, the inbound rules are presented (Table 3.1):

Table 3.1: Inbound rules for the security group rule.

IP version	Type	Protocol	Port range	Source
IPv6	HTTPS	TCP	443	::/0
IPv4	RDP	TCP	3389	0.0.0.0/0
IPv6	HTTP	TCP	80	::/0
IPv4	HTTP	TCP	80	0.0.0.0/0
IPv4	HTTPS	TCP	443	0.0.0.0/0

After the inbound rules are defined, the back-end server can be accessed via the public Internet Protocol version 4 (IPv4) address with the port number defined as 80.

3.2.6.3 Front-end

The front-end implementation was always with the objective of following the mockups that were planned. Accompanied by many tests developed through the *Expo*, it was possible to make several improvements and identify what may or may not facilitate the user's experience.

Therefore, for the development of the front-end, a division of development was made:

- A main screen for user authentication, where the user has to type their first and last name and verify the check boxes.
- A second screen will provide chat with the bot accompanied by a menu and an option to close the application.

Authentication screen

In this screen is where the user puts his name, verifies terms and conditions, privacy policy and then submits these actions. So in order to accomplish this, firstly it was made input validation to force the user to follow the defined requirements. After verifying the input and the validation, there is a button that the user confirms his actions and completes the authentication. In this button it is made a call to the back-end via *WebSockets* with the name of the user. The back-end will generate an identifier for this name, and will send back to the front-end that receives and stores this information through *SecureStore* that provides a way to encrypt and securely store key–value pairs locally on the device. These key-value pairs are essential

for the application to work: if there is a user identifier stored locally on the device the authentication is bypassed; with the user identifier it is possible to load all messages exchanged with the bot that are stored on database; when user wants to ask a question that the bot cannot answer, the identifier is essential as it is stored in the database so that a suitable answer can be added later. The *Terms and Conditions* or *Private Policy* screens were created simply being that for the time being they are in the form of prototypes (Figure 3.4).

In order to create this screen, it was necessary to provide a way for the application to make transition between screens such as moving to *Terms and Conditions* or *Private Policy*. This was accomplished with the introduction of Stack Navigator.

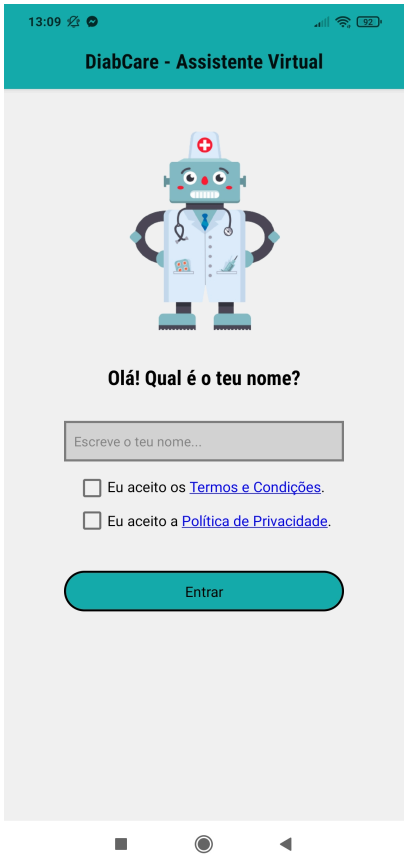

Figure 3.4: Authentication Screen.

Chat interface screen

This screen is where the user will be able to chat with the bot and clarify his/her doubts. If the bot is unable to answer a question, it will prompt the user to access the main menu and then go to the help screen in order to send the question if relevant. In addition to the help functionality, there are other sections such as the terms and conditions, the privacy policy, and an explanation of what the application is about.

In a first phase, the main screen of the chat interface was developed with the aim of the user being able to communicate with the bot. The communication was all done through *WebSockets*. A loading screen will open, while two calls are made to the back-end: one to get the user name that is associated with the

locally stored identifier and another to load all messages exchanged between the user and the bot. After the messages are loaded, the chat interface screen is presented to the user.

The chat interface was developed using *Gifted Chat*, the most complete chat UI for *React Native*. The best approach for creating this screen was to use a *Drawer Navigator*, as it provides access to destinations and application functionality. Thus, in addition to the chat screen, it is possible for the user to access a help section in order to contribute to the development of this application with new questions and answers.

- **Chat**

  On the chat, when the user sends or deletes messages communications are made. In order to send or delete a message, it is necessary to send the message object and then, make the necessary changes in the database. A message is an object (Figure 3.5) composed of the following attributes:

  (i) **text**: Message content.

  (ii) **user**: The user is characterized by his/her identifier, name and image.

  (iii) **createdAt**: Date and time that the message was sent on *ISO* format.

  (iv) **_id**: The identifier for the message that was sent.

```
{
    _id: '05f69224-7c7b-4dfb-b946-ff7b93113a23',
    text: 'Olá',
    createdAt: new Date(),
    user: {
        _id: 1,
        name: 'BOT',
        avatar: 'https://i.imgur.com/g9KrzbX.png'
        }
}
```

Figure 3.5: Message object composition.

In case the user sends a message, he/she will automatically have to wait for a response from the bot, which will eventually answer through a communication from the back-end. On this screen (Figure 3.6), the user can also copy a message or, if he/she wants, he/she can close the application.

Through the features of *Gifted Chat* it was possible to add features such as the status of the bot (whether it is writing or not) and the automatic scroll to the end of the conversation that contribute to a significant improvement in the usability of the application.

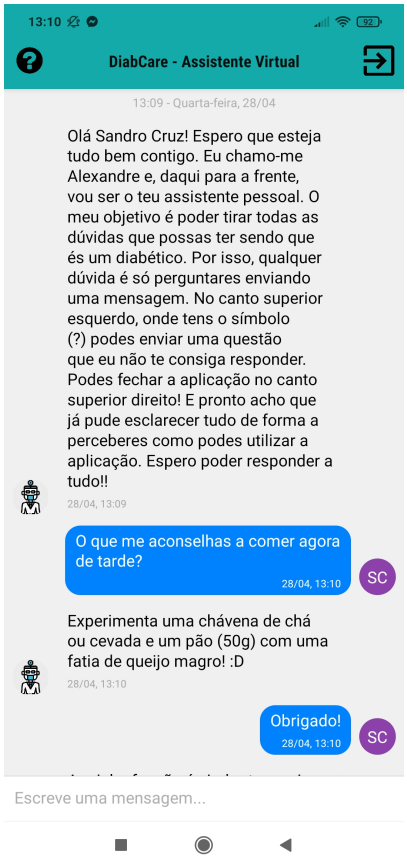

Figure 3.6: Chat screen.

- **Help Section**

  This section is very important for the application as it allows the user to send a new question that the bot cannot answer, as shown in Figure 3.7. If the bot is unable to answer a question from the user, it will send an automatic message asking the user to go to the help section and submit the question. Later the database will be updated and the data will be trained accordingly along with any new answers that may come. With the database updated, the user will receive a message with a bot response to that question.

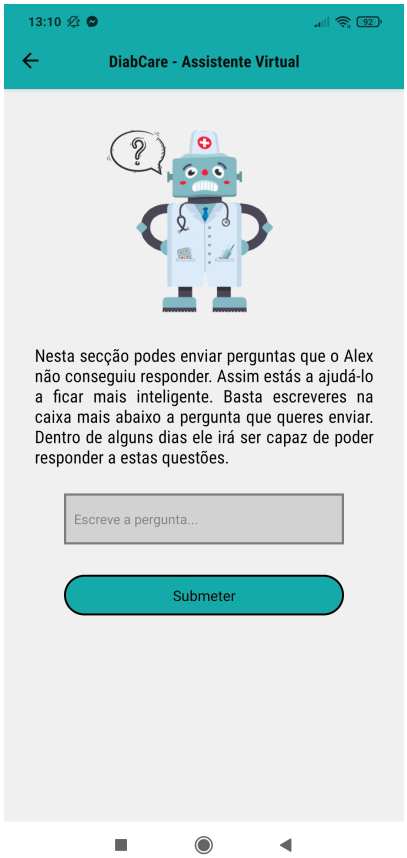

Figure 3.7: Help screen.

3.3 Human-Centered Design

3.3.1 Usability Tests

Usability is defined as the degree to which a program can be used to achieve quantified objectives with effectiveness, efficiency, and satisfaction in a specified context of use. Furthermore, it is a critical aspect in interactive software systems and so it is essential to incorporate usability in chatbots, to improve user experience.

The usability tests were made with users on the group age greater or equal than 40 years because it is in this age group that there is a higher incidence of DM, that is, a greater number of people are diagnosed and therefore they are users with characteristics similar to those of potential chatbot users; and to people who had DM for some time. The task described the performance of a test in order to identify potential usability problems of the current state of this mobile application *DiabCare - Assistente Virtual*. Before conducting usability testing, a prototype that would allow a simple conversation with the chatbot was created.

3.3.1.1 Usability testing plan

The usability testing plan included the definition of the main objectives of the tests, the appropriate choice of participants, the design of scenarios and tasks to be proposed, the location of the tests, the equipment used and the analysis of results.

The analysis of the results included quantitative and qualitative methods. Thus, it was possible to standardize the test in more detail, covering not only issues of efficacy and efficiency, but also the participant's opinion, their reactions, posture and approach to the use of this technology.

In this model, the user data insertion times, the capture and sending of information, the exchange of messages with the bot and the comments made by the participants during the test were followed by *Think Aloud* method and conducted in a remote or personal environment for more convenience.

Context for testing

All sessions were recorded on video, with the aim of quantifying the number of errors and assistance, as well as the recording of the task, for each participant.

During this presentation, the participant was invited to read the informed consent and sign it, if they accepted the proposed terms. At the end of this process, and if the participant has accepted the terms, the moderator will explain to the participant how the application is constituted and what he/she will have to do for its correct use. The participant can ask any question in order to clarify any doubts he/she has before using the application, if necessary. All participants were asked about demographic characteristics, namely, age, gender and previous experience with a chatbot.

The next step focused essentially on the presentation of the scenario: the participant was presented with the context in which the test should take place, the platforms with which it will interact, what will be analyzed and what the final objective of their tasks will be. During the test, the participant is asked to comment on their experience of interacting with the system, in order to complement the analysis made by the usability tests and observation made by the moderator. At the end, the moderator informs the participant that the test is over, thanking for the participation. Participants are also asked to make a brief summary of their experience, in order to highlight the challenges of the system in the real context of use and showing the images captured during the test.

The objective here would be to be able to make an analysis with the user regarding the use of the application that they use in their daily to chat, according to their age group and gender.

3.3.1.2 Participants

In order to carry out these usability sessions, a total of 12 individuals were recruited: 2 individuals with DM and 10 people from the age of 40 with one participation each. In order to participate in this session, each participant was asked to sign an informed consent in order to know the entire context of these usability tests.

3.3.1.3 Test Local

Usability tests were performed in two ways: remotely or in person. In this way, it was always approached where the user preferred to do it, and then it would be explained how they would be done.

The tests that were carried out in person took place in a room with good visibility conditions, so that a recording of the user trying the application could be made. These recordings were made through a smartphone (*Xiaomi Redmi 9*). On the other hand, tests that were done via remote were performed using *Zoom* or *Microsoft Teams*. Thus, the user would be asked if there could be a recording of the browser's screen because all the conditions for the application to run in an online emulator were met. That being said, it would be possible for the user to do the test by computer in a simple way.

3.3.1.4 Scenario

After an initial introduction to the *DiabCare - Virtual Assistant* application, the user was asked to proceed with the use of the application, imagining that it was a patient who needed to clarify their doubts related to the topic of DM.

The user was told that the main objective of the session was evaluate whether the user would really be able to use the application in an accessible way and that he/she would not have any knowledge about what questions he/she should ask in the chat. Thus, the application would be used, sending a random question simply to check if it could use it in the best way and if there was something to improve related to the user interface.

3.3.1.5 Tasks to be performed

In order to perform the usability test of the *DiabCare - Virtual Assistant* application it was necessary to divide it into single tasks where the user could check whether he/she could use it easily or not. Therefore, these tasks will be presented below, as well as a description of them.

(i) **Application Authentication**

In the first task, the participant is asked to start running the application and start the authentication that is initially required. It is briefly explained that the user's name must be placed in the text box, and the user must accept the terms and conditions as well as the privacy policy in order to proceed.

(ii) **Exchange Messages**

The next step included the use of chat by the user: read the introductory message that the bot sent to understand how the application is constituted, send a message and receive a response from the bot. In the end the user would say if it was done easily or if there could be improvements.

(iii) **Access help section**

This task was used to identify if the participant could access the help screen without needing any explanation, thus realizing what the bot explained in the chat when it did not perceive a message. Therefore, the participant had to go to the help screen, send a completely random question as it was just to check usability and then go back to the chat interface again. At the end, the user gave feedback about it, alerting if the way it was developed would be enough or if there was something better to use.

(iv) **Exit the application**

The final phase deals with the part of the user closing the application and he/she can use different ways to exit. The objective here, would be to see how the user left to be able to understand the easiest way.

3.3.1.6 Application Display

Initially, the *DiabCare - Virtual Assistant* application was developed in a very simple scheme. Its operation was intended to make it easier to use for the various users who experienced every aspect in detail.

On the authentication screen the user would have to enter his/her name and accept the terms and conditions as well as the privacy policy to proceed. After this authentication, a chat screen will appear, which will already be familiar to users who chat on a daily basis through applications of the same kind, where the user will have to carry out a conversation by sending a message so the bot can respond. If the bot cannot understand the message that was sent, it will ask the user to press the button located in the upper left corner and then the question will be placed in that section to be sent to a database to be processed and sent back with a concrete answer.

At the end, it will be discussed with the user if the display is designed to be used very easily or if there is any aspect to improve. Through the opinions of various users, a record will be made of what can be changed and what is not needed.

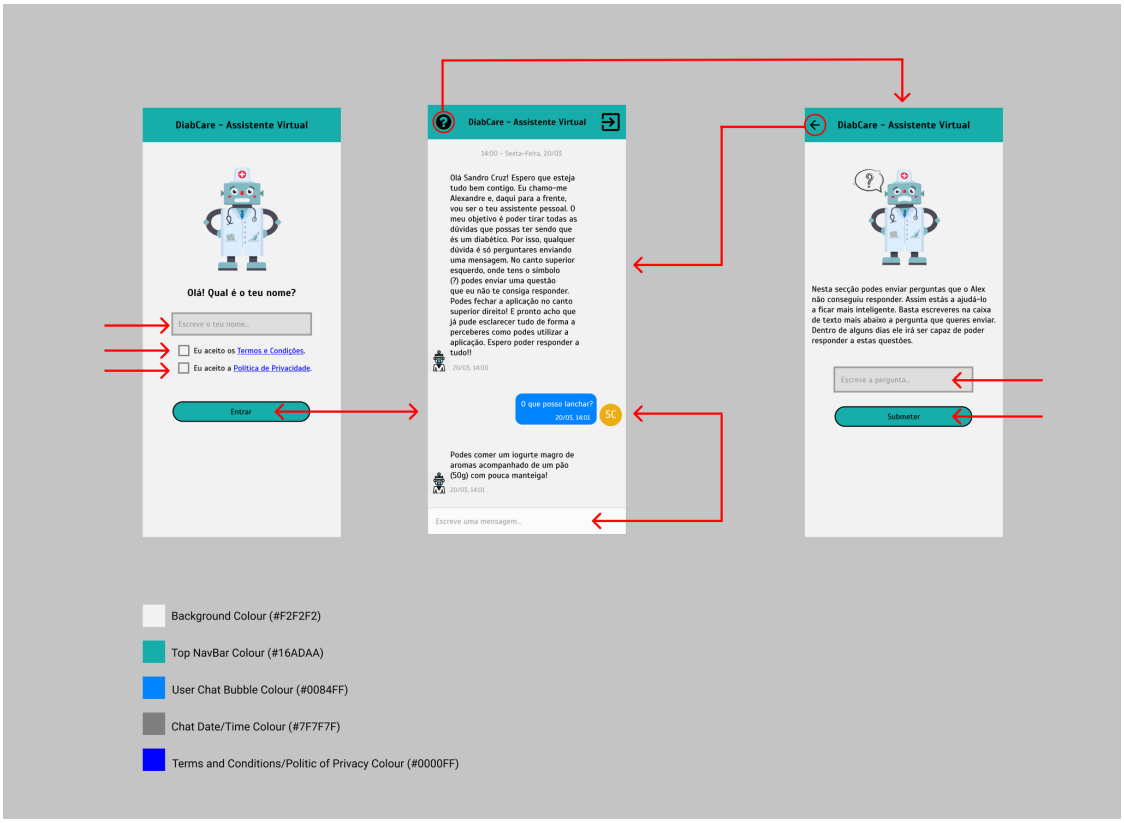

Figure 3.8: Flow navigation of the first version of the application.

3.3.1.7 Analysis Metrics

The system's effectiveness was measured by the rate of completion of tasks, errors and assists. A task will only be completed if its condition is true. An error will be counted whenever the participant performs an action that does not contribute to the task's completion.

An assistance is considered whenever the participant requests the assistance of the moderator to perform the task. If assistance is required it means that the task has not been explained well, it is not considered assistance in completing the task. If the facilitator intervenes because he feels the participants need help, even if it does not come forward, this is also considered assistance.

The efficiency metric will be used measuring the time required to complete the task and used as a benchmark for time performance. Field observation and the *Think Aloud* protocol were the metrics used to qualitatively analyze device usage. In this way, it was possible to characterize the test in more detail, considering the participant's opinion as well as their reactions, posture and approach to the use of this technology.

3.3.2 Analysis of results

The project coding scheme for this analysis includes errors, assists and tasks. In certain tasks there are cases where the participant may make mistakes or need some assistance. In this case, an error is

considered whenever a participant's action does not contribute to the completion of the task. In turn, assistance is considered whenever the moderator has to intervene either at the participant's request or when the participant commits several wrong actions followed in order to help the participant with the completion of the task. Then, the tasks that the participants enjoy are explored, and in some cases, in addition to errors and assistances, several tips were considered that will add new features and improvements to the application.

Participants who collaborated in this analysis are divided into two groups that are people who have not contracted DM, and people with DM who already have some experience in daily life (participants with type 1 DM). In this case it would make sense to invite people who does not have DM in the 40s age group due to the incidence of DM. Before starting their participation, guests signed an informed consent (Appendix H). Afterwards, the participants are presented.

Table 3.2: Users' information for the application usability test.

Participant	Age	Gender	Context	Experience with chats (0-3)
1	53	Female	Age group ≥ 40	2
2	57	Female	Age group ≥ 40	3
3	44	Female	Age group ≥ 40	2
4	49	Male	Age group ≥ 40	3
5	59	Male	Age group ≥ 40	1
6	43	Male	Age group ≥ 40	3
7	42	Female	Age group ≥ 40	3
8	47	Female	Age group ≥ 40	3
9	41	Female	Age group ≥ 40	3
10	38	Female	Age group ≥ 40	3
11	23	Male	Type 1 DM	3
12	22	Female	Type 1 DM	3

3.3.2.1 Application Authentication

In general, all participants were able to perform this task successfully and simply. The efficiency in which the task was performed ranged between 75% and 100%, with the majority performing the task with 100%. This iteration in the prototype is reflected, then, in a clear improvement in the overall time of the task and will serve as a reference for the next development cycles, as it will be possible to implement and

test even more agile and efficient interactive components so that the user can understand how to proceed without having any doubt.

Table 3.3: Final results for the task - Application Authentication.

Participant	Task Time (MM:SS)	Errors	Assistances	Task Effectiveness (%)
1	00:38	1	2	75%
2	00:25	0	0	100%
3	00:15	0	0	100%
4	00:15	0	0	100%
5	00:30	1	1	75%
6	00:10	0	0	100%
7	00:12	0	0	100%
8	00:12	0	0	100%
9	00:10	0	0	100%
10	00:11	0	0	100%
11	00:13	0	0	100%
12	00:11	0	0	100%
Average	00:17	0 ± 0,25	0 ± 0,25	100% ± 0,25
Max	00:38	1	2	75%
Min	00:10	0	0	100%

3.3.2.2 Exchange Messages

Almost all participants performed this task successfully, and the average time was influenced by the speed of writing for each one and the response time by the bot. In this case, there was also an efficiency that varied between 75% and 100%. Only one person achieved this worst efficiency with the rest at the level of 100%. The error verified with a participant focused on the area where should be clicked in order to write a message. This was explicit in the interface but the participant was not able to find out. After an assistance it was easy to be noticed. The difficulty index was relatively nil, as all participants already recognized this type of interface from other chat applications.

Table 3.4: Final results for the task - Exchange Messages.

Participant	Task Time (MM:SS)	Errors	Assistances	Task Effectiveness (%)
1	02:03	1	1	75%
2	01:22	0	0	100%
3	00:50	0	0	100%
4	00:42	0	0	100%
5	01:20	0	0	100%
6	00:45	0	0	100%
7	00:41	0	0	100%
8	00:40	0	0	100%
9	00:46	0	0	100%
10	00:41	0	0	100%
11	00:48	0	0	100%
12	00:40	0	0	100%
Average	01:10	0 ± 0,25	0 ± 0,25	100% ± 0,25
Max	02:03	1	1	75%
Min	00:40	0	0	100%

3.3.2.3 Access help section

The efficiency of this task focused on 100%, that is, all participants performed the task successfully. All participants were able to access this screen without any difficulty and then were able to submit a question as they are already familiar with text boxes. The average time is considered to be close to one minute and this time may be subject to a longer delay when the participant addresses a longer question or takes longer to write.

Some participants raised that, normally, in the upper left corner a generic menu is displayed. In this case, the icon displayed in this location is to access directly the help screen and not a menu that presents the various possible options. Therefore, it was one of the aspects that was found to be important and that would help to improve the presentation of the interface for the user.

Table 3.5: Final results for the task - Access help section.

Participant	Task Time (MM:SS)	Errors	Assistances	Task Effectiveness (%)
1	01:21	0	0	100%
2	01:19	0	0	100%
3	01:00	0	0	100%
4	00:54	0	0	100%
5	00:28	0	0	100%
6	00:25	0	0	100%
7	00:20	0	0	100%
8	00:21	0	0	100%
9	00:30	0	0	100%
10	00:23	0	0	100%
11	00:28	0	0	100%
12	00:32	0	0	100%
Average	00:50	0	0	100%
Max	01:21	0	0	100%
Min	00:20	0	0	100%

3.3.2.4 Exit the application

This task was carried out very easily by the participants with 100% efficiency. The outcome of this task was balanced as the participants used a lot a button presented in the upper right corner and also the back to back key on the navigation bar. The conclusion drawn is that both options can and should be present as they are used quite frequently by users.

Table 3.6: Final results for the task - Exit the application.

Participant	Task Time (MM:SS)	Errors	Assistances	Task Effectiveness (%)
1	00:05	0	0	100%
2	00:05	0	0	100%
3	00:05	0	0	100%
4	00:05	0	0	100%
5	00:08	0	0	100%
6	00:03	0	0	100%
7	00:03	0	0	100%
8	00:04	0	0	100%
9	00:03	0	0	100%
10	00:03	0	0	100%
11	00:05	0	0	100%
12	00:04	0	0	100%
Average	00:04	0	0	100%
Max	00:08	0	0	100%
Min	00:03	0	0	100%

3.3.3 Application Improvements

In order to improve the interface for a better interaction by users, several recommendations were given that addressed various aspects regarding most of the existing features.

Regarding the display of information and, as this chatbot can reach a large part of people in the most adult age group, it was recommended to change the way of communication in the application. Previously, the user used an application that had a more informal language, treating the person always in the second person. With all the changes, it was opted for a formal language, as this application must be something seen as reliable and objective for the user. It was also recommended to use a font that is more understandable to the user. Usually, the font of the frequently used letter is *Roboto*. Therefore, reading is simpler and more accessible.

Furthermore, according to the participants in the usability tests, one of the key aspects was the user's comprehension of the message because messages were too long and it would be tough and tiring for the user to read. Thus, to make it more appealing and accessible, the information that is transmitted was shortened, e.g., in the greeting message and in other screens that display another type of content.

3.3.3.1 Requirements

Regarding the application requirements some have been changed and others have been added. The changes focused on the changes that were made to the interface for the user to access.

Functional

1. The user must authenticate himself/herself in the application using his/her first and last name.
2. In the main menu of the application the user will be able to have access to the following functionalities:
    a) Open the generic chat interface
    b) Ask a question that the bot was unable to answer (Help screen)
    c) Read terms and conditions
    d) Read privacy policy
3. The user can check the essential information of the application content in about screen such as the project scope and the application content with appropriate references.

3.3.3.2 System Modeling

After changing the requirements, it is necessary to make a new modeling for the system in relation to the application. Due to new features the layout was changed in new aspects. Therefore, before proceeding to change the interface, it was necessary to lay out everything.

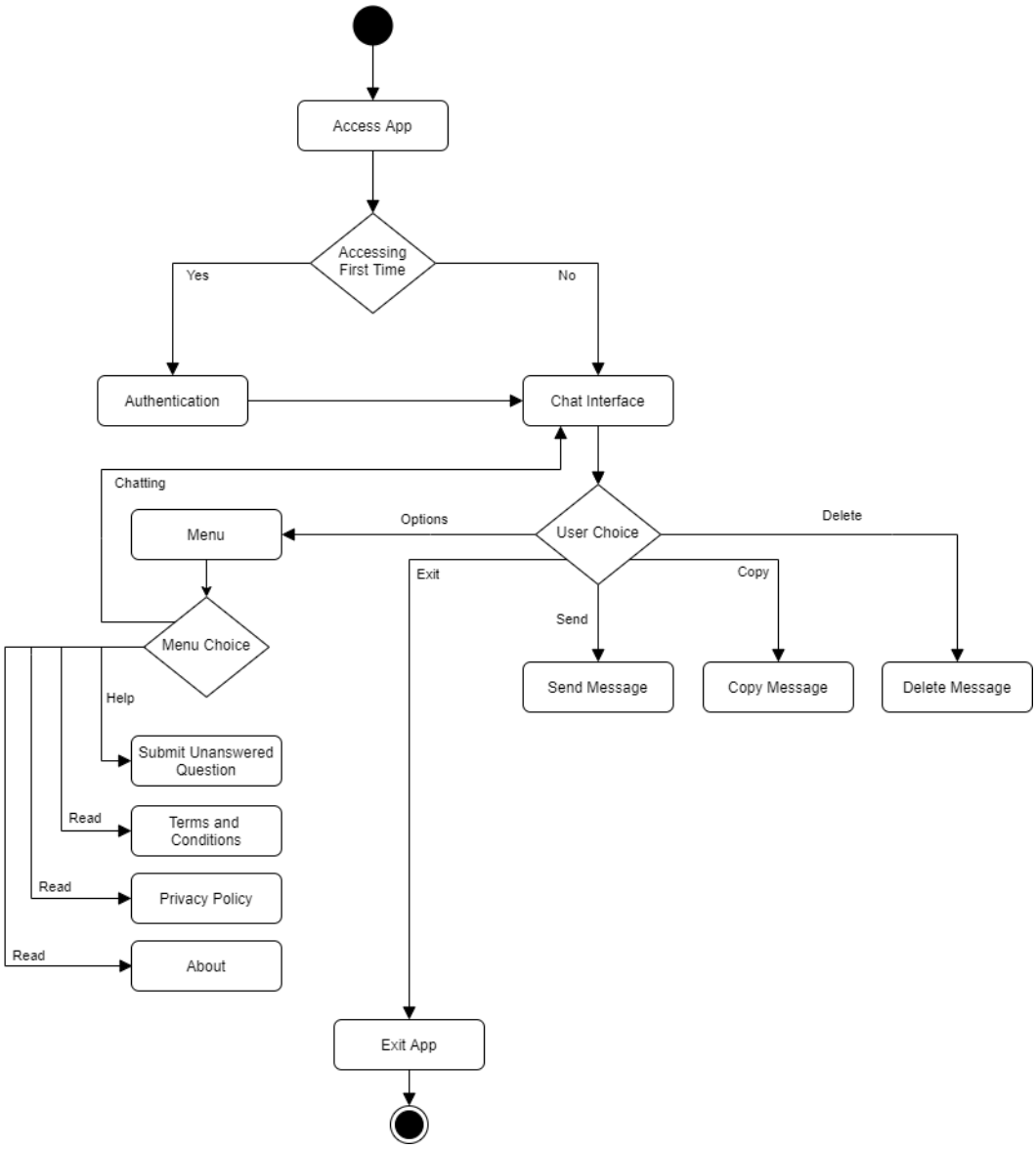

Figure 3.9: UML activity diagram of the application - Final version.

3.3.3.3 Interface

Authentication interface screen

In the authentication interface, it was suggested to specify what the user would have to type in the text box. This was possible to verify because in several usability tests users asked what they had to type because it only indicated to write the name and therefore it was difficult to understand. The improvement consisted of precisely this same indication: a specification was added that the user's first and last name must be written in the text box. With this, it was possible to avoid conflicts about what can be put there. An input validation is also carried out to verify if in fact two proper names are written.

Figure 3.10: Authentication Screen.

Chat interface screen

In the chat interface, concerns were directed towards how the bot communicates with the user. The indication messages are now shorter, and communication with the user is formal and direct. The initial message that the bot sends has been modified in order to be more direct and where the user clearly understands what this application is for. It is a very important and essential message for those who do not know what this application is about.

Figure 3.11: Chat initial message screen.

One of the biggest innovations in terms of the interface itself was the change of the button that was positioned in the upper left corner that allowed the user to access the help screen section.

Usually, users associate the upper left corner to access a menu and there were doubts about that. With the implementation of a menu, not only is it easier for the user to understand, but it also allows adding new sections for various functions.

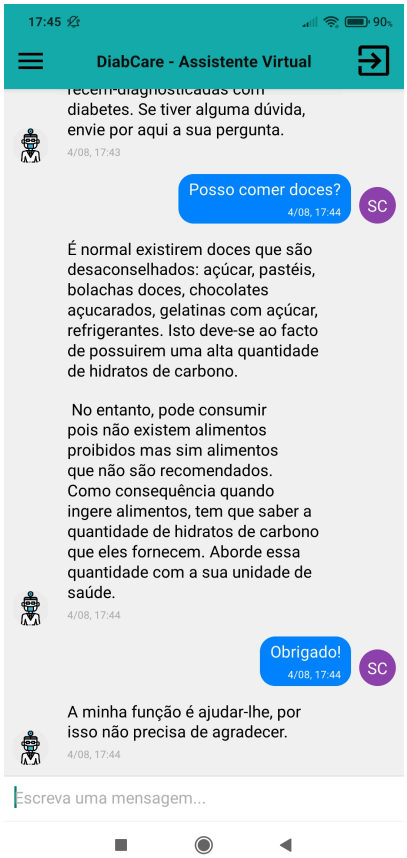

Figure 3.12: Chat Screen.

In cases where the bot is unable to understand certain issues, it is much simpler to inform the user that they should go to the menu in the upper left corner and access the section called *Help*. Several users motivated the creation of this new feature.

The menu was created by the concept of *Modal Drawer* that uses a scrim to block interaction with the rest of the application's content. This drawer is elevated above most applications elements and do not affect the screen's layout grid. With this *Drawer Navigator* functionality, the user can easily access the sections he/she wants, opening the menu and choosing the one he/she wants.

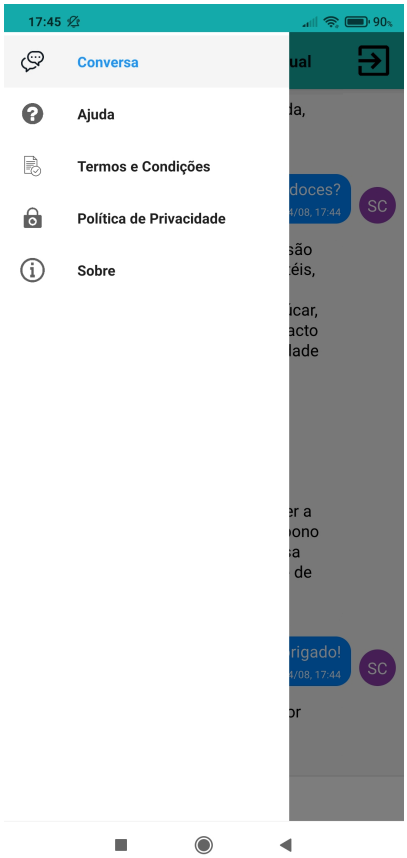

Figure 3.13: Menu *Drawer Navigator*.

The menu will allow the user to see other information about the application and the content provided. It is important to always have an approach to various topics and think about new perspectives for the future. New features can be added in this way, being easily upgradable in this menu. From the user's point of view it is even simpler as it will be something more observable than if there were no such menu. At the moment, the menu has the following features:

- **Conversation**: It allows the user to access the chat.
- **Help**: On this screen, changes were also made in the form of communication to be more concise. Therefore, the user more quickly understands the purpose of this feature.

Figure 3.14: Help Screen.

- **Terms and Conditions**: This screen is the same that appears on the authentication. It is in case the user wants to review.
- **Privacy Policy**: This section exists for the same purpose as the previous one but with a different theme.
- **About**: This section was one of the missing ones. In the sessions with users, the creation of a section where the main sources of content should be added was addressed. Users are very concerned about the reliability and veracity of the product, always checking the source of information. Thus, in a way, the application will have greater robustness and the user will not have so many concerns about the reliability of the application.

Figure 3.15: About Screen.

A change was also made that consists of the moment when the user presses the button in the upper right corner to exit the application. The user often ends up pressing the button to exit the application, but then he/she does not want it for his/her reasons. Thus, a confirmation dialog box was created for the user to confirm whether he/she wants to exit the application or not.

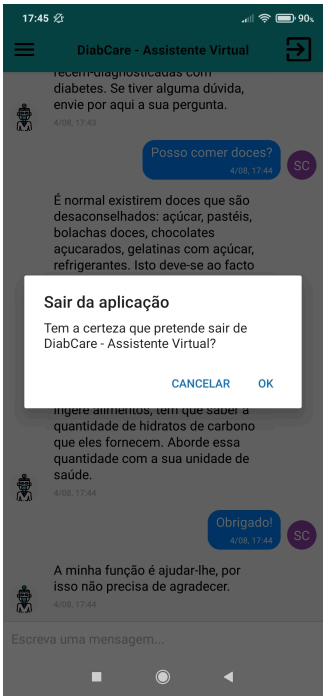

Figure 3.16: Exit Screen.

Final Version

The final version has all the features that were covered above. In the first use of the application, the user will enter the authentication screen (Authentication section) where he will be able to type his first and last name in order to be able to register in the application. If the user has already used the application, this screen will no longer be available.

Then the user has a chat where he/she can send all their questions (Chatting section), and a menu (Access Menu section) to obtain additional information about the application as well as access the help menu explained above. Below in figure 3.17 the final prototype of the application is presented.

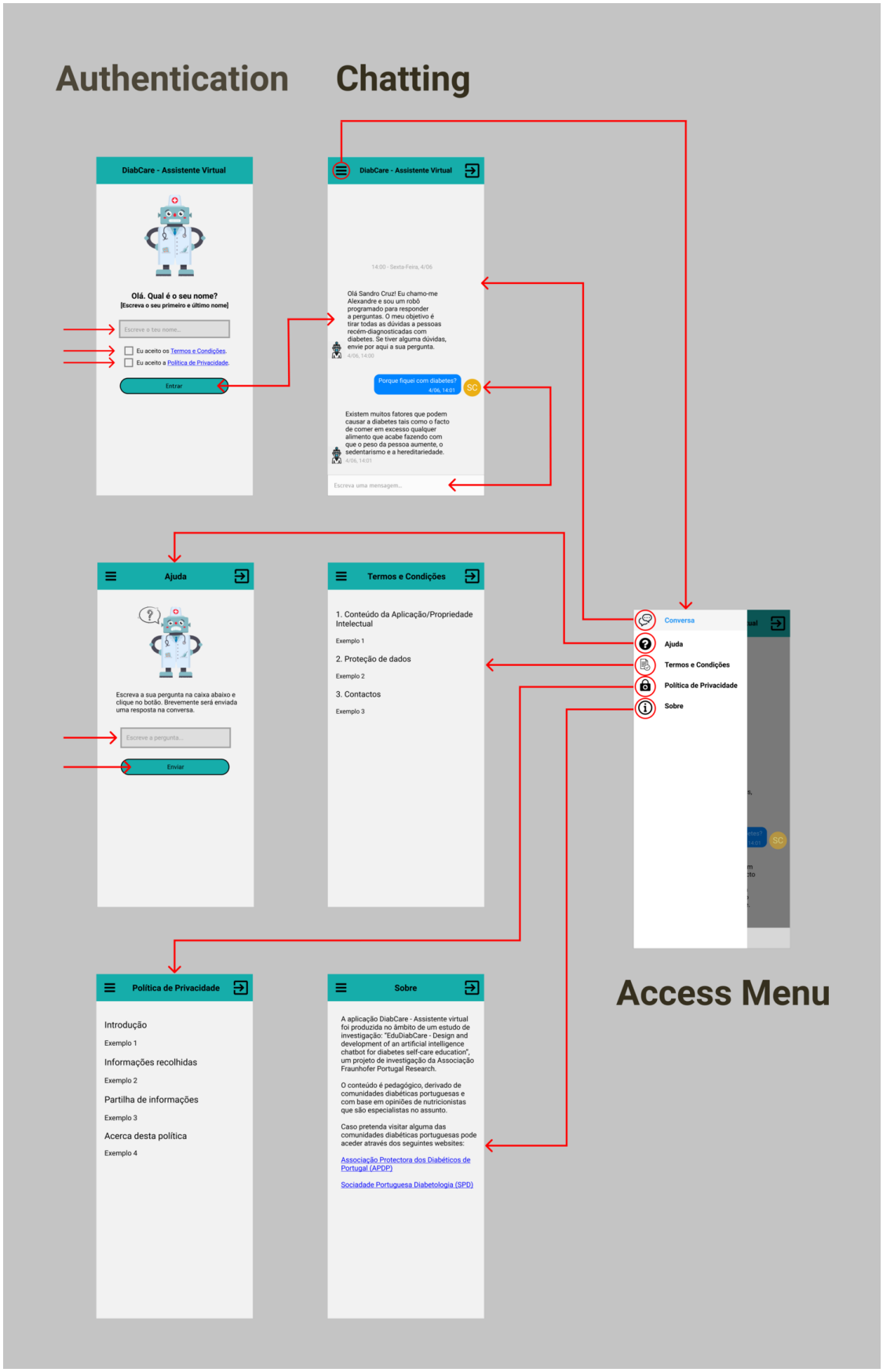

Figure 3.17: Final prototype - Flow navigation of the application.

3.3.4 Usability Measurement

After making the improvements and developing the application in its final state, metrics are needed to be able to calculate the final usability results. In this case, the best way would be to invite people who are embedded in the context of the application so that they can give their opinions through a final assessment.

3.3.4.1 System Usability Scale

For the usability measure it had been used System Usability Scale (SUS). SUS provides a "quick and dirty", reliable tool for measurement the usability [80]. It consists of a 10 item form with 5 response choices for respondents: from strongly agree to strongly disagree [80]. Originally created by John Brooke in 1986, it permits the analysis of a large type of product and services, as well as hardware, software, mobile devices, websites and applications [80].

The final score for each question can vary from 0 to 4, as follows: for odd questions (1, 3, 5, 7 and 9), the value considered is the answer given minus 1; and for the even-numbered questions (2, 4, 6, 8 and 10), the score is 5 minus the value of the assigned answer [81]. Subsequently, the sum of the scores is multiplied by 2.5 to obtain the global SUS score. The SUS score ranges from 0 to 100, where scores below 60 are classified as poor, between 60 and 69 as weak, between 70 and 79 as average, between 80 and 89 as good, and 90 and above as excellent [81].

3.3.4.2 Results

In order to evaluate the SUS, 5 people with DM were invited to a session where they could fill the standard questionnaire available at *usability.gov* website (Annex I).

The requirement to recruit participants is that they must have already been diagnosed with some type of DM-related problem: type 1 DM, type 2 DM or gestational DM. Prior to their participation, guests signed an informed consent (Appendix H). The following table 3.7 presents the characteristics of the participants.

Table 3.7: Participants' information for SUS.

Participant	Age	Gender	Context
1	45	Female	Gestational DM
2	71	Male	Type 2 DM
3	68	Female	Type 2 DM
4	20	Female	Type 1 DM
5	23	Male	Type 1 DM

The opinions of the participants regarding the use of the application were always divided into two distinct fields, these being close to each other, that is, the opinion of each statement did not have very different results.

In statements 1, 3, 8, 9, and 10 almost everyone has the same answer. There was one statement where everyone agreed that it was 8, where everyone totally disagreed. This question is related to the difficulty of using the application, and it is therefore quite relevant that users have totally disagreed because this means that the application is user-friendly. The following table 3.8 the results of the users' opinions regarding each statement.

Table 3.8: Participants' opinions for SUS.

Statement	Strongly Disagree	Somewhat Disagree	Neutral	Somewhat Agree	Strongly Agree
1	-	-	P4	P1, P2, P3, P5	-
2	P3, P4	P1, P2, P5	-	-	-
3	-	-	-	P2	P1, P3, P4, P5
4	P3, P4, P5	P1, P2	-	-	-
5	-	-	-	P1, P3, P5	P2, P4
6	P2, P4, P5	P1, P3	-	-	-
7	-	-	-	P1, P2, P5	P3, P4
8	P1, P2, P3, P4, P5	-	-	-	-
9	-	-	-	P1, P2, P3, P4	P5
10	P1, P2, P3, P4	P5	-	-	-

In general, all participants advised a future use of the application and gave a positive score regarding the usability of the application, with the worst score falling into the classification of good. In the next table 3.9, are the scores as well as the classifications given by each participant in order to evaluate the application.

Table 3.9: Results of SUS.

Participant	**SUS score**	**Classification**	**App Recommendation (0-10)**
1	82.5	Good	7
2	85	Good	8
3	90	Excellent	9
4	95	Excellent	9
5	87.5	Good	9

The result of the SUS obtained is at the level of good, being the scale of average value 88 which means that the overall rating is between good and excellent. The average of the application's future recommendation is situated at a rating of 8, which is a good perspective for people with DM to use.

The fact that younger participants (under 40 years) more rigorously assessed the usability of the application is understandable since in theory, overall it can be said that what makes a good UX on chatbots

is very similar to what makes a good conversation with another human being [82]. It may be the case that a productivity-oriented chatbot may benefit from a friendly or empathic appearance.

Chapter 4

Conclusion

4.1 Discussion

The AI chatbot mobile application developed in this study supports people newly diagnosed with DM in the self-management of this chronic disease. In this scenario, the chatbot mechanism (back-end) was developed in *Python* and the interface (front-end) in *React Native*. The most common design method employed in developing chatbots is pattern matching for text understanding and response generation. This application uses precisely this method. The literature refers that one of the reasons for using this method is that pattern matching methods are more reliable in practice because they produce exact responses to well-defined queries, resulting in fewer mistakes [83]. Another reason for the possible lack of using ML methods could be the fact that ML–based approaches need to be trained using large amounts of domain-specific data, which might be scarce and difficult to access in the medical field [83]. In terms of data management, the type of database kept depends on the chatbot type and target functionality. As most chatbots developed for DM analyze the questions also from an emotional point of view and tries to respond appropriately where it recognizes fear or stress in the users' words, it is concluded that these chatbots use context switching based users emotions usually kept in a user information database [83]. On the other hand, the chatbot that was developed in this work used a dialogue script database including all possible entries of conversational text responding to users since it did not address the previously mentioned aspects of emotion. The reason for not implementing emotions was precisely to overcome this limitation because as the application is recommended for newly diagnosed people and the average age of this diagnosis is 40 years old and over, it was something that was not thought of at first because these people only have care about ease of use and understanding. Most related chatbots for DM studies were developed in the context of a web application [32–35]. Another aspect is the fact that these chatbots do not have a help section implemented. If a user cannot get an answer to a question, the bot simply does not respond. One of the features that this chatbot has is precisely the introduction of a section so that those questions can

be placed in a database in order to improve the chabot's response efficiency. Moreover, to our knowledge this study is the first to develop a chatbot for DM management using Portuguese language. Most of the developed chatbots uses English as the language of communication with the users [83]. So the chatbot that was developed in this work was developed in Portuguese and for mobile phones because they accompany people on a daily basis and so patients have disease support in the application anywhere and anytime in their native language that is Portuguese. Therefore, this work adds an important scientific contribution in providing real-time assistance to DM patients in Portugal.

This work also addressed the usability of the application. In this study the AI chatbot was developed in an iterative way with participation of users, thus helped develop an application with which patients can interact easily and conveniently. So, from the obtained SUS value (88), it is possible to conclude that the application has a pleasant usability, with few aspects to improve as it is not yet in an excellent rating. The fact that the participants use chat applications made the process of using this chatbot application easier as they have a similar structure and may have influenced the results obtained for its usability. The results obtained show that people aged 40 or above were able to use the application quite efficiently. The value of SUS presents an average of 88, standing in the classification of good. In relation to people under 40 years of age, it was possible to obtain a more positive result where the SUS evaluation was classified as excellent (95). It can be seen then that people under 40 years of age feel completely comfortable using this application while people aged 40 or above usually face difficulties or are not used to using applications of this type and the score turns out to be reduced. Everyone has come to a consensus on one aspect that is in total disagreement with what they think the application is complicated to use. Furthermore, people aged under 40 used the application without any difficulty and always recommend new features so that the application is even better. People age 40 or above, on the other hand, only worry about using the application and always expect it to be something quite easy and accessible to use, otherwise they end up giving up using it. Literature suggests that users aged under 40 may be particularly sensitive to playful and emotionally engaging chatbots, whereas older users may be preoccupied with the efficiency and effectiveness of chatbots [84, 85]. Results from usability tests show that the application is user-friendly, which means that in general users did the tests without having any major difficulties and thought that there would be no major problems, nor should there be any significant changes but only in terms of accessing the features. One of the most essential aspects is the reliability of the content. Users will not use chatbot if the content is irrelevant. Users need to fulfill a valued productivity goal, such as getting help or access to information on the fly [86]. Notably, the final tests addressed the part of the user being able to recommend the use of this application. The score regarding the perceived usefulness was high and it can be concluded that users with DM, found the contents of the application useful for people newly diagnosed with DM, based on the experiences and doubts they had at the onset of the disease, and therefore would recommend that newly diagnosed patients use this application. In general, the score given by users on ease of use indicates that users consider the application to provide answers in a fast, easy to use, accessible language, conversational tone that makes it user friendly. A study indicates that for chatbots to be successful in the studied user group, they must help users resolve a task or achieve a concrete goal in an effective and

efficient manner; in other words, they need to be easy, fast, and convenient [86]. The success of chatbots as personal assistants and health advisors exemplifies the need to design for productivity [82, 86].

The chatbot developed in this work contains the basic characteristics of a chatbot but the parts of emotion towards the user are not worked. If an improvement was made in this aspect, perhaps the recommendation and the usability scale would be at a higher level. Another aspect to be improved is the chatbot's responsiveness. A study refers that the participants' responses suggested that they highly appreciated when chatbots helped them save time or made it easier and faster to obtain help or information [86]. Content evaluation was not addressed, but the content was developed with the help of health professionals and guidelines available.

4.2 Conclusions and Future Work

Overall, this study suggests that the use of a chatbot application for a concept as global as DM is something that serves to innovate in the health area. In this case, people who have doubts, in addition to using platforms available online to clarify doubts, can use an application such as a chatbot that will clarify doubts at any time of the day without the need for a long wait for an answer.

Currently, the chabots that exist to help people with DM exist only as web applications and people of an older age group would find it difficult to access. So, with an iOS/Android application, all they need to do is install it on the mobile device and it would be ready to use. Another important aspect is that other chatbots do not support the language in Portuguese which is something essential for people here in Portugal.

This work addressed three different components: the content approach, the application development and a HCD study which valued the part of the user experience with the aspect of there being an improvement in the application. First, an initial study of the content was carried out using the guidelines provided online. Through interviews and surveys with health professionals and people with DM, it was possible to deepen the content. The application development followed the HCD methodology, where its usability was being improved to provide a pleasant UX.

Further work is needed to determine what to improve to obtain better results in terms of the UX and a more careful analysis of the content through the evaluations of health professionals using predefined metrics. In view of the implementation of the chatbot, a study should be conducted to assess the feasibility of using the bot by newly diagnosed patients with DM to support self-management of the disease.

Future users of this application will be able to enjoy an application that provides information and educational character whose content has already been discussed with health professionals.

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Appendix A

Application Content

A.1 Questions

A.1.1 Porque tenho diabetes?

R: A diabetes tipo 1 é uma doença autoimune e não está relacionada com comportamentos ou alimentação incorreta. Isto deve-se às células beta do pâncreas que deixam de produzir insulina - hormona que regula o nível de glucose no sangue. Apesar de não se conhecer o processo na sua totalidade, sabe-se que é o próprio sistema imunitário que ataca e destrói as suas células beta pancreáticas, responsáveis pela produção de insulina.

Por outro lado, a diabetes tipo 2 está relacionada com o estilo de vida da pessoa sendo que existem muitos fatores envolvidos: o facto de se comer em excesso qualquer alimento que acabe fazendo com que o peso da pessoa aumente (relacionado com a obesidade), o sedentarismo e a hereditariedade.

A.1.2 Qual é a lista do que posso comer para o pequeno-almoço?

R: A Federação Internacional da Diabetes recomenda-lhe a comer:

- Água, chá ou café não açucarados.
- Pão integral ou de mistura de farinhas pouco refinadas.
- Cereais de pequeno-almoço pouco açucarados e ricos em fibra.
- Leite magro.
- Iogurte magro e sem adição de açúcar, ao qual se pode adicionar sementes, frutos secos ou fruta fresca.
- Queijo pouco gordo (1 porção pequena, por exemplo 1 fatia fina).
- Fiambre de aves (1 porção pequena, por exemplo 1 fatia fina).
- Ovo cozido ou escalfado sem adição de gordura.
- Fruta fresca (1 peça, por exemplo maçã, pera, laranja, pêssego).

Desejo-lhe um bom pequeno-almoço.

A.1.3 O que posso comer no pequeno-almoço?

R1: ATENÇÃO

Caso possua diabetes tipo 2 e esteja numa fase inicial, estas refeições podem ser consideradas porque, no geral, deve ingerir uma quantidade idêntica todos os dias. Caso tenha diabetes tipo 1 ou esteja numa

fase pior da diabetes tipo 2 e realize a terapia intensiva deve fazer a contagem dos hidratos de carbono para saber o que está a comer e determinar a quantidade que vai ingerir. Por isso tem de ter o devido cuidado.

Pode tomar um copo de leite meio gordo ou magro (250mL) acompanhado de um pão de centeio (60g) com uma colher de sobremesa de manteiga magra ou creme vegetal. Depois come 1 maçã pequena.

Desejo-lhe um bom pequeno-almoço.

R2: ATENÇÃO

Caso possua diabetes tipo 2 e esteja numa fase inicial, estas refeições podem ser consideradas porque, no geral, deve ingerir uma quantidade idêntica todos os dias. Caso tenha diabetes tipo 1 ou esteja numa fase pior da diabetes tipo 2 e realize a terapia intensiva deve fazer a contagem dos hidratos de carbono para saber o que está a comer e determinar a quantidade que vai ingerir. Por isso tem de ter o devido cuidado.

Pode comer um iogurte magro e sem adição de açúcar acompanhado de seis colheres de sopa de aveia e depois come dois kiwis pequenos.

Desejo-lhe um bom pequeno-almoço.

R3: ATENÇÃO

Caso possua diabetes tipo 2 e esteja numa fase inicial, estas refeições podem ser consideradas porque, no geral, deve ingerir uma quantidade idêntica todos os dias. Caso tenha diabetes tipo 1 ou esteja numa fase pior da diabetes tipo 2 e realize a terapia intensiva deve fazer a contagem dos hidratos de carbono para saber o que está a comer e determinar a quantidade que vai ingerir. Por isso tem de ter o devido cuidado.

Experimente uma caneca de chá sem açúcar e um pão de sementes (90g) com queijo fresco. Depois pode comer uma laranja pequena.

Desejo-lhe um bom pequeno-almoço.

A.1.4 O que posso comer no almoço/jantar?

R: ATENÇÃO

Caso possua diabetes tipo 2 e esteja numa fase inicial, estas refeições podem ser consideradas porque, no geral, deve ingerir uma quantidade idêntica todos os dias. Caso tenha diabetes tipo 1 ou esteja numa fase pior da diabetes tipo 2 e realize a terapia intensiva deve fazer a contagem dos hidratos de carbono para saber o que está a comer e determinar a quantidade que vai ingerir. Por isso tem de ter o devido cuidado.

A ementa recomendada é a seguinte:

SOPAS: Creme de couve roxa | Sopa de gaspacho | Sopa de legumes o dia a dia | Creme de ervilhas com coentros | Sopa de Coentros | Sopa de abóbora com agrião | Sopa verde com couve-flor e cenoura | Creme de abóbora com hortelã | Sopa de beterraba

PRATO (PEIXE): Tomates recheados | Pudim de peixe | Paté de sardinhas | Filetes no forno | Carapau em escabeche | Bacalhau cozido com todos | Pescada com espinafres | Pescada no tacho | Filetes de pescada com legumes e batata à murro

PRATO (CARNE): Frango com tomates e pimentos | Perna de peru assada com molho de laranja | Peito de perú no tacho | Coroa de perú com molho de tomate | Coelho em vinha d'alho | Coelho à saloia | Peito de peru recheado com couve e broa | Coelho de caldeirada | Lombo de porco com leite e ameixas

MASSAS/ARROZ: Massa especial | Pudim de arroz com atum | Massa espiral com legumes assados | Espargue com tamboril | Cotovelinhos com alinho | Arroz de feijão especial | Lacinhos com frango | Coroa de arroz com lentilhas | Lasanha de perú e vegetais

SALADAS: Salada rica em tomate | Salada fresca de alface | Salada de frutas tropicais | Ervilhas com ovos escalfados | Almoço do campo | Salada de rúcula e alface | Lentilhas mimosa | Courgetes recheadas | Salada de verão | Salada fria de grão

SOBREMESAS: Fruta com limão e canela | Salada de frutos tropicais | Sobremesa de maçã com iogurte e miolo de noz | Salada de frutas | Mousse de manga | Leite creme | Fatias douradas | Farófias | Amoras com iogurte

A.1.5 O que posso comer de tarde/para o lanche?

R1: ATENÇÃO

Caso possua diabetes tipo 2 e esteja numa fase inicial, estas refeições podem ser consideradas porque, no geral, deve ingerir uma quantidade idêntica todos os dias. Caso tenha diabetes tipo 1 ou esteja numa fase pior da diabetes tipo 2 e realize a terapia intensiva deve fazer a contagem dos hidratos de carbono para saber o que está a comer e determinar a quantidade que vai ingerir. Por isso tem de ter o devido cuidado.

Pode comer um iogurte magro de aromas acompanhado de um pão (50g) com pouca manteiga.

R2: ATENÇÃO

Caso possua diabetes tipo 2 e esteja numa fase inicial, estas refeições podem ser consideradas porque, no geral, deve ingerir uma quantidade idêntica todos os dias. Caso tenha diabetes tipo 1 ou esteja numa fase pior da diabetes tipo 2 e realize a terapia intensiva deve fazer a contagem dos hidratos de carbono para saber o que está a comer e determinar a quantidade que vai ingerir. Por isso tem de ter o devido cuidado.

Experimente uma chávena de chá ou cevada e um pão (50g) com uma fatia de queijo magro.

A.1.6 Qual é o tratamento da diabetes tipo 1?

R: O objetivo do tratamento da diabetes tipo 1 consiste em colocar os níveis de açúcar no sangue dentro dos parâmetros aconselhados para a idade. Os 3 elementos fundamentais para o tratamento da diabetes tipo 1 são:

1. A insulina, que é fundamental desde o diagnóstico pois o organismo já não produz a insulina que necessita.
2. A alimentação equilibrada.
3. O exercício físico regular.

A autovigilância da glicemia é fundamental para gerir todos os aspetos do tratamento. O conhecimento sobre a doença e de si são muito importantes para o tratamento! Quanto mais elevado for o seu grau de motivação melhor será o controlo da gestão da diabetes.

A.1.7 Qual é o tratamento da diabetes tipo 2?

R: O objetivo do tratamento da diabetes tipo 2 consiste em conseguir um ótimo controlo metabólico, para que possa ter uma vida com qualidade, evitando ou atrasando as complicações crónicas.

Sendo assim, o tratamento deve ser contínuo (para toda a vida) acompanhado dos seguintes aspetos:

1. Uma alimentação equilibrada que ajuda a controlar os níveis de glicose no sangue e no peso.
2. O exercício físico, que reduz o problema da insulinorresistência, melhora a circulação, fortalece os músculos e articulações e contribui para a redução do peso.
3. A medicação através de comprimidos ou insulina, que é tomada regularmente ajudando a manter uma boa compensação. Atualmente, existem alternativas de medicação onde não é usada insulina: a medicação subcutânea.

A.1.8 Como posso tratar do meu filho que tem diabetes?

R: Deve seguir os seguintes passos:

1. Para um bom rendimento físico e intelectual, não deixe o seu filho sair de casa sem tomar o pequeno-almoço!
2. Inclua alimentos com hidratos de carbono em cada refeição. Aconselhe-se com um nutricionista sobre as quantidades adequadas.
3. Toda a família deve iniciar as refeições principais com sopa de legumes. Inclui também salada ou legumes no segundo prato.
4. Escolha carnes magras e insista no consumo regular de peixe!
5. Tem de garantir que o seu filho ingere diariamente 2 a 3 peças de fruta.
6. O leite e o iogurte devem fazer parte da alimentação.
7. Varie a forma de cozinhar, optando por métodos saudáveis: estufados, cozidos, grelhados e assados. Use preferencialmente o azeite, para temperar e confecionar, reduza o sal e evite caldos ou molhos industrializados!
8. Ao longo do dia e às refeições deve-se optar sempre pela água.
9. Não substitua as refeições com guloseimas ou alimentos desequilibrados, ricos em gorduras e açúcares! Estes tiram o apetite para outros alimentos mais saudáveis e podem levar ao aumento excessivo de peso.

10. Reserve guloseimas para dias especiais ou de festas e aconselhe-se com a sua unidade de saúde para saber como pode fazer as adaptações necessárias na alimentação e na insulina.

11. Lembre-se da higiene dentária após as refeições!

A.1.9 Que exercício físico devo fazer?

R: Primeiramente vou-lhe dar dicas para melhorar a adesão ao exercício físico:

1. Escolha uma atividade que possa e que goste de fazer.
2. Aumente gradualmente a duração e a intensidade das sessões
3. Escolha um local acessível para a sua prática.
4. É preferível praticar em grupo ou com amigos.
5. Estabeleça objetivos realistas.
6. Troque de vez em quando as atividades para evitar a saturação.
7. O apoio e incentivo de amigos e familiares é algo importante.

Cuidados que deve ter:

1. Ingira água antes, durante e após a atividade.
2. Pratique exercício físico com roupa confortável e calçado adequado.

Dicas para aumentar a prática de atividade física:

1. Vá a pé em vez de ir de carro/autocarro.
2. Em vez de utilizar elevadores ou escadas rolantes, utilize as escadas.
3. Registe o tempo e a intensidade da atividade física que realiza de forma a controlar o seu exercício semanal e conseguir no mínimo 150 minutos por semana.
4. Caminhe no mínimo 10 000 passos por dia, sempre contabilizados fora de casa.
5. Faça exercícios em casa quando o tempo atmosférico não o permitir.

A.1.10 Quando posso viajar?

R: Antes de fazer qualquer viagem deve saber a seguintes informações:

1. Duração da viagem.
2. Temperatura.
3. Condições de higiene do sítio a visitar.
4. Tipos de alimentos que vai encontrar.
5. Associações locais de pessoas com diabetes.
6. Avaliar o nível de cuidados de saúde no sítio a visitar.

Documentação que deve levar:

1. Cartão em língua inglesa e do país a visitar a informar que tem diabetes e as atitudes a tomar em caso de hipoglicemia.
2. Se viajar dentro da Europa peça o Cartão Europeu de Saúde via online, num balcão de atendimento da Segurança Social ou numa loja ou espaço do cidadão. Caso queira fazer o pedido online necessita do seu número de beneficiário/a. Basta aceder a este website aqui => https://eportugal.gov.pt/servicos/reque o-cartao-europeu-de-seguro-de-doenca-da-seguranca-social. Se precisar de ajuda pode ver um tutorial em vídeo aqui => https://www.youtube.com/watch?v=s_purGfGC7Q.
3. Se fizer insulina, leve uma carta do médico em língua portuguesa e inglesa, informando que tem diabetes e que precisa de transportar insulina na bagagem de mão.

Como pode organizar a bagagem:

1. Levar lanches (Bolachas, pão).
2. Aparelho de avaliação da glicemia e lancetas. Tiras de testes para determinação da glicemia (em caso de indicação médica tiras de cetonémia).
3. Duas embalagens de Glucagen (em caso de indicação médica).
4. O dobro da insulina/comprimidos necessários para o período da viagem.
5. Caneta suplente de insulina e seringas de insulina para o caso de extravio ou avaria das canetas.

Atenção: Nunca leve o material da insulina no porão.

A.1.11 Quais são as precauções antes de engravidar?

R: É importante planear a gravidez. É necessário avaliar previamente as condições de saúde, atingir um bom controlo glicemico e mudar as terapêuticas que não sejam adequadas para a gravidez. Deve manter a contraceção até atingir o objetivo. Deve cuidar da alimentação da seguinte forma:

1. Distribua os alimentos para pelo menos seis refeições por dia.
2. Inclua alimentos ricos em fibras.
3. Diminua o consumo de gorduras saturadas.
4. Beba um litro e meio de água por dia.
5. Evite beber bebidas açúcaradas.
6. Diminua o consumo de sal e de alimentos salgados.

Aconselhe-se junto de um médico. Eles enviam-lhe para uma consulta específica.

A.1.12 O que é a gravidez gestacional?

R: A gravidez gestacional é diagnosticada no período da gravidez quando a glicemia estiver a partir de determinados valores. No entanto, pode ter diabetes mellitus caso tenha valores muito altos e esteja no intervalo que está num espetro de valores definido.

O facto de ter uma gravidez gestacional aumenta o risco de poder ter uma diabetes mellitus no futuro. As pessoas com diabetes que engravidam ou que contraem algum tipo de diabetes na gravidez vão sempre ser seguidas por consultas específicas com um endocrinologista.

A.1.13 O que posso comer durante a gravidez?

R: Devido ao ambiente hormonal existem algumas particularidades pois existem alturas do dia em que é mais complicado normalizar os níveis de glicemia. As comunidades científicas recomendam que uma pessoa com gravidez deve ingerir uma quantidade mínima de 175g de hidratos de carbono por dia.

A.1.14 O meu filho pode ter diabetes?

R: Não é garantido que o seu filho tenha diabetes. Caso tenha a diabetes tipo 1 a probabilidade é muito menor do que se tiver a diabetes tipo 2. Por isso deve planear sempre a gravidez com a sua unidade de saúde!

A.1.15 Posso amamentar o bebé?

R: Sim, pode.

A.1.16 A minha gravidez é diferente do normal?

R: A gravidez não é igual comparando a uma pessoa que não tem a diabetes. Por isso deve planear sempre.

A.1.17 A diabetes é hereditária?

R: Muitos estudos apontam que o fator da hereditariedade é mais frequente para as pessoas que têm diabetes tipo 2 sendo que os seus principais genes predisponentes ainda não foram identificados. Caso tenha a diabetes tipo 1 a probabilidade é muito menor do que se tiver a diabetes tipo 2.

A.1.18 Tive diabetes por abusar nos doces?

R: Caso tenha diabetes tipo 1, não teve diabetes por abusar nos doces. A diabetes tipo 1 é uma doença autoimune e não está relacionada com comportamentos ou alimentação incorreta. Isto deve-se às células beta do pâncreas que deixam de produzir insulina - hormona que regula o nível de glucose no sangue. Apesar de não se conhecer o processo na sua totalidade, sabe-se que é o próprio sistema imunitário que ataca e destrói as suas células beta pancreáticas, responsáveis pela produção de insulina.

Caso tenha diabetes tipo 2, pode-se afirmar que não é o fato de comer especificamente açúcar ou doces que causa este tipo de diabetes, mas sim o fato de comer em excesso qualquer alimento que acabe fazendo com que o peso da pessoa aumente. E, além do excesso de peso, é preciso juntar outros fatores, como sedentarismo e a hereditariedade.

A.1.19 A diabetes tem cura?

R: A diabetes é uma doença crónica. Significa isto que, apesar de ser possível fazer o controlo e poder-se viver livre de sintomas mais graves, não existe ainda aquilo que se pode designar por cura. Ainda assim, quer na diabetes tipo 1 quer na diabetes tipo 2, há várias investigações em curso com resultados promissores e, quem sabe, com descobertas passíveis de se aproximarem de uma tão ansiada cura.

A.1.20 Posso comer doces?

R: É normal existirem doces que são desaconselhados: açúcar, pastéis, bolachas doces, chocolates açucarados, gelatinas com açúcar, refrigerantes. Isto deve-se ao facto de possuirem uma alta quantidade de hidratos de carbono.No entanto, pode consumir pois não existem alimentos proibidos mas sim alimentos que não são recomendados. Como consequência quando ingere alimentos, tem que saber a quantidade de hidratos de carbono que eles fornecem. Aborde essa quantidade com a sua unidade de saúde.

A.1.21 O que posso beber?

R: Relativamente às bebidas alcoólicas: para alguém do sexo masculino como tem maior capacidade de metabolização de álcool é aconselhado duas porções por dia; no sexo feminino é aconselhada uma porção por dia.

O excesso de álcool já não é bom para uma pessoa que não tenha diabetes. Com diabetes, a pessoa poderá ter efeitos secundários porque vai descontrolar a sua própria diabetes. O excesso de álcool gera um excesso de triglicerídeos e a glicose é usada para produzir estes triglicerídeos (potencialização de outra patologia).

Relativamente ao outro tipo de bebidas deve ter sempre em conta a quantidade de hidratos de carbono. Por isso verifique sempre e aborde essa quantidade com a sua unidade de saúde.

A.1.22 Vou ter de estar sempre a picar-me?

R: Se tiver diabetes tipo 1, desde que ingira hidratos de carbono sim tem de forma a poder colocar a insulina e monitorar com frequência os valores da glicemia.
Na diabetes tipo 2, normalmente, grande parte não necessita do tratamento intensivo e são utilizados fármacos como forma de tratamento. Atualmente, existem alternativas de medicação onde não é usada insulina: a medicação subcutânea. Informe-se melhor na sua unidade de saúde.

A.1.23 O que posso comer?

R: O padrão alimentar que deve seguir é o padrão da dieta mediterrânica: consumo reduzido de carnes vermelhas, consumo controlado de hidratos de carbono, utilização de leguminosos.

O problema da alimentação é a quantidade de hidratos de carbono que se pode ingerir pois o organismo pode não estar preparado para metabolizar. Se esta quantidade for em demasia pode haver problemas como as glicemias estarem elevadas.

Portanto, resumidamente: não existem alimentos proibidos mas sim alimentos que não são recomendados e que, como consequência, uma pessoa com diabetes ao ingeri-los tem que saber a quantidade de hidratos de carbono que eles fornecem.

A.1.24 Que complicações posso ter?/Quais são as complicações da diabetes?

R: Aproximadamente 40% das pessoas com diabetes vêm a ter complicações tardias da sua doença. Estas complicações evoluem de forma silenciosa e muitas vezes já estão instaladas quando são detetadas. De

um modo geral as complicações existentes são:

- Microvasculares: retinopatia, nefropatia e neuropatia.
- Macrovasculares: doença coronária, doença cerebral, doença arterial dos membros inferiores e hipertensão arterial.
- Neuro, macro e microvasculares: pé diabético.
- Outras complicações: disfunção sexual, infeções.

A.1.25 O que é o pé diabético?

R: O pé diabético é uma das complicações mais frequentes na diabetes, sabe-se que 25% das pessoas com diabetes tem condições que aumentam o risco de pé diabético. Esta complicação é responsável pela maioria das amputações em Portugal.

Para evitar esta complicação é importante não só um bom controlo da diabetes mas também uma série de cuidados com os pés:

1. Lave os pés todos os dias com água tépida.
2. Utilize gel ou sabonete com pH neutro.
3. Seque bem os pés, passando a toalha entre os dedos.
4. Passe vinagre de cidra/maçã nas unhas e na pele com algodão ou uma gaze. Com isto, vai prevenir o desenvolvimento de fungos e/ou bactérias.
5. Observe os seus pés regularmente para verificar se existe alguma ferida que não tenha visto.
6. As meias não devem ter costuras nem elásticos e devem ser de lã ou algodão.

O seu calçado deve seguir os seguintes requisitos:

1. Deve possuir espaço para os dedos com cerca de 1 centímetro a mais para além do dedo mais comprido.
2. Deve ser alto e largo para não existir pressão na parte lateral dos dedos.
3. Se usar tacão este não deve ultrapassar os 2 a 4 centímetros.
4. A parte do calcanhar deve ser firme e o dorso alto.
5. Deve apertar com cordões ou fecho de velcro ajustável na zona do tornozelo.

6. Enquanto caminha o pé não deve deslizar dentro do sapato nem deve sentir nenhum ponto de pressão.

7. Se tiver risco médio ou alto, o sapato deve ser fundo e ter palmilha amovivel para a substituir por uma palmilha adaptada ao seu pé que evite pressão excessiva na planta do pé.

Os problemas no pé são consequência dos efeitos de dois fatores: a aterosclerose (acumulação de placas de gordura e outras substâncias nas artérias) e a neuropatia (degeneração dos nervos).

A.1.26 Que cuidados dever ter com o pé?

Para evitar esta complicação é necessário prevenir com especiais cuidados e atenção com os seus pés:

1. Lave os pés todos os dias com água tépida.

2. Utilize gel ou sabonete com pH neutro.

3. Seque bem os pés, passando a toalha entre os dedos.

4. Passe vinagre de cidra/maçã nas unhas e na pele com algodão ou uma gaze. Com isto, vai prevenir o desenvolvimento de fungos e/ou bactérias.

5. Observe os seus pés regularmente para verificar se existe alguma ferida que não tenha visto.

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7. Se tiver risco médio ou alto, o sapato deve ser fundo e ter palmilha amovivel para a substituir por uma palmilha adaptada ao seu pé que evite pressão excessiva na planta do pé.

A.1.27 O que é a nefropatia diabética?

R: O nefrónio é a unidade funcional do rim, existem milhões de nefronios e cada um trabalha na filtração do sangue e na formação da urina. Quando, ao longo de anos, as artérias são sujeitas e níveis de glicemia elevados, elas começam a ficar danificadas, este dano é ainda mais grave se coexistir hipertensão arterial.

É extremamente importante prevenir esta situação através de um controlo eficaz da glicemia. A taxa de filtração glomerular deve ser avaliada anualmente na pessoa com diabetes, é um valor que varia consoante o sexo, a idade e a superfície corporal.

A.1.28 O que é a hipertensão arterial?

R: A hipertensão arterial e a diabetes são doenças inter-relacionadas que, se não tratadas, aumentam o risco de doenças cardiovasculares (enfartes do miocárdio, acidentes vasculares cerebrais e doença dos membros inferiores). Esta complicação é duas vezes mais comum em pessoas com diabetes e aumenta com a idade.

No momento do diagnóstico da diabetes, a hipertensão já existe em cerca de 40% das pessoas, o que sugere uma relação entre as duas: a obesidade e resistência à insulina levam à hipertensão arterial e esta agrava a intolerância à glicose (açúcar). Na maioria dos casos não se encontra uma causa para a hipertensão arterial, por isso, designa-se de essencial, isto acontece em particular na diabetes tipo 2.

Nas pessoas com diabetes, hipertensão sistólica isolada (elevação apenas da pressão arterial máxima) é mais frequente que nas pessoas sem diabetes. Constitui, ao contrário do que se supunha anteriormente, um maior risco de complicações cardiovasculares, principalmente de acidente vascular cerebral (trombose ou hemorragia cerebral).

A.1.29 O que é a disfunção sexual?/O que é a disfunção eréctil?

R: No homem, a disfunção eréctil é a incapacidade persistente de atingir e manter uma ereção suficiente para realizar uma atividade sexual satisfatória. A diabetes, quer a tipo 1, quer a tipo 2 é a causa mais frequente de disfunção eréctil.
Estas complicações só surgem, habitualmente após mais de 10 anos do diagnóstico e tem uma incidência de 30% a 50% nas pessoas com diabetes mal controladas, o risco aumenta exponencialmente quando existem outros fatores de risco como a hipertensão ou o tabagismo. O tratamento deve ser sempre discutido com a tua unidade médica e o tratamento mais adequado para uns casos pode não o ser para outros.

A.1.30 O que é a retinopatia diabética?

R: A retinopatia diabética é uma manifestação oftalmológica da diabetes e uma das principais causas de perda de visão a nível mundial. O aumento dos níveis de açúcar no sangue (glicemia) provocam alterações nos pequenos vasos sanguíneos da retina. Estes vasos alterados deixam sair líquido e sangue para a retina.

Nesta doença não há habitualmente alterações da visão. Pode, portanto, evoluir para formas bastante avançadas sem provocar qualquer sintoma. A frequência da retinopatia depende dos anos de duração da diabetes.

Após 20 anos de evolução, mais de 90% das pessoas com diabetes tipo 1 e mais de 60% das pessoas com diabetes tipo 2, desenvolvem retinopatia diabética. O mau controlo metabólico (glicemia e pressão arterial) constitui também um fator de risco para o aparecimento da retinopatia.

Deve realizar anualmente um rastreio da retinopatia diabética. Se lhe forem diagnosticadas alterações, a sua unidade médica deve informar-lhe da regularidade com que deve ir à consulta.

A.1.31 O que é a doença coronária?

R: O sintoma mais frequente da presença de uma lesão ou obstrução das artérias coronárias é dor no peito. Os fatores de risco cardiovasculares como a obesidade, a hipertensão e a dislipidemia são comuns em pacientes com a diabetes.

A.1.32 O que é a doença cerebral?

R: A diabetes está associada a défices cognitivos moderados, a alterações neurofisiológicas e estruturais no cérebro: encefalopatia diabética. Sendo assim, a diabetes aumenta o risco de demência, particularmente em idosos.

A.1.33 O que é a neuropatia diabética?

R: A neuropatia diabética é um distúrbio nervoso causado pela diabetes. O início da neuropatia pode ser tão lento que nos estágios iniciais pode não apresentar sintomas ou sinais.

Os sintomas podem variar de acordo com o tipo de dano dado às fibras nervosas afetadas. O aumento da glicemia (hiperglicemia) é uma das causas mais importantes desta complicação.

É possível prevenir a neuropatia através de uma prática de um estilo de vida saudável (alimentação, atividade física, não fumar e evitar bebidas alcoólicas) e cumprindo o tratamento farmacológico adequado.

A.1.34 Onde posso encontrar uma tabela de nutrição?

R: A melhor tabela de nutrição é a Tabela de Composição dos Alimentos Portugueses do Instituto Nacional Ricardo Jorge.Pode consultar no website do PortFIR através do grupo de alimentos que pretende. É só carregar no site aqui => `http://portfir.insa.pt/foodcomp/category?catId=0`.

A.1.35 Existem riscos se tiver covid-19?

R: A diabetes descontrolada é um risco aumentado para várias situações (não só relativamente à COVID-19). As pessoas são mais ou menos sensíveis para outros problemas de saúde. Uma pessoa com diabetes é um alvo mais fácil para ter outras doenças devido à dificuldade da defesa. Algo que seja infecioso é mais complicado para as pessoas que possuem a diabetes.

A.1.36 O que é a insulina?

R: A insulina é uma hormona que faz naturalmente parte do organismo, e que serve essencialmente para fazer com que o açúcar existente no sangue – que é a nossa fonte energética principal – seja bem aproveitado, para nos dar energia.

A.1.37 O que é a hiperglicemia?

R: A hiperglicemia pode acontecer devido aos seguintes casos:

- Insuficiente produção de insulina pelo organismo.
- Insuficiente ação da insulina.
- Combinação dos fatores anteriores.

Quando de repente deixa de existir insulina no organismo (Diabetes Tipo 1) ou quando existe em quantidade insuficiente, ou não consegue actuar (Diabetes Tipo 2), o açúcar acumula-se no sangue (provocando hiperglicemia) em vez de entrar nas células do organismo, para dar a energia necessária para o dia a dia. Os sintomas de hiperglicemia podem ser:

- Falta de forças.
- Urinar em grande quantidade e mais vezes.
- Ter sede constante e intensa.
- Sensação de boca seca.
- Fome constante e difícil de saciar.
- Cansaço.

- Comichão no corpo (sobretudo ao nível dos órgãos genitais).
- Visão turva.

A.1.38 O que é a hipoglicemia?

R: A hipoglicemia geralmente ocorre em pessoas com diabetes que utilizam fármacos para baixar os níveis de açúcar no sangue, seja insulina ou comprimidos (antidiabéticos orais). Esta situação pode acontecer essencialmente por três motivos (isolados ou em conjunto):

- Toma excessiva/incorreta da medicação.
- Jejum prolongado ou refeições sem alimentos ricos em hidratos de carbono.
- Exercício físico exagerado ou não programado.

A hipoglicemia corresponde a valores de glicemia iguais ou inferiores a 70mg/dl. Quanto melhor for o controlo metabólico menor será a probabilidade de ocorrer uma hipoglicemia. Saber tratar uma hipoglicemia é extremamente importante para evitar complicações graves que podem advir, como o coma hipoglicémico. A glicose (açúcar) é a principal fonte de energia utilizada pelo nosso corpo, o cérebro, por exemplo, só utiliza glicose como fonte de energia. os sintomas de hipoglecimia podem ser:

- Visão turva.
- Fraqueza.
- Tonturas.
- Náuseas.
- Sensação de fome (vontade extrema de comer tudo).
- Dor de cabeça.
- Tremores.
- Suores frios.
- Palpitações cardíacas.
- Palidez.
- Ansiedade/irritabilidade.

Apenas alguns destes sintomas podem estar presentes consoante a gravidade da hipoglicemia, podendo variar de pessoa para pessoa. Em situação de hipoglicemia grave os sintomas podem ser:

- Confusão mental.
- Amnésia.
- Desmaio.
- Convulsões.
- Coma.

A.1.39 O que é a insulina?

R: A insulina é uma hormona que faz naturalmente parte do organismo, e que serve essencialmente para fazer com que o açúcar existente no sangue – que é a nossa fonte energética principal – seja bem aproveitado, para nos dar energia.

Existem dois tipos de insulina: a rápida e a lenta. A insulina lenta costuma cobrir o dia todo enquanto a insulina rápida costuma dar-se antes das refeições de forma a cobrir as refeições.

Normalmente, a insulina lenta funciona muito bem para as pessoas com diabetes tipo 2 devido a uma absorção ao longo de 24 horas que mudam a ingestão alimentar.Numa pessoa que faz a contagem dos hidratos de carbono podem dar-se as unidades de insulina rápida de acordo com a contagem. Caso a pessoa não consiga fazer a contagem dos hidratos de carbono, pode-se fazer uma contagem mediante o valor da picada da glicemia que tiver antes da refeição.

A.1.40 Tenho que fazer sempre insulina?

R: Caso possua diabetes tipo 1 sim, vai ter de fazer sempre insulina.

Para as pessoas com diabetes tipo 2, existem alternativas de medicação onde não é usada insulina: a medicação subcutânea. Aconselhe-se junto da sua unidade médica.

A.1.41 O que é a hemoglobina glicada?/Estou a tratar bem da diabetes?

R: No tratamento da diabetes, quando a pessoa quer saber a medicação que deve tomar ou se está a tratar bem da diabetes deve recorrer ao procedimento da hemoglobina glicada.

A hemoglobina glicada é um parâmetro sanguíneo de uma análise que se faz no sangue que dá uma média do açúcar nos últimos 3 meses.

A.1.42 Que vacinas devo tomar?

R: Como as pessoas que possuem diabetes têm maiores riscos de terem complicações devem tomar as seguintes vacinas:

- A vacina contra infeções: Streptococcus pneumoniae (esclarecer o período com a unidade médica).

- A vacinação contra a gripe (todos os anos).
- Atualmente, deve tomar-se a vacinação contra a COVID-19 que permite a proteção contra a doença e as suas complicações.

A.1.43 O que são hidratos de carbono?

R: Os hidratos de carbono (HC) ocupam a fatia maior na roda dos alimentos. Isto deve-se ao facto da sua função principal ser o fornecimento de energia ao nosso organismo.

No caso dos hidratos de carbono, a glicose é a molécula mais simples que resulta da digestão. E a partir da qual o organismo obtém a energia que necessita para as mais variadas atividades. Por cada grama de hidratos de carbono, o organismo obtém 4 quilocalorias de energia (kcal).

Existem outras funções para além da produção de energia que são:

- Armazenar a energia produzida pela glicose para se utilizar em situações de necessidade.
- Ajudam a preservar a massa muscular, porque se estiverem em circulação o corpo não tem de ir buscar energia aos músculos, deteriorando-os para a obter.
- Existe um tipo de hidratos de carbono que são as fibras onde não existe a transformação em glicose e é essencial na saúde digestiva.

A APDP recomenda a pesagem dos alimentos, a leitura dos rótulos e a utilização dos materiais recomendados na consulta de nutrição, para conferir a quantidade de hidratos de carbono que serão consumidos durante a refeição e reforça que a quantidade total de hidratos de carbono ingeridos deve ser sempre controlada por um nutricionista, sendo que esta será diferente para cada pessoa, dependendo de vários fatores, como a idade, o peso e o nível de atividade física, entre outros.

A.1.44 Como faço a contagem de hidratos de carbono?

R: Para a correta contagem de hidratos de carbono, a APDP recomenda a pesagem dos alimentos, a leitura dos rótulos e a utilização dos materiais recomendados na consulta de nutrição, para conferir a quantidade de hidratos de carbono que serão consumidos durante a refeição e reforça que a quantidade total de hidratos de carbono ingeridos deve ser sempre controlada por um nutricionista, sendo que esta será diferente para cada pessoa, dependendo de vários fatores, como a idade, o peso e o nível de atividade física, entre outros.

A.1.45 Como posso controlar o stress?

R: Quando a depressão surge numa pessoa com diabetes, os próprios sintomas dela podem mimetizar os sintomas da diabetes, ou seja, podem surgir mais queixas de fadiga, dificuldades de concentração, alterações do apetite, alterações do sono, sensação de agitação ou lentificação. Por outro lado, a depressão

pode amplificar os sintomas da diabetes, como a fadiga, as alterações da visão, as queixas urinárias, as alterações da sensibilidade no corpo, as tonturas, a sensação de fome ou de sede excessivas, a sonolência ou as dores.

O tratamento da depressão em diabetes é semelhante aos das pessoas sem diabetes e tem resultados muito semelhantes. Consegue-se voltar à normalidade na maioria das depressões, sobretudo se forem tratadas no seu início. Esta melhoria tem consequências positivas também na própria diabetes, tanto no peso subjetivo relacionado com os autocuidados, como no controlo da glicemia.

A.1.46 O que são cetonas?/O que são corpos cetónicos?

R: O açúcar é a fonte energética natural do corpo humano. Quando deixa de ser utilizado como fonte de energia, o organismo passa a utilizar as reservas de gordura como alternativa. A presença de corpos cetónicos no organismo resulta desse processo, da degradação da gordura, e é um sinal de alarme que obriga a agir e a procurar as causas. Um dos corpos cetónicos mais conhecidos é a cetona.

Os corpos cetónicos podem aparecer devido a vários factores tais como:

- Jejum prolongado.
- Falta/Ausência de administração de insulina.
- Situação de doença.

Na presença de corpos cetónicos, geralmente a glicemia apresenta valores superiores a 250mg/dl. No entanto, em situação de doença em que há presença de vómitos e/ou diarreia, a glicemia pode ser inferior a 140mg/dl mas com presença de corpos cetónicos.

A.1.47 Quais são os valores normais de glicemia?

R: Os valores de glicemia estão divididos em dois casos: quando a pessoa está em jejum ou 2 horas depois da refeição. Nos casos em que a pessoa está em jejum, os valores normais de glicemia variam entre os 70mg/dl e os 100mg/dl. Quando a pessoa faz uma refeição, passadas 2 horas os níveis devem estar entre os 70mg/dl e os 140mg/dl.

Uma pessoa com diabetes deve tentar aproximar-se o mais possível destes valores ou atingir os objetivos indicados pela equipa de saúde, que são variáveis e individualizáveis, consoante a idade da pessoa e os anos de evolução da diabetes.

A.1.48 O que é o índice glicémico?

R: O índice glicémico é um sistema útil para avaliar alimentos que contêm hidratos de carbono quanto à influência que terão nos níveis de glicemia após a ingestão de uma determinada porção do alimento.

Neste sistema, todos os alimentos são classificados numa escala de 0 a 100 por comparação com um alimento padrão.

Os alimentos com um elevado nível glicémico são rapidamente digeridos, absorvidos e metabolizados pelo organismo, levando a maiores flutuações da glicemia. Por outro lado, os alimentos com baixo índice são absorvidos lentamente, resultando em menores flutuações do nível de açúcar no sangue.

A.1.49 Devo comer alimentos com baixo índice glicémico?

R: Não, a alimentação deverá ser sempre o mais variada possível e não necessita de afastar completamente os alimentos com elevado índice glicémico da sua dieta. É, contudo, importante que conheça o índice dos alimentos para controlar a sua influência na glicemia, consumindo-os com consciência moderação.

Appendix B

Form for individuals with Diabetes

(1) Tipo de diabetes:

◯ Diabetes Tipo 1
◯ Diabetes Tipo 2
◯ Diabetes Gestacional
◯ Outro

(2) Questões que foram abordadas quando foi recém-diagnosticada/o com Diabetes Mellitus. (Caso possua, indique um conjunto de perguntas):

Appendix C

Consent for content - Health professionals

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CONSENTIMENTO PARA PARTICIPAÇÃO EM INVESTIGAÇÃO

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No estudo EduDiabCare pretendemos desenvolver um *chatbot* para apoio a pessoas com diabetes relativamente ao auto-cuidado, de forma a ajudá-las na gestão da sua doença. Para esta investigação necessitamos de avaliar as necessidades no dia-a-dia dos doentes recém-diagnosticados com diabetes. Propomos, por isso, a sua participação numa entrevista remota (por telefone ou através de uma plataforma, por exemplo Zoom ou Microsoft Teams). Na entrevista irão ser abordadas as diversas questões que os doentes eventualmente poderão ter, assim como as respetivas respostas, com uma duração total prevista de 45 minutos. Os dados sócio-demográficos referentes a si a recolher serão apenas profissão e n.º de anos de atividade profissional, de forma a caracterizar os participantes. A entrevista será gravada (som), para facilitar a posterior análise por investigadores da *Associação Fraunhofer Portugal Research* envolvidos neste estudo. A gravação será destruída no final deste estudo, nomeadamente após a publicação dos resultados.

Os dados recolhidos são confidenciais e anonimizados. A *Associação Fraunhofer Portugal Research* tomará todas as medidas necessárias à salvaguarda e proteção dos dados recolhidos por forma a evitar que venham a ser acedidos por terceiros não autorizados.

Os seus direitos no âmbito da proteção de dados serão sempre assegurados, tendo em consideração as normas específicas para o desenvolvimento da atividade de investigação. A sua participação é voluntária, podendo em qualquer altura cessá-la sem qualquer tipo de consequência. Também poderá pedir a retificação ou destruição da informação recolhida a qualquer momento. Para qualquer comunicação para este efeito, assim como informações adicionais, deverá enviar email ao Investigador Responsável abaixo identificado.

Gostaríamos de contar com a sua participação. A participação não envolve qualquer prejuízo ou dano material e não haverá lugar a qualquer pagamento. A participação não terá custos para o participante.

Agradecemos muito o seu contributo, fundamental para a nossa investigação!

O participante:

Declaro ter lido e compreendido este documento, bem como as informações verbais fornecidas e aceito participar nesta investigação. Permito a utilização dos dados que forneço de forma voluntária, confiando que apenas serão utilizados para esta investigação e com as garantias de confidencialidade e anonimato que me são dadas pelo investigador. Autorizo a comunicação de dados de forma ***anónima*** *a outras entidades que estabeleçam parceria com a Associação Fraunhofer Portugal Research para fins académicos e de investigação científica.*

Nome do participante: _____

Assinatura do participante: _____

Data ___ / ___ / _____

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CONSENTIMENTO PARA PARTICIPAÇÃO EM INVESTIGAÇÃO

Estudante:

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Appendix D

Interview Guide - Nutritionist

Nome do Estudo: EduDiabCare

Olá, o meu nome é Sandro Cruz, sou estudante da Universidade do Minho e estou a fazer uma dissertação de mestrado em colaboração com a *Associação Fraunhofer Portugal Research*. Para poder avançar com o estudo, denominado EduDiabCare, gostaria que participasse numa entrevista. O objetivo da entrevista pretende avaliar as necessidades no dia-a-dia dos doentes recém-diagnosticados com diabetes.

Nesta entrevista, serão abordadas as diversas questões que os doentes eventualmente poderão ter com as respetivas respostas, com uma duração total prevista de 45 minutos. Se concordar, o áudio da entrevista será gravado, para uma posterior análise.

A participação não envolve qualquer prejuízo ou dano e não haverá lugar a qualquer pagamento nem terá custos. Os seus dados pessoais e a informação recolhida serão analisados pelos investigadores da *Associação Fraunhofer Portugal Research* e utilizados apenas para este estudo, não serão partilhados com ninguém fora do projeto e serão destruídos no final do estudo.

Obrigado.

Aceita participar neste estudo? Aceita que a entrevista seja gravada? Posso começar a gravar?

Entrevistador: Bem, antes de mais queria agradecer por ter aceitado participar neste estudo. Como questão introdutória pretendia saber quais são as questões que grande parte das pessoas recém-diagnosticadas com diabetes costumam ter e as suas respostas. Sendo normal essas pessoas ficarem preocupadas, acho que é algo que devem procurar logo esclarecer.

Entrevistado: ....

Entrevistador: Em geral, todos os tipos de diabetes costumam envolver várias dúvidas ou existe algum tipo em que as pessoas não se sentem tão à vontade e necessitam mais ajuda?

Entrevistado: …

Entrevistador: Existem vários casos em que os pais ficam bastante preocupados porque os seus filhos desenvolvem diabetes. As questões que possuem costumam ser diferentes? Queria saber se existe diferença no ponto de vista das pessoas que não têm esta doença ou que têm.

Entrevistado: …

Entrevistador: Que tipo de alimentação os diabéticos devem seguir? Existe alguma lista de receitas saudáveis? (Neste caso eu segui as receitas da APDP (Associação Protectora dos Diabéticos de Portugal).

Entrevistado: …

Entrevistador: Dentro do mesmo tema, quando um diabético vai a uma festa ou um convívio deve colocar muitas questões sobre o que não deve comer ou no que não pode abusar. Neste caso quais seriam? São comuns questões sobre o que fazer caso não tenha cumprido o regime alimentar recomendado?

Entrevistado: …

Entrevistador: Outra das dúvidas que tenho é relativamente ao exercício físico. Mais uma vez segui as guidelines da APDP. Existe algum plano de treino recomendado para quem está a começar? São necessários ajustes na alimentação do diabético antes e depois de praticar exercício físico?

Entrevistado: …

Entrevistador: Relativamente ao trabalho, verifiquei que existem algumas questões como em que pode influenciar a escolha do trabalho de um diabético pois existem algumas profissões que este não pode exercer e as suas principais condicionantes. Quais as recomendações?

Entrevistado: …

Entrevistador: As grávidas recém-diagnosticadas com diabetes gestacional também devem possuir bastantes dúvidas já que nunca tiveram algo parecido. Qual a alimentação recomendada? E que questões costumam ter, sendo que existe aquele risco de poderem desenvolver a diabetes tipo 2 caso não cumpram em rigor as recomendações.

Entrevistado: …

Entrevistador: A COVID-19 e a diabetes são hoje duas pandemias que se cruzam, com consequente grande impacto para a saúde pública global. Estudos epidemiológicos mostram que a diabetes é a segunda comorbilidade mais associada à COVID-19. Visto isto, deve ser normal que as pessoas estejam bastante preocupadas relativamente a esta nova doença. Pretendia saber se existem questões ligadas à diabetes que as pessoas costumam fazer sobre a COVID-19.

Entrevistado: …

Entrevistador: Ao longo do tempo as pessoas vão ganhando mais experiência e cada vez têm menos dúvidas. Uma das questões que mais notei nestas pessoas foi a utilização do melhor aparelho de medição de glicemia bem como a sua precisão. É verdade?

Entrevistado: …

Entrevistador: Cheguei a ter uma conversa com o administrador do grupo Diab®etes-Portugal em que ele disse que o tipo de questões que os diabéticos costumam ter são relativas a um tratamento que é individualizado e que não permite uma questão de “se”, “então”. Para a aplicação que estou a desenvolver seria complicado pois é de carácter muito subjetivo, dado que a resposta depende sempre de fatores. Pretendia saber se só com as questões mais objetivas já poderia ajudar as pessoas recém-diagnosticadas de certa forma.

Entrevistado: …

Entrevistador: Por fim, existe alguma página na web que me aconselha (além da APDP) e que possua boas guidelines?

Entrevistado: …

Entrevistador: Já pude esclarecer várias dúvidas que tinha. Espero que sejam as suficientes para desenvolver a aplicação de forma a ajudar as pessoas recém-diagnostadas. Mais uma vez queria agradecer por ter participado e respondido às várias questões que foram abordadas ao longo desta entrevista. Obrigado.

Appendix E

Interview Guide - Doctors

Nome do Estudo: EduDiabCare

Olá, o meu nome é Sandro Cruz, sou estudante da Universidade do Minho e estou a fazer uma dissertação de mestrado em colaboração com a *Associação Fraunhofer Portugal Research*. Para poder avançar com o estudo, denominado EduDiabCare, gostaria que participasse numa sessão. O objetivo da sessão pretende avaliar o conteúdo da aplicação móvel que irá servir para atender as necessidades no dia-a-dia dos doentes recém-diagnosticados com diabetes.

Na sessão irá ser abordada uma discussão relativamente ao conteúdo pedagógico existente na aplicação como as questões e as respostas que são abordadas nesta, com uma duração total prevista de 30 minutos. Se concordar, toda a sessão será gravada, para uma posterior análise.

A participação não envolve qualquer prejuízo ou dano e não haverá lugar a qualquer pagamento nem terá custos. Os seus dados pessoais e a informação recolhida serão analisados pelos investigadores da *Associação Fraunhofer Portugal Research* e utilizados apenas para este estudo, não serão partilhados com ninguém fora do projeto e serão destruídos no final do estudo.

Obrigado.

Aceita participar neste estudo? Aceita que a sessão seja gravada? Posso começar a gravar?

Entrevistador: Bem, antes de mais queria agradecer por ter aceitado participar neste estudo. Vou enviar-lhe um PDF que contém todas as questões e respostas relevantes existentes para poder fazer uma avaliação deste.

Entrevistado: ....

Entrevistador: O conteúdo que enviei considera adequado? Existem outras questões que deveriam ser colocadas?

Entrevistado: ....

Entrevistador: As pessoas que são diagnosticadas com diabetes costumam ter este tipo de dúvidas?

Entrevistado: ....

Entrevistador: Possui alguma observação extra relativamente à aplicação e o seu conteúdo?

Entrevistado: ....

Entrevistador: Já pude esclarecer várias dúvidas que tinha. Mais uma vez queria agradecer por ter participado e respondido às várias questões que foram abordadas ao longo desta sessão. Obrigado.

Appendix F

Consent for content - Individuals with Diabetes

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Os dados recolhidos são confidenciais e anonimizados. A *Associação Fraunhofer Portugal Research* tomará todas as medidas necessárias à salvaguarda e proteção dos dados recolhidos por forma a evitar que venham a ser acedidos por terceiros não autorizados.

Os seus direitos no âmbito da proteção de dados serão sempre assegurados, tendo em consideração as normas específicas para o desenvolvimento da atividade de investigação. A sua participação é voluntária, podendo em qualquer altura cessá-la sem qualquer tipo de consequência. Também poderá pedir a retificação ou destruição da informação recolhida a qualquer momento. Para qualquer comunicação para este efeito, assim como informações adicionais, deverá enviar email ao Investigador Responsável abaixo identificado. A fim de garantir a segurança do participante, ser portador de pacemaker impede a participação neste estudo.

Gostaríamos de contar com a sua participação. A participação não envolve qualquer prejuízo ou dano material e não haverá lugar a qualquer pagamento. A participação não terá custos para o participante.

Agradecemos muito o seu contributo, fundamental para a nossa investigação!

O participante:

Declaro ter lido e compreendido este documento, bem como as informações verbais fornecidas e aceito participar nesta investigação. Permito a utilização dos dados que forneço de forma voluntária, confiando que apenas serão utilizados para esta investigação e com as garantias de confidencialidade e anonimato que me são dadas pelo investigador. Mais declaro não ser portador de pacemaker. Autorizo a comunicação de dados de forma ***anónima*** *a outras entidades que estabeleçam parceria com a Associação Fraunhofer Portugal Research para fins académicos e de investigação científica.*

Nome do participante: _____

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CONSENTIMENTO PARA PARTICIPAÇÃO EM INVESTIGAÇÃO

Assinatura do participante: _____

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Estudante:

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Investigador responsável pelo projeto:

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E-mail: silvia.rego@fraunhofer.pt

Assinatura:_____

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Appendix G

Interview Guide - Individuals with Diabetes

Nome do Estudo: EduDiabCare

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Na sessão irá ser abordada a utilização da aplicação bem como as diversas questões que o utilizador eventualmente poderá ter com o objetivo de poderem ser apontados os principais problemas e será feita uma discussão relativamente ao conteúdo pedagógico existente na aplicação como as questões e as respostas que são abordadas nesta, com uma duração total prevista de 30 minutos. Se concordar, toda a sessão será gravada (imagens de som e de vídeo e ecrã do telemóvel), para uma posterior análise.

A participação não envolve qualquer prejuízo ou dano e não haverá lugar a qualquer pagamento nem terá custos. Os seus dados pessoais e a informação recolhida serão analisados pelos investigadores da *Associação Fraunhofer Portugal Research* e utilizados apenas para este estudo, não serão partilhados com ninguém fora do projeto e serão destruídos no final do estudo.

Obrigado.

Aceita participar neste estudo? Aceita que a sessão seja gravada? Posso começar a gravar?

Entrevistador: Bem, antes de mais queria agradecer por ter aceitado participar neste estudo. Como questão introdutória pretendia saber quais foram as dúvidas que teve quando teve a diabetes pois é algo de facto importante para se relacionar com o conteúdo da aplicação.

Entrevistado: ....

Entrevistador: Vamos proceder da seguinte forma: vou enviar-lhe um PDF que contém todas as questões e respostas relevantes existentes para poder fazer uma avaliação deste.

Entrevistado: ....

Entrevistador: O conteúdo que enviei considera adequado? Existem outras questões que deveriam ser colocadas?

Entrevistado: ....

Entrevistador: Teve estas dúvidas quando foi diagnosticado com a diabetes?

Entrevistado: ....

Entrevistador: Possui alguma observação extra relativamente à aplicação e o seu conteúdo?

Entrevistado: ....

Entrevistador: Já pude esclarecer várias dúvidas que tinha. Mais uma vez queria agradecer por ter participado e respondido às várias questões que foram abordadas ao longo desta sessão. Obrigado.

Appendix H

Consent for usability tests

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Os seus direitos no âmbito da proteção de dados serão sempre assegurados, tendo em consideração as normas específicas para o desenvolvimento da atividade de investigação. A sua participação é voluntária, podendo em qualquer altura cessá-la sem qualquer tipo de consequência. Também poderá pedir a retificação ou destruição da informação recolhida a qualquer momento. Para qualquer comunicação para este efeito, assim como informações adicionais, deverá enviar email ao Investigador Responsável abaixo identificado. A fim de garantir a segurança do participante, ser portador de pacemaker impede a participação neste estudo.

Gostaríamos de contar com a sua participação. A participação não envolve qualquer prejuízo ou dano material e não haverá lugar a qualquer pagamento. A participação não terá custos para o participante.

Agradecemos muito o seu contributo, fundamental para a nossa investigação!

O participante:

Declaro ter lido e compreendido este documento, bem como as informações verbais fornecidas e aceito participar nesta investigação. Permito a utilização dos dados que forneço de forma voluntária, confiando que apenas serão utilizados para esta investigação e com as garantias de confidencialidade e anonimato que me são dadas pelo investigador. Mais declaro não ser portador de pacemaker. Autorizo a comunicação de dados de forma ***anónima*** *a outras entidades que estabeleçam parceria com a Associação Fraunhofer Portugal Research para fins académicos e de investigação científica.*

Nome do participante: _____

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Assinatura do participante: _____

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Assinatura:_____

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Annex I

Form for System Usability Scale

Número de participante: ____

System Usability Scale (SUS)

A realização deste questionário padrão tem como função medir a usabilidade geral de um sistema. Selecione a resposta que melhor expressa como se sente sobre cada afirmação depois de utilizar a aplicação DiabCare – Assistente Virtual.

		Discordo Totalmente	Discordo	Neutro	Concordo	Concordo Totalmente
1.	Acho que gostaria de utilizar esta ferramenta com frequência.	□	□	□	□	□
2.	Achei a ferramenta desnecessariamente complicada.	□	□	□	□	□
3.	Achei que a ferramenta era fácil de utilizar.	□	□	□	□	□
4.	Acho que necessitaria do apoio de um técnico para poder utilizar este sistema.	□	□	□	□	□
5.	Achei que as várias funções desta ferramenta estavam bem integradas.	□	□	□	□	□
6.	Achei que havia muita inconsistência nesta ferramenta.	□	□	□	□	□
7.	Imagino que a maioria das pessoas aprenderia a utilizar esta ferramenta muito rapidamente.	□	□	□	□	□
8.	Achei a ferramenta muito complicada de utilizar.	□	□	□	□	□
9.	Senti-me muito confiante ao utilizar a ferramenta.	□	□	□	□	□
10.	Precisei de adquirir aprendizagens antes de começar a utilizar esta ferramenta.	□	□	□	□	□

Qual é a probabilidade de recomendar esta aplicação para outras pessoas? (Rodeie a sua resposta)

Não provável 0 1 2 3 4 5 6 7 8 9 10 Extremamente provável