Filipe
Reis

ObeOne 2.0: para além dos números numa abordagem mHealth para a obesidade.

ObeOne 2.0: going beyond the numbers in an mHealth approach for obesity.

"Unless you try to do something beyond what you have already mastered, you will never grow."

— Ronald E.Osborn

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Dissertação apresentada à Universidade de Aveiro para cumprimento dos requisitos necessários à obtenção do grau de Mestre em Engenharia de Computadores e Telemática, realizada sob a orientação científica do Doutor Samuel de Sousa Silva, Investigador do Instituto de Engenharia Eletrónica e Informática de Aveiro, e do Professor Doutor Ilídio Fernando de Castro Oliveira, Professor Auxiliar do Departamento de Eletrónica, Telecomunicações e Informática da Universidade de Aveiro.

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Palavras chave

obesidade, *mobile health*, tecnologias móveis, relação médico-paciente, user centered design

Resumo

A obesidade, frequentemente apelidada de uma das pandemias do século é uma doença que se encontra sobre numa preocupante curva ascendente da sua incidência. Ainda que seja normalmente associada a problemas nutricionais e físicos, a componente psicológica tem um peso significativo quer enquanto factor motivador da condição, quer enquanto consequência, por via de redução da autoestima e problemas de integração social. Estas múltiplas dimensões associadas à obesidade são, do ponto de vista clínico, acompanhadas por diferentes especialidades médicas que procuram melhorar a condição do paciente em cada uma delas.

Tendo em conta o crescente relevo das tecnologias móveis, enquanto instrumentos de suporte em situações de saúde, os sistemas de mobile Health (mHealth) têm sido propostos para o contexto da obesidade. No entanto, ainda existem diversos problemas com parte das abordagens que levam a uma rápida desmotivação dos seus utilizadores e consequente insucesso dos tratamentos. Grande parte destes problemas são potenciados por uma forte componente de quantificação do desempenho (e.g., engordei 1 Kg) e um inexistente ou muito pobre suporte à relação médico paciente.

Tendo em conta estes aspetos, este trabalho alicerça-se numa abordagem iterativa centrada no utilizador para, partindo de trabalho anterior numa ferramenta mHealth para suporte ao paciente obeso, propôr estratégias e funcionalidades que possibilitem um suporte ao paciente obeso que tenha em maior consideração a componente psicológica.

Nesse sentido, são propostas abordagens de psicologia positiva e qualitativas sempre que algum tipo de avaliação tenha de ser feito. Dentro deste princípio orientador do trabalho, foi ainda considerada a integração de um dispositivo que permita ao paciente, de forma simples, com base nos alimentos que tem disponíveis, ter a sugestão da quantidade de alimentos que deve ingerir mediante a sua refeição.

No que respeita ao suporte da relação médico-paciente, foi dada a ambas as partes a possibilidade de se associarem entre si, de modo a que o médico consiga ter um maior impacto na informação a que os pacientes podem ver. No sentido contrário, com vista a que o médico tenha acesso ao maior número possível de informação sobre os pacientes, é dado aos pacientes a possibilidade de automáticamente partilharem informação sobre a sua rotina.

O trabalho desenvolvido permite agora suportar uma discussão e avaliação mais alargada sobre o impacto e receptividade das abordagens propostas, quer no sucesso das aplicações mHealth para com o tratamento da obesidade, como da relevância e valor que a relacão médico-paciente pode adicionar aos tratamentos por esta via.

Keywords obesity, mobile health, mobile technologies, doctor-patient relationship, user centered design

Abstract

Obesity, frequently nicknamed as one of the pandemics of the century, is a disease that is currently over an alarming upward curve of his incidence. Even though obesity is usually associated with nutritional and physical problems, the psychological component has a very significant weight, either as a motivation factor, with psychological problems that result in eating disorders, or as a consequence, by self-esteem reduction and social integration problems. These multiple conditions directly related to obesity, are from the doctor point of view, accompanied by different medical specialties that aim to improve the patient condition at each of them.

Given the rising impact of mobile technologies as support tools in different health situations, Mobile Health (mHealth) systems have been proposed to the obesity context. However, there are still diverse problems with most of the approaches that result in rapid user demotivation and, consequently, treatment failure. A big part of these problems is exacerbated by a strong performance quantification (e.g., gained 1 Kg) and inexistent or very poor medical-patient support.

With these aspects in mind, this work is based on a user-centered iterative approach, so that, from previous work in a mHealth tool to obese patients, new strategies and functionalities are suggested that allow higher support to obese regarding the psychological component.

In these terms, positive psychology and qualitative approaches are proposed every time there is a type of evaluation that has to be done. From this guiding principle, there was considered the integration from a device that allows patients to, effortless, from the possible ailments, have a suggestion from the quantity that he shall ingest upon his meal.

Regarding the medical-patient support, it was given to both parts the possibility of an association between, so that doctors can have more impact on the information that patients can see. In the opposite direction, with the goal of providing doctors the highest quantity of information possible about their patients, it is given to patients the possibility of automatically sharing information about their routine.

The developed work allows now to support a more in-depth discussion about the impact and receptivity from the proposed approaches, either int the success of mHealth applications regarding obesity treatment, as the relevance and value that the medical-patient relationship can add to treatments by this via.

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Acronyms

BF Body Fat

BMI Body Mass Index

CSS Cascading Style Sheets

eHealth Eletronics Health

GRPD General Data Protection Regulation

IEETA Institute of Electronics and Informatics Engineering of Aveiro

IOT Internet of Things

IT Institute of Telecommunications

mHealth Mobile Health

QUIS Questionnaire For User Interaction Satisfaction

UCD User Centered Design

UI User Interface

Chapter 1

Introduction

The last three decades have witnessed an alarming increase in obesity rates around the world [1]. Figure 1.1 illustrates the prevalence over the last decades and a estimate for the upcoming one.

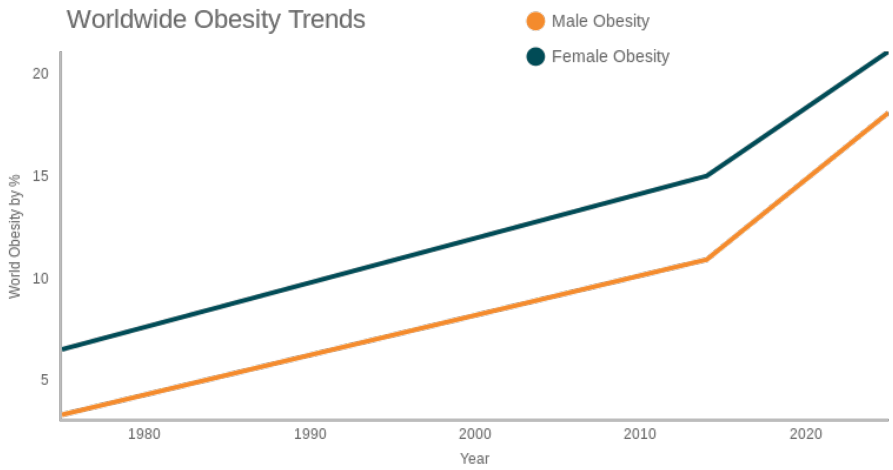

Figure 1.1: Male and Female obesity prevalence around the world on the last fours decades[1]

The word "obesity" defines a complex disease related to an abnormal fat accumulation. This condition is characterized by excessive body fat, hormone deregulation and metabolic problems that exerts an abnormal force on bones and organs which can lead to personal character disorders or other mental problems. Even though obesity is still not treated as a

[1]Global obesity, a very weighty problem, Available at `https://www.chartblocks.com/en/blog/post/global-obesity-a-very-weighty-problem/`

common disease, the issues directly resulting from it [2], like Type 2 diabetes, Heart diseases, strokes, or sleep apnea, are seen as high-risk problems that must be addressed in early stages.

1.1 Context and motivation

Although directly measuring Body Fat (BF) would be the best way to estimate how obese an individual is, it is a complex operation, which can result in considerable result variations when not done correctly and in a coherent form. From doctor to doctor the procedure that estimates body fat is very likely to be different, leading to results that can vary depending on the professional performing the measurement. As stated above, the concept of obesity is characterized by having too much body fat, as the process of measuring BF is not reliable, doctors tend to make use of a more reliable method to determine a persons condition, it is called Body Mass Index (BMI), and consists of the ratio of weight per height square [3].

Since it does not directly take into consideration a persons body fat, muscle, and bones, which are denser than fat, BMI is not a perfect measurement, but the most suitable one for obese patients [3], mostly due to his consistency.

When a person BMI is not in the range of 18.5 - 24.9, according with the figure 1.2, it likely has weight-related problems and is prone to the issues associated with them. The initial obesity treatment consists of a modest weight loss. The human body can be seen as a car. It needs gas to work, just like humans need food to survive. However, once we stop the vehicle, the remaining gas is kept in the tank, the human body follows the same process, the calories that are not used to survive are stored as adipocytes (fat cells). Considering this analogy, it becomes easy to understand that the most effective and healthy way to lose weight is to have an lower calorie intake than the body daily requires.

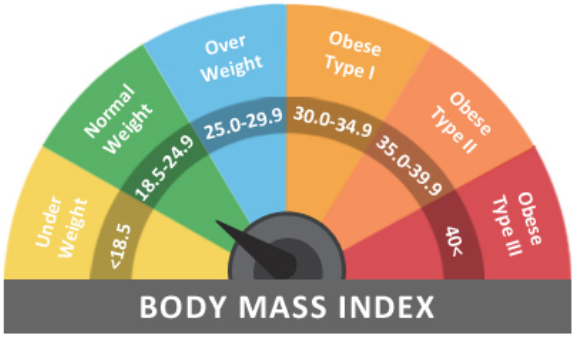

Figure 1.2: Body mass index chart from underweight until obese type III, being the obesity level $\geq$ 30 BMI [2].

[2]Body mass Index, Available at `https://www.weightlosslatvia.com/initial-assessment`

On the big picture, the main problem when addressing obesity cases is to find proper and scientific-proven methods that do not just directly address the reduction of a patient daily intake but a dietary re-education considering the bio-individuality of each patient. And this approach needs to tackle other dimensions that have a direct impact on the outcomes of this reeducation regarding both physical and mental aspects.

The availability of mobile technology is growing fast, in the last four years, a thousand million persons have started to make use of smartphones.[3] Along with this growth, the number of health applications has also skyrocketed, fitness/weight loss applications are the fastest-developing Eletronics Health (eHealth) sector making of mHealth a new trend on mobile applications, the fast access to fitness-related information along with the provision of new features and device integrations, if used wisely, may result in a boost to the traditional weight loss methods. The main reason for the proliferation of this type of applications and its growing exploration by users is the ease of access provided by the smartphone. However, there are still many problems that have not been addressed, which provides space and motivation to improve existing tools or for new tools to be developed.

Relying on these applications to perform calculations on the number of calories a patient shall ingest to lose weight based on their height, weight, and lifestyle are usually characterized by patterns, that along with the development of generic tools focused on patient re-education were the last big achievement on mHealth technologies. The need for more automated systems that can be personalized according to the patient needs is not fulfilled, there is still a lack of obesity focused applications, not all patients want to get muscular or lose weight temporarily, there is a large slice of the mHealth users that need to have professional support to get their problems solved. A wide variety of studies (e.g., [4] [5], and [6]) concluded that mHealth interventions were found to be as effective or more than conventional approaches in the process of achieving behavior modifications that promote weight loss. Developing strategies that have in consideration the user bio-individuality, is perhaps the main challenge when the goal is to make systematic methods that can help an individual reach his goals.

Treating obese patients can be seen as a multidimensional process composed of three parts: 1) physical, where patients are instructed and followed on how physically active they are; 2) mental, to provide support to the very likely most weak point in an obese, and to understand what are the causes of the eating disorders and compulsions that have to lead the patient to an obese condition; and, finally, 3) nutritional, which is the part that determines if and how much weight a patient is loosing [7].

[3]Number of smartphone users worldwide from 2016 to 2021 (in hundred millions), Available at `https://www.statista.com/statistics/330695/number-of-smartphone-users-worldwide`

1.2 Challenges

An obese patient is usually followed by a team of at least three doctors, each responsible for one of the health departments mentioned above, however the progress on each of them can have an direct impact on the sucess of the others. The literature shows that the relationship among doctors is as essential as the relationship between doctor and patient [6]. However, doctors do not usually talk between them, either due to a miss-perception of their role, damaged relationships, or even to the lack of in-clinic paid time that would be need to discuss possible treatments [8]. For a patient to achieve success, the experts who monitor the process must communicate and make conclusions based on what they know and what other doctors have diagnosed on the patient.

Considering that this genre of applications purpose is to support obesity treatment, it must provide the support and tools needed for a communication flow to be understandable by all the intervening parties, doctor-doctor, and doctor-patient. The consideration of these different levels of support faces challenges in three different dimensions: 1) problems that result from patient usage; 2) problems that result from the doctor-doctor and doctor-patient lack of communication; and 3) lack of research on methods that increase the applications evolution reliability.

The first challenges are related to problems that directly result from the patient usage of this type of system and is composed by the next list:

- A strong quantification of the different parameters associated with progress and performance can result in demotivated patients. Finding strategies that directly output qualitative results can potentially reduce the discouragement and, consequently, user retention of the application in the cause.
- The lack of motivational and interactive factors that make users to quickly get bored and abandon the treatments.
- The patients frequent lack of understanding with the guidelines provided by the medical team.

On the second set of challenges, there are problems that can be identified on the doctor-patient and doctor-doctor relationships:

- The lack of support for doctor-doctor and doctor-patient communications, that are very prone to result in unsuccessful treatments.

- The rare and low inclusion of doctors on patients treatment is also one of the aspects where most applications fail.

- While on treatment, obese can keep with their routine, developing strategies that help the enrichment of doctors office time, such collecting patients daily information to be later used during this appointments.

- The lack of a tool that allows the registration of guidelines by the team of doctors, makes the process more difficult and time consuming.

The last dimension, related to the research of methods that provide a early validation of the system with the target audience, the resolution of the following challenges can potentially provide a strong foundation for any application to be developed:

- When addressing technology problems, developers tend only to evaluate the solutions by their point of view. Evolving an application while using a UCD approach, can significantly increase the success of the application on the target public.

- Currently, mHealth applications only provide standard input and output methods, having other input and output modalities can ease and accelerate the usage of certain functionalities.

- Applications visual are usually left by the side. However, the bridge created between the users and the system is based on it. User retention is severely affected by first impressions. Providing an good user experience is as important as all the features, especially in a large and diversified sector such as mHealth.

1.3 Goals

Considering the challenges identified above, the work presented here capitalizes on previous work regarding ObeOne, an mHealth approach to support obesity patients, and aims to expand its scope exploring novel directions. Specifically, it targets increasing application usability, developing new strategies that provide more robust support to psychological aspects and providing a first level of support to the doctor-patient relationship. To this end, the work presented here aims to:

1. Understand the literature and current proposals for mHealth-based support to obesity.

2. Adopt a user-centered methodology to understand and characterize the needs and motivations of obesity patients along with the doctor-patient relationships.
3. Research and propose approaches to the different dimensions required to support obesity patients that move away from an explicit quantification of performance.
4. Investigate methods to establish and improve the doctor-patient relationship supported on mHealth approaches.
5. Deploy and evaluate a proof-of-concept of the proposed vision and methods applying it to the context of mHealth based support to obese patients.

1.4 Document Structure

The remainder of this document is organized as follows:

2. **Background and Related Work** provides a detailed overview on the existing solutions regarding the mHealth sector to obesity as well as the problems found on them, along with a discussion on the used methodology, the relevance of mental aspects on this type of applications and the possible inclusion aspects that aim to improve the doctor-patient relationship.
3. **Target Audience, Scenarios and Requirements** considers Personas and scenarios to describe the target users and define the proposed approaches. These, then, result in a set of requirements that guides the following stages of the work.
4. **ObeOne Patient System Development** presents the mains aspects for the different stages of designing, developing and evaluating ObeOne, resulting in a functional prototype regarding the patient system.
5. **ObeOne Doctor System Development** presents the development process of the doctors application from designing until a functional a prototype and associated evaluation.
6. **Conclusion and Future Work** presents the overall conclusions and proposes some routes for future work.

Chapter 2

Background and Related Work

Technological systems can be invaluable tools for health treatments[9]. For the last decade eHealth has seen most of his evolution leaning into the mobile direction in the form of dedicated applications and hardware devices. This chapter focuses on understanding the exiting solutions, their advantages, problems and subsistent challenges regarding the previously stated problems. The literature review will provide a baseline and reveal aspects that either were not explored or were not taken in-depth by the majority of the sector. These will provide the grounds that should help identify the application scenarios that can be addressed, in this work. For this to be achieved, the ten most popular mHealth applications of the current panorama were analysed, a summary can be seen in the table 2.1.

2.1 Obesity Contextualization

Obesity is a medical condition where an excessive amount of body fat has been accumulated to the extent that it may harm health. Although it may seem that the cure to it is as simple as eating less, obesity can be caused by a large number of reasons such as genetic factors, and hormonal disturbs, theoretically, it can be cured by reducing the number of calories to a point where the human body makes use of his energy reservoirs that is nothing more than fat. However, a clinician cannot merely ask an obese to reduce his daily intake. The challenge is to find methods that allow patients to be nutritionally reeducated to a point the amount of calories ingested is lower than the amount of calories his body needs, but not by following an restrictive approach since that this type of methods are very prone to only reveal improvements on the short term followed by an abrupt worsening of the patient condition.

An obese patient can be characterized by someone who acquired nutritional disturbances

and compulsions [10], those mental disorders have to be diagnosed and studied. Providing solutions to psychological disorders will most likely reduce the pace of obesity, however will most likely by itself not solve the already damaged routine of an obese. The ideal obesity treatment is composed by three dimensions, nutritional, physical and mental, that work in synergy making of them more than the sum of the parts. These three dimensions have to be appropriately addressed. Some patients will require a more physically focused approach, while others, in contrast, may require an more focused mental or nutritional approach, still, it is common for the three dimensions to work better when used in synergy.

Like many other diseases, obesity makes part of the group that must be under constant monitoring. Most obese do not have the mental strength or the autonomy needed to stay on track. The need for a total routine reeducation is expected since the large majority of them do not have control over their lifestyle, resulting in poor decisions when it comes to nutritional or physical aspects.

The use of mHealth approaches on obesity, as stated on the previous chapter has already been proved as an invaluable tool, the flexibility and accessibility that they can provide when addressing weight loss and lifestyle changes that aim to prevent and control obesity, are some of the factors that make of mHealth such a well-suited approach into the treatment of obesity.

2.2 mHealth Approaches for Obesity

This section aims to describe the main features and the positive/negative points of the most popular applications that claim to help users loosing weight on Google Play Store and Apple App Store, considering that they are the most popular applications, it might be possible to notice patterns that had gave to this applications such a popularity and how they can be improved.

The main goal of this analysis was to obtain an overall view of the current research state and approaches, so the aspects that shall be focused on future mHealth approaches are pointed and the improvement opportunities identified.

The table 2.1 is a summary from the reviewed applications, from it, it is possible to understand the application type, the presence of support to the three main dimensions, education and doctor-patient relationship support, the inclusion of multimodality, devices availability and other features that might have interest in the obesity treatments spectrum, such as tools that aim to increase patients motivation or to make the process more comfortable.

Table 2.1: Summary of recent mHealth systems concerning obesity along with their main features deemed relevant for the scope of this work.

Name	**Type**	**MS**	**NS**	**PS**	**ES**	**DPS**	**MM**	**Other Features**	**Plataform**
My Fitness Pal	Calorie counter	No	Yes	Yes	No	No	No	•Meal plan •Macro calculators	•iOS •Android •Web
Google Fit	Tracker	No	No	No	No	No	No	•Sleep, heartrate and weight tracker •Gamification	•iOS •Android
Nike Training Club	Training	No	Yes	Yes	Yes	No	No	•Training suggestion •Gamification	•iOS •Android
Health Pal	Tracker	No	Yes	Yes	No	No	No	•Large number of calculators •Reminders	•Android
Health Mate	Tracker	No	Yes	Yes	Yes	No	No	•Competition •Badge system	•iOS •Android •Web
Huawei Health	Training with addons	Yes	Yes	Yes	No	No	No	•Sleep and stress tracker •Badge system	•iOS •Android
Lose It!	Calorie counter	No	Yes	Yes	Yes	No	Yes	•Meal plan •Macro calculators	•iOS •Android
FatSecret	Calorie counter	No	Yes	Yes	No	No	No	•Meal plan •Macro calculators	•iOS •Android •Web
Fooducate	Calorie counter	No	Yes	Yes	No	No	No	•Meal restriction support •Meal suggestions •Bloglike module	•iOS •Android •Web
ObeOne	Geral	Yes	Yes	Yes	Yes	No	No	•Proof-of-concept for doctor-patient communication	•iOS •Android

MS - Mental Support **NS** - Nutritional Support **PS** - Physical Support
ES- Educational Support **DPS** - Doctor Patient Support **MM** - Multimodality

2.2.1 MyFitnessPal

MyFitnessPal is a trendy mobile and web application that has fitness purposes. The following study proves the efficiency of the application on users that have as goal weight loss [11], on this particular study, 105 participants diagnosed with eating disorders were invited to make use of the application during 140 days, afterwards, it was possible to conclude that 73.1% have related that MyFitnessPal has somehow helped them with their eating disorders.

From an obesity treatment point of view, this application can be quite helpful, but it does not contemplate all of the features that are need for a full treatment. MyFitnessPal offers a robust set of tools for nutritional support purposes, possible, having the best calorie tracker due its enormous dataset and innovative interaction where there is only required to point the smartphone camera to the bar code of the food that is being eaten for it to be tracked. However, the patients psychological sector has not been explored, resulting in quick demotivation. Physical support is present but only on the most rudimentary being explicitly not part of the general purpose of MyFitnessPal, being it expansable by using devices that can be integrated with the application. Although the application has an impressive success rate, since it does not provide any hints or education information that helps users change their lifestyle, making of it not specially interesting for an obese patient that requires support to the remaining dimensions. MyFitnessPal does not provide any doctor-patient support, reinforcing the need for at least an educational purpose module.

From an interaction point of view, almost all mobile and desktop devices can run MyFitnessPal. The standard inputs methods are the only possible, mostly touch in mobile devices, and keyboard/mouse in desktops, considering some scenarios that are common in obese patients, this type of input methods can not be the most suitable ones. However, it is important to note that MyFitnessPal has already the code bar scanning tool, which is a step outside the box and improves the mobile applications usability.

By analyzing play store reviews on the application, many of the comments rely on the problems stated above, such as lack of an educational module, but overall reviews are good.

2.2.2 Google Fit

Google Fit is a sleep, heart rate, weight tracker that runs on mobile devices background and works as health and fitness information aggregator. It allows users to self-gamify the application by defining a number of points for a specific task such as walking or reaching a particular heart rate. It is also possible for users to work with physical activity in reverse order allowing them to define goals. For example, they can define a priori the number of steps

they have to walk during a day, and the application will notify them once it is accomplished. Those type of tools reveals an interest in patient motivation by the Google Fit developers team. Consequently, it can be pointed out as an application that had in consideration the mental aspect of the overall problem. The application is easy to use and does provide users with a large set of tools to explore, such as daily used calories. However, many of the presented tools are inadequate to obesity problems, making this application more suitable for non obese. This application does not focus on any of the three dimensions, some psychological patterns that aim to increase user well-being can be found. However, the application does not offer much more relevant tools that can be used on an obesity context nor doctor-patient support, leading to a lack of interest regarding this type of treatments.

The application only works on mobile devices. There is not much to interact since it mainly works in the background. On the interaction side, it is only possible to use the standard input and output methods, and there is not any feature that seems to indicate a future adoption of new interaction methodologies.

Reviews on Google Fit are not the best, between problems stated by users there are problems such as inaccurate reads, lack of customization and minimal tracking options.

2.2.3 Nike Training Club

Nike training club is a physical focused application that can have a nutritional component if a premium subscription is bought. On the first use of the application, users are asked to create an account providing all the necessary details that can be relevant during the process, such as weight and height. Once the account is created, the application will automatically suggest a theoretically good training plan. However, it does not consider any medical counselling or attention to the user already existent health problems. For a regular fitness user, those details might not be relevant, however to an obese, a non-personalized training plan can worsen the already known problems or even originate new ones. The application also has an article feed with tips and summaries of information that can be important for an obese to acknowledge, allowing them to learn how the human body works, resulting in a positive behaviour change during weight loss and afterwards. The only lacking dimension on Nike training club is mental support. There is nothing that allows the tracking and solution of possible self-esteem or lack of motivation. Such as MyFitnessPal and Google Fit, Nike Training Club also does not have any support for doctors and their respective patients. It is a cross-platform application, that means, it is almost compatible with all mobile devices. However only the traditional interaction methods are possible to be used.

Overall reviews on the application are positive. Most users claim it works and that the

suggested plans effectively have caused a positive effect on their body. For the reasons stated above, trying to make an obese patient follow and pre-programmed routine can be dangerous. Considering that, it is possible to infer that Nike Training Club is an application more focused on fitness than on overweight individuals treatment.

2.2.4 Health Pal

Health Pal is a complete application. It can track almost everything that is needed for a healthy lifestyle. It is currently possible to identify nutritional and physical dimensions, making the application only to lack mental support. The application counts with an immense number of calculators related to health metrics such as BMI and calorie intake, it is quite rare for applications to have such a set of tools that can add value to an obese journey. It is also possible to add reminders for different tasks, such as water or medicine intake. HealthPal is a application that has been released into the market with the large set of tools enunciated before, however there is not any evidence that all of them have been validated on the clinic point of view or that the calculators present accurate results. Having a large set of tools can be invaluable, however, if none of them was made considering scientific-proven information, it can also induce patients in new errors. Considering that all the tools were developed using proven methods, Health Pal is a great allied when used together with clinical support. Health Pal joins the rest of applications with the lack of native support for clinical and patient requirements.

This application is an Android only application and also does not have any support for new interaction modalities. The reviews are good, being the only bad reviews about the interface.

2.2.5 Health Mate

Health Mate is an application built by Withings that is a company specialized in the development of mHealth technologies. It offers a set of helpful tools during obesity treatment, such as tracking a large group of physical activities, food intake tracker or heart-related metrics. Withings app can be seen as a very complete and clean application that has potential for obese treatments. To increase user retention and motivation, the application has a badge system implemented, and new badges are awarded by achieving specific goals. Regarding the same topic, Health Mate also has an exciting feature that allows the transition and data migration from an old mHealth application into it and vice versa. This system has a "Leaderboard" ranking populated with the scores from family and friends chosen by the

user. To gain points, users must perform healthy activities. This feature aims to increase user engagement and motivation, considering that this feature will gamify activities that will help on patients treatment, it is very likely to create an healthy competitiveness between the intervening from where everyone can benefit by pushing themselves further. On the overall, the application is very well built and offers a wide set of potentially relevant features on the obesity context. However, there is not any clinical-patient support. Although mental issues such as motivation are addressed, the used approach is not direct, considering this, until now, it still can be seen as the only suitable tool into obese patient treatment support.

Health Mate, is a cross-platform application, that allows the integration of a wide range of hardware devices, such as smartwatches and scales. However the interaction with it is still the same as the ones above, there is no support for multimodality.

User reviews are excellent, and there is a minimal number of users who have had any problem with the application.

2.2.6 Huawei Health

Huawei Health, is a mHealth application that has in consideration all the three dimensions involved in obesity treatment. However, they are not explored to the desirable depth. It is possible to track physical activities, but there is barely any feature associated regarding the other two dimensions. It is also possible to control sleep quality and stress levels. The mental and nutritional side is present, but not in a way that is relevant to obese treatments. Like some of the other apps, there is a badge system that awards users by completing specific tasks. Huawei Health can be seen as a physical activity application with some ad-dons, there is nothing special on it nor a way to use the collected data from the application to other purposes outside of it.

From the interaction point of view, it is a cross-platform mobile application. Consequently, it is supported in nearly all mobile devices. On the interaction perspective, the possible interaction means are only the traditional ones in mobile devices.

User reviews are bad, and many individuals relate an extensive range of problems with the application along with the lack of some features compared to other mHealth apps.

2.2.7 Lose It!

Lose It! is a calorie counter application that follows the same approach as MyFitnessPal, the free version allowing users to track their daily food intake and physical activity. This version of the application does not have any educational module. The premium version provides two educational modules, one for physical activity and one for nutritional. It also enables the possibility of having meal suggestions, making the app a potentially useful application for obese treatments. A pilot study [12] was made to understand how better is Lose It! free version in comparison with traditional paper-and-pencil methods. Three groups were created, one composed by 18 individuals, that were thought about using Lose It!, the second one with 19 individuals trained to use random tracking applications, and the last group composed by 20 that used paper-and-pencil methods. After eight weeks, results were taken, and it was possible to detect that all the groups have had the same results, all of them have noticed differences in their weight and nutritional habits. The conclusions made were that the best possible outcomes could be achieved by mixing paper-and-pencil methods with tracking applications. The traditional techniques provide other variables such as physical activity and mental factors that Lose It! did not have tracked, and those variables have a significant impact on the motivation and effort from patients.

Lose It! is a reliable cross-platform tracker, however, is lacking mental and doctor-patient support. Nevertheless, Lose It! has a feature that differentiates it from the rest, it allows users to make use of speech as input, that is a feature extremely useful when applied on the right context.

User reviews are excellent, and there are very little to non-existent bad reviews.

2.2.8 FatSecret

FatSecret is a calorie counter application that follows the same approach as Lose It! and MyFitnessPal. It allows users to track the calories of their meals individually alongside sleep and exercise. A study was made on the reliability of FatSecret and other applications that have as a base user self-monitoring [13]. During six months, 41 overweight or obese individuals were asked to perform self-monitoring of their lifestyle using one of the existing calorie counter applications. The results of the experiment reported a significant amount of lost weight, around 2.5 Kilograms. However, considering the period in question, it is a non-viable strategy for an obese patient that sometimes has to lose more than 50 kilograms, that on a one to one ratio would translate into around 12 and half years. Considering the above-stated calorie counters, it is not hard to understand that self-monitoring without any

mental, physical, nutritional or educational support will not be the right tool for a patient that can not control his impulsive eating, patients will be able to count their calories however they will not know how much they have to eat or which foods provide the necessary nutrients for their health.

In terms of interaction, FatSecret is a cross-platform application. Consequently, it is compatible with almost all existent mobile devices. A web version is also offered, making the use of the app even possible in desktop devices.

By looking at the application reviews, almost all of them are good reviews, yet, just like all the ones stated, there is missing some crucial modules for obese patients treatment.

2.2.9 Fooducate

Fooducate is probably one of the best applications so far. It is a calorie tracker, but has implemented some very particular features that make it one of the best from the reviewed set. It is possible to get meal suggestions, create meals and have an instant evaluation of them. There is also a robust educational component in a blog-like module, which addresses questions such as how the human body reacts to some foods aliments and why some foods are considered healthy while others do not. Back to the nutritional part, one feature that this application has is the ability to also get tips for some diet free plans, such as gluten-free and vegan, that due to being a niche of the population are often forgotten. To improve the applications dynamism, the team in charge has decided to create a community module where users can share recipes, opinions, motivational phrases, and diet results in the same line as a small social media app. This type of features can be seen as indirect mental support since the motivation will be provided not by the application itself but by its community.

Considering that the app has been very well thought, it was expected for mental and medical-patient support to be present, which is not directly, but indirectly in the form of the community. The application is currently supported by iOS and Android operating systems in the form of a mobile app and on desktop by a web-based version.

Overall reviews on the application are great, and there are no bad reviews other than the need of paying a premium version to unlock some essential features.

2.3 ObeOne

ObeOne is an long term effort that is still in process with a relatively strong UCD foundation and clinical opinion. It has born on 2019 from a Master Thesis at Institute of Electronics and Informatics Engineering of Aveiro (IEETA), and the goal is to validate ideas and evolve into a system that can be evaluated on a sustained and quantified way focused in providing the support obese need during their treatment. The figure 2.1, illustrates the concepts that have already been identified and that shall be targeted. It is possible to see that the system shall have physical, nutritional and educational modules, and that those systems shall be as customizable as possible. Those modules, shall also provide information for long-term statistics, to improve the patients engagement the whole system shall have any type of gamification incorporated in certain features. Last but not least, mental support plays a big role on obesity treatments, this type of support, can and shall have a dedicated module, however, the application as a whole shall provide indirect support to mental problems.

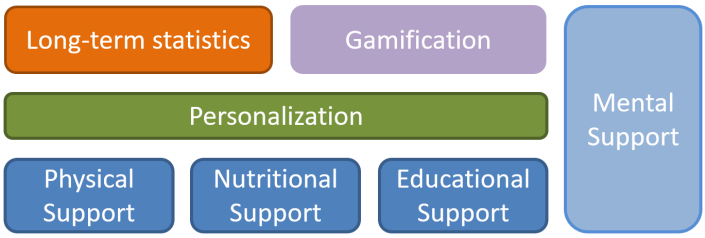

Figure 2.1: ObeOne long-term logical architecture, with the physical, nutritional and educational support composing the first level, followed by the possibility for personalization, long-term statistics and gamification respectively. All of these concepts shall directly or indirectly provide the mental support patients need.

For that to be achieved, the purposed idea was to engineer a system that could enhance the time spent with the doctor on his office, to that, there was created a system that would split into two branches that were materialized on the form of mobile applications, one for doctors usage that has yet not been covered and the second for patients use, where they would have the chance to register information about their routine and performing tasks that were previously recommended by his doctors.

Considering the purposed architecture represented in the figure 2.2, during the development of ObeOne application, there were considered eight modules, three of them directly related with the dimensions involved in the treatments, mental, physical and nutritional, one with patient progression, one with gamification, one with education, one with patient information and lastly a second psychological module. One of the problems with this approach, was the existence of two dedicated mental support modules that resulted in the duplication of the educational module since one of them got very similar to the already existent educational

module.

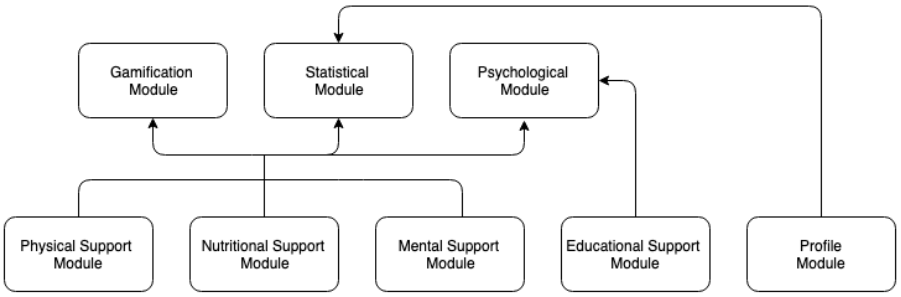

Figure 2.2: The previous version of ObeOne, was divided between into eight logical modules, that communicated among them to provide six modules to the user interface and direct usage.

As stated above, everything on this system was developed using a UCD approach, but, when having a closer look to the system, it is clear that there is no need in having two modules with educational purposes, and not having a settings module. Even though the application appearance can be considered something subjective, the current approach, have had very little to no attention regarding UI/UX questions, as possible to see on the figure 2.3, it is likely not to be the most attractive, creating chances of early demotivation.

The central modules, physical, nutritional, and mental modules have followed a basic yet functional approach, making of them an incomplete solution, nutritional and physical dimensions lack aspects such as meal suggestions, daily water intake, and training history. However, on the opposite side, the progress module has too much information. Three charts are currently representing each dimension progress and six other buttons that lead to charts related to an enormous number of metrics. Having the representation of some of the statistics inside the three dimensions modules would make the application more comfortable to use and motivate patients to continue making progress.

While, ObeOne conceptualized the existence of modules concerning the doctor-patient relationship, the work has yet to evolve, in that regard given the importance of these aspects as explained in the following section.

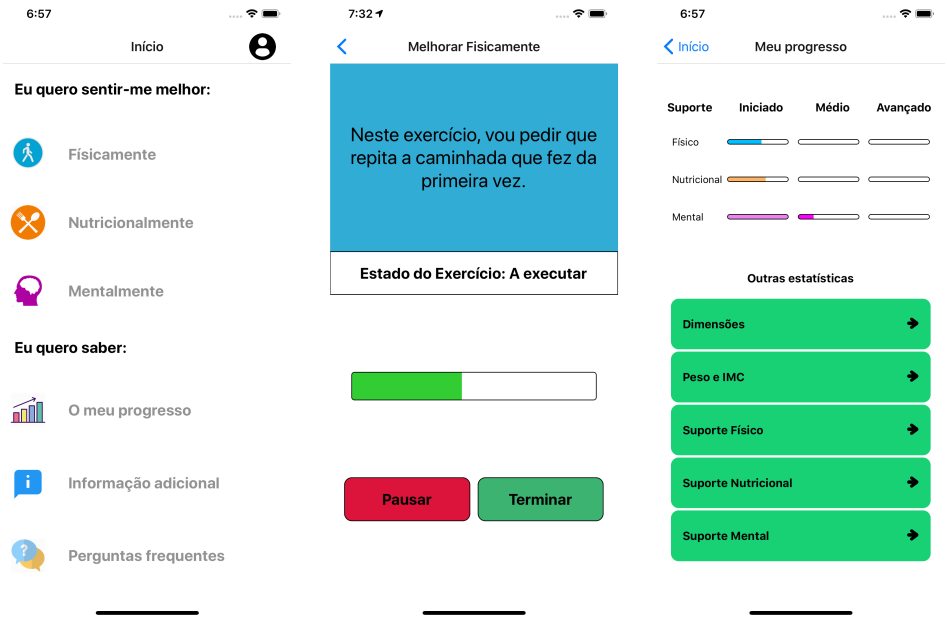

Figure 2.3: The three screens presented, illustrate the key areas from ObeOne state before the beginning of the project, by looking at it, it is possible to notice that there have not been made a big effort on keeping the application attractive.

2.4 The Doctor-Patient relationship in obesity context

The doctor-patient relationship is a keystone on healthcare [14], considered by some the core element in ethical principles of medicine. Being it a relationship, it requires effort from the two sides to be dynamic. The following aspects characterize a healthy relationship:

- **Trust** among patients with their physicians and treatments, a trustworthy relationship between patient and doctor provides room for discussion and enables patients to feel more comfortable with the treatments prescribed [15].
- **Empathy** between intervening results in extra motivation and interest from the physician within the patient and his pathology, and in a higher level of confidence on the patient side [16].
- **Communication** can be seen as the main ingredient in medical care, the capacity a physician has to have to awake interest on patients is tremendous, however when accomplished, the doctor-patient relationship will see major benefits from it, such as less risks of misunderstandings, increased levels of empathy and better patient compliance with the treatment [17], [18].
- **Consistency** a doctor-patient relationship on the long term will benefit from the con-

tinued growth from all the aspects stated so far, improving patient satisfaction in general [19].

The communication outside the clinical office was missing in all of the applications. Yet, it has been proved how important it is for all the parties involved, for doctors to have a better understatement on the patient habits and, by consequence, to be able to define the aspects that shall be addressed first and to which type of patients.

As previously discussed, the support to tackle obesity should cover several dimensions and this entails that different doctors are enrolled with each patient. Considering that it is common for questions regarding a patients health state to be raised between the medical team, as e.g, personal trainers shall know if the patient has any problem that will prevent him from performing a particular exercise. A study [8], made in Lethbridge University, Canada, has evaluated the effect of interdisciplinary collaboration on the treatment of obese patients, The 5As (Ask, Assess, Advise, Agree, Assist) were proposed to standardize teaching and the art of encouraging behavioural changes. The study has shown that there are a couple of aspects that have a direct influence in the doctor-patient relationship. For a treatment to be successful, the team in charge of him must follow the next patterns presented in the figure 2.4.

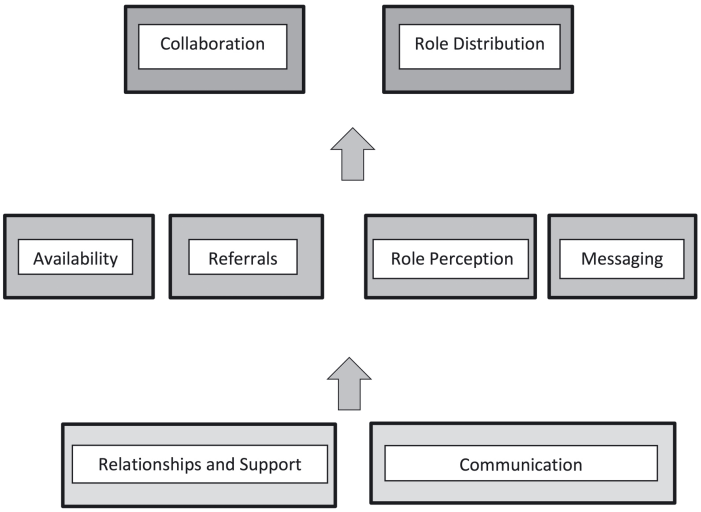

Figure 2.4: For a treatment to be successful, doctors shall have an health relationship, support and communication between them and with their patients, that then results into an increased availability, betters referrals, and better role perceptions, which finally result into an higher collaboration and role distribution level. [8].

The lack of in-clinic time for discussion among doctors lead to an increased difficulty on scheduling reunions between medical teams, the lack of proper referrals to other doctors

and the role imperception, are some of the aspects that negatively affect the doctor-patient relationship. On an ideal scenario, a patient shall be accompanied by a team of doctors and that communication between patient and the doctors shall be one of the priorities, however, the relationship and communication between the members of the medical team is as important as the communication with the patient for the treatment to be successful.

On an ideal relationship between all the intervening regarding a patient obese treatment, there should exist communication between the different doctors so they can align and discuss the best treatment strategies for the patient. Considering that the logistics for this type of initiatives are commonly not on the favourable side, there shall at least exist the option to see what each of the doctors is advising to the patient or a common shared point where possible critical information can be listed.

2.5 Iterative User-Centred Design and Development

Considering the previously analysed applications, it was common to find applications that although claimed to help people loosing weight, do not have the right tools to make it possible [20], [21]. Including the target audience on the early developing stages can help identifying errors, missed opportunities and provide an early validations of the project ideas. UCD is an approach for developing systems that aim to incorporate user-centred activities during the development process. It can be characterized as an iterative process illustrated in the figure 2.5, in which users are directly involved from the start, on the design and development of a system by using different methods that allows their participation, where the goal is to understand the needs of the targeted audience along with their feedback regarding how to tackle common problems through their continuous involvement along the different stages of the work. It requires a continuous effort to understand which are the type of users that are going to make use of the system, which characteristics they have, the problems they are facing, their motivations and needs [22].

1. **Research and user analysis** the first phase is necessary to define the targeted audience and understand the usage context of the development product.

2. **Concept Design** on the second stage the goal on a UCD perspective is, according with the audience defined on the previous step, to understand the problems and needs they are facing and purpose methods that aim to solve and suppress them.

3. **Requirements** on the third phase, the requirements are extracted from the previously found problems.

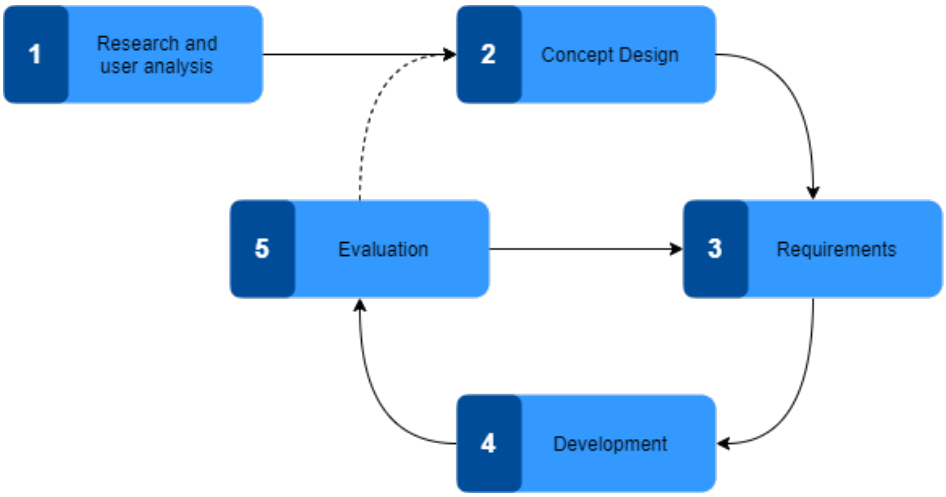

Figure 2.5: Illustration of the iterative cycle and involved process of a UCD methodology.

4. **Development** is the fourth phase, is the hand-on stage, by the end of this stage, it shall be possible to provide users a prototype of the conceptualized ideas.

5. **Evaluation** last but not least, perhaps the most critical phase, the last stage consists of evaluating the purpose solution by ideally the targeted audience. This evaluation will give birth to a new possible partial iteration, from where will surge new requirements that shall follow the same process. Evaluation, helps developers to have an eased understatement on the final users point of view, to have a notion on the real progress achieved so far, and to have guarantees on the product reliability.

2.5.1 Research and user analysis

A key component of UCD is User Analysis, which aims to gather details among those who use the product. User Analysis identifies possible roles and characteristics such as their skills, technological experience and personal environment, allowing designers to put themselves on the same point of view of a potential end-user. By the end of user analysis, the designer shall be able nearly think in the same way as a final user providing him with the sensibility to details that only a real user could have.

2.5.1.1 Personas

A persona is a hypothetical user created during User Analysis. It can be considered as a fictional representation of the main characteristics from the target user(s). The purpose

of personas is to create a common shared understanding of what is expected from a user perspective[23].

Personas have names, face and other characteristics of possible users. They allow designers to create the entire concept around them and by consequence around what users expect from the product [24].

2.5.2 Concept design

A concept design defines a set of user tasks to reach a goal. By looking to a workflow at a granular task level, designers can extract smaller and more objective requirements leading to higher efficiency and progress knowledge.

2.5.2.1 Scenarios

Scenarios are one of the methods that aim to help to perform workflow analysis, a scenario is a description of a persona workflow while making use of the product. Scenarios are commonly used to describe a problem-solving story, that show how users might act to achieve a goal in the system. The use of scenarios allows developers to understand users motivations, needs, constraints, and usage context which are invaluable tools to perform the conceptualization of solutions to all of them [25]. For a scenario to fulfil his purpose, it must have a context from

- **Who** uses the system and details that can be invaluable to the easier understanding of it.
- **What** the user is trying to achieve.
- **When** it happens, specific scenarios can benefit from having temporal stamps.
- **Where** the stack-holder is doing it, can also increase the understatement of the scenario as a whole.
- **Why** they want to achieve that goal, all the scenarios shall have a purpose that can or not be divided into sub-tasks.

2.5.3 Requirements

The concept design phase, allows us to identify the existing problems and missed opportunities in the current approaches. From them, usually, it is possible to extract requirements that shall later be addressed so our approach does not replicate the already identified problems. During the development of the application, it is common for this stage to be run every time a evaluation is performed until there is not found any critical problem from the evaluation or problems are so severe that the project shall be abandoned. This phase shall act as ground to any new update to the application concept.

2.5.4 Development

2.5.4.1 Prototyping

Prototyping allows the designing process to occur faster with the cost of incomplete or unusable outputs. It allows developers to have quicker feedback on the concept by having the possibility of early-stage evaluations among the stack-holders.

Paper prototyping is the fastest prototyping method and can be extremely help-full at early stages, on the other side, functional prototypes are slower however, more aesthetically pleasing and behave more similar with final result, allowing different types of actions to also be evaluated, e.g feedbacks. Creating prototypes should aim to output increasing similarity level interfaces in comparison to that final project is planned to be as iterations evolve, which means, that it is an good practice to add more fidelity to the prototypes according with the project evolution.

2.5.4.2 Prototyping tools

There are a large number of tools that can be used to materialize ideas into mockups, on a sector where Adobe completely dominates the market of high fidelity prototypes, it is hard to find a low-cost tool that could be used to develop this type of prototypes. Adobe Photoshop, Illustrator or Indesign, are popular tools used for this type of projects, however, they have a high cost associated, which is a deal-breaker for this project. Consequently, a not so popular tool was investigated, Adobe XD, which is a tool that is being developed and is currently on its first releases by the same company, Adobe, however, free of cost.

Adobe XD is a tool that has the purpose of helping designers to develop closer to the functional versions of the planned concept. It has the possibility of including actions to the

different elements present in a screen, which means that a project developed with this app can have the navigation possibility, almost exactly like a functional application would have. Considering a system that is composed of two application based on a set of modules, there is a high chance that there will be UI elements that are going to be replicated, Adobe XD allows the creation of elements that can later be reused. Obviously, high fidelity prototypes require a much bigger initial effort than low fidelity, however when they are properly done, on the long term, they can be nearly as fast developing as low-fidelity prototypes due to the continuous increase of elements library and respective reuse, each element has associated a Cascading Style Sheets (CSS) base so it can later be replicated into a web developing context without many upsets.

2.5.4.3 Interface Impact

Having a functional application is a great start, however, having something that will provide the ability to show it off and engage users to make use of the application itself is also an essential part on the design of any system. It is common for back-end developers to have very little to no interest in the applications front-end. On an ideal scenario, a team is responsible by the back-office and another one by the front-office. However, not all projects have that possibility. That shall not mean that the project has to be a tedious system that will leave users with barely any interest in using it even though it could have some hidden exciting features. According to the following study on the effects of mobile applications interface [26], the interface quality will lead to a perception of the quality of the application, the emotions that are triggered by the interface, have a significant effect on the overall perception of the application features and quality.

2.5.4.4 Multimodality Approach

Such as humans communicate naturally using multiple senses, the communication with the application should become more natural and adaptive [27] too. To accomplish it, it must encompass a whole new set of modalities and options to communicate. The current interaction consists of nothing more than touch on the input side and an arrangement of graphic elements on the output. Considering the patients needs, this is not the best scenario possible, having other options that are not touch for input and graphic elements for output would improve the accessibility by allowing a whole new set of possible use cases such as, controlling the application while eating using speech or using the smartphone as ”remote” to a TV Version application.

2.5.5 Evaluation

One of the significant advantages of UCD is the possibility of early evaluations that result in a new iteration and establishes checkpoints into the development process. A high number of assessments imply an also increased number of iterations. Considering that the projects success rate increases at each iteration, it is possible to conclude that evaluation is probably the most critical aspect on UCD approaches since it is responsible for increasing the acceptance of the product the targeted audience [28].

2.5.5.1 Heuristic Evaluation

Heuristic evaluation is a usability assessment method that aims to identify usability problems in the User Interface (UI) Design of the product and identify ways to resolve them. This type of evaluation involves having a group of stakeholders judging the interface based on the a set of usability principles, also known as heuristics [29].

2.5.5.2 Usability Testing

Usability testing is another method used in the evaluation phase on a UCD approach. The usability tests goal is to identify design problems and uncovered opportunities and perceive how well users can learn and use the product to their purposes. This method typically uses at least five testers to perform real tasks with the provided product. A usability test can either be qualitative, quantitative or a mix. Qualitative testing focuses on collecting and finding data about how the participants use the product, they are usually used to discover problems on the user experience. Quantitative testing focuses on collecting metrics that describe the user experience, such as the success rate, making of this type of tests more suitable to collect data that provides information about which flows can be improved. The mix of both testing types provides the best of both worlds simultaneously, however, at the cost of having the process significantly slower[30].

2.5.6 UCD on Obesity

With the advancement of technology, the tools needed to provide a sophisticated self-care level to patients appear. On obesity it is not different, the increment of hardware and software that targets excessive weight is enormous, and with them, UCD approaches are getting more popular. On a sector where the whole goal is the end-users success with their treatments, it is

critical to understand the needs of the users who provide the treatments and follow them. An UCD approach allows designers to exactly understand those requirements by collecting them directly from the sources, with those requirements in hand and the first version, both user types can provide feedback about the methods taken. Since UCD is an iterative approach, the complexity and fidelity of product shall increase along with the iterations number, that when applied into a case as obesity shall mean that success rates on treatments shall be growing too.

Although finding the targeted audience into a product directed for obesity was not a problem, collecting group users that could be direct users of the application could be a difficult job. Even though it would be possible to cheat and perform the whole process around a similar group, the designers shall consider that the reliability of the provided feedback is not at is peak and can induce them in error.

2.6 Discussion

After analysing the literature and a set of the most popular mHealth approaches to obesity (a summary can be found in 2.1), it is possible to notice that sectors such as physical and nutritional, are already very well explored, however, there is still some lack of consideration within the bio-individuality present on this type of problems. Even though it is a fact that a large number of the tools found on the analyzed applications will very likely cause improvements on a patient condition, it might not work to all of them, which is precisely the goal of this type of projects.

Although the analyzed literature had stated innovative methods to help with the process of self-monitoring, they were not directly focused on obesity but more on fitness-related purposes, obesity is a severe disease that to be treated shall be adequately addressed by a set of health professionals, to that, the tools provided for obesity treatment shall not only focus on self-monitoring but in increasing the bond between doctor and patient. Since none of the covered applications had even the most basic support to the doctor-patient relationship, it is reasonable to state that there is not much ground covered when addressing this type of problem. Even though all of the applications above have been tested and validated by a large user-base, most of them are focused on nutritional and physical aspects, leaving mental issues forgotten. From the ten applications taken into consideration, only 20% (2) provide any direct or indirect support to psychological elements. It is difficult to find applications that would cover all the dimensions involved in obesity treatments, being the most important one, psychological support, the one left out. Increasing patient motivation, consistency and effort levels are all actions that have to be addressed by either on a direct way by specific

module or on indirect form materialized as e.g. in qualitative beside quantitative measures and a special care with features and messages all along the application. Since nearly none of the applications had covered ground on such problems, it can also be seen as a severe problem into this type of systems.

It is also possible to notice that there is not any application that provided any type of support for the doctor-patient relationship. All of them purely focused on the patient, more precisely on the self-treatment being the only way to include doctors on the treatment to mix the traditional methods with the usage of the applications that provide the support for some of the traditional inputs.

The chance of interacting with the system using different input/output methods is something that is starting to get explored by the developers on this type of applications, with currently one one of the ten analysed applications having any type of new interaction modality, having the option to communicate for example using speech, would be an invaluable tool in certain scenarios.

Finally, UI/UX aspects seem not to be mainly addressed in this genre of applications. However, on a sector such as health and especially obesity where treatments are often long, the effect that the interface and the system itself have on patients emotions can differentiate between a successful treatment or an early quit.

Chapter 3

Target Audience, Scenarios and Requirements

Considering that this work follows an user-centred design approach, one important stage of the work is the characterization of the potential users in order to understand their needs, motivations, and how the proposed solutions will help them reach their goals. This is performed by considering several Personas, profiting from previous work in this regard, and by proposing a set of scenarios. These, are then analysed to extract requirements that will serve the design and development stages described further ahead, in this dissertation.

3.1 Personas

To ease the process of understanding the users needs, there were created Personas. A Persona is a fictional representation of an potential end-user which purpose is to ease the process of understanding the point of view of potential users about the system. On the context of this work, there were considered two types of personas: Primary, which are the main characters involved in the system use and, secondary, if their objective is to use a subsystem or complement certain central system aspects. In order to evaluate the ideas for the newer version of ObeOne, there have been created having as base the previous work from ObeOne [31] and improved considering the obtained feedback from the reviewed literature and doctors. Those improvements were mainly focused on the inclusion of information related with the doctor-patient relationship and the usage on new tools that aim to solve the challenges stated in the first chapter 1.2.

3.1.1 Primary persona: José, an obese patient

Figure 3.1: José, an obese patient.

José is a divorced forty-years-old man who lives with his kid in a flat on the fourth floor with no elevator. During the major part of his life, José has been living with health problems such as diabetes type 2, and sleeping apnea. With age passing by, he starts to feel insecure about what his future will bring, José does not admit it, but his condition have led him to a depressive state. To get worse, he started to develop problems on his back and joints due to the excessive stairs he has to climb to get home, sometimes loaded with shopping bags. At the age of 8-year-old, his kid is a very active boy who likes to play football. José wants to be able to play with him more often. However, he has very little stamina and is not able to perform some movements.

On the professional side of his life, he works as a gardener for a local company. His disease is also affecting how he performs at work when he sees his colleagues work nearly twice as fast than him. José lacks the motivation he needs to improve his lifestyle, and desperately pursues speedy results with very little to none effort, time or medical support. He would like to follow a treatment in which regular monitoring and motivation aspects are addressed without making him leave his routine too much. Along with the physical monitoring, José would also like to have his mental side addressed as he feels a part of his obesity is due to compulsive eating he does when he is feeling lower.

Once he started his treatment, the team that is following him regularly provided him a set of guidelines that he should perform in order to increase his success chances, however, due to his lack of knowledge about the area, it is common for him to do not understand what all of the guidelines really mean, making of some days difficult for him to execute what his medical team wants him to. **Motivation: José would like to change his lifestyle so that he enjoys more the time he spends with his kid, improve his efficiency on his job, increase his overall motivation, get rid of all the pain, disorders, and diseases that resulted from obesity and to have a better knowledge about his body.**

3.1.2 Primary persona: Marta, an obese patient

Figure 3.2: Marta, an obese patient.

Marta is a twenty-five years-old woman that is currently on her first job. She graduated from Aveiro University in Informatics Engineering, and due to her profession, she spends much time sitting in front of a computer. Her physical appearance has led her to extremely low self-esteem. During her academic career, she never was a social or popular person. Marta used to be discriminated against due to her obesity condition. She believes that overweight young adults have lower chances of success building relationships, so she tends to get away from everyone and self-isolate with the fear of rejection. She does not have any control over her diet or physical activity. Since she is not used to having breakfast and stays during long intervals, she tends to abuse by far on the quantities when she eats. The desire she has to eat unhealthy food has come to a point she can not control anymore.

Allied with her already high body weight and low self-esteem, Marta started to get depressive and developed various eating disorders. To suppress them, Marta would like a system that could have feedback about the meal she is about to eat, however she founds quite boring to have to manually register on a system all the quantities and foods she will eat and later to analyze a chart with the macro-nutrients about the meal in order to understand if it was a good or a bad meal, to solve that she has found a system that allows her to not only have an evaluation right after the registration of her meal but also that allows her to make the registration process more comfortable and easy by using her voice and a special tabletop that acts as a scale to register her meals. She also thinks that she would benefit from having a system that allows her to monitor her mealtime duration and increase her chewing time with personalized challenges, since she knows she is currently eating to fast.

Motivation: Marta would like to increase her self-esteem and also improve her eating habits so that she can start to have more motivation for her obesity treatment and to relate with others, decreasing her weight and changing her lifestyle.

3.1.3 Secondary persona: Rita, a clinical

Figure 3.3: Rita, a young clinical.

Rita is a young clinical that has been working in S.Sebastião Hospital for two years. Rita always had a passion for medicine, but it was a case of obesity in her family that made her want to be responsible to treat this type of patients.

She had already been able to get some results with her patients. However, she is not satisfied with them and believes better results can be achieved. Lately, she has been searching for innovative and modern methods that, mixed with their methods, can elevate them to a new level of success rates. Along the time she has worked with obese, she learned that more than not being able to eat right, they suffer from severe mental problems that affect their self-esteem and lead them to eat more without having the sense of it.

Rita knows that it is very likely for the innovative idea that she is looking to exist in the form of an application for desktops or smartphones, however, she has not yet found the perfect tool. **Motivation: Rita wants to be a better doctor, she wants to improve her skills and treatment methodologies so that patients can have better results.**

3.1.4 Primary persona: Paulo, a personal trainer

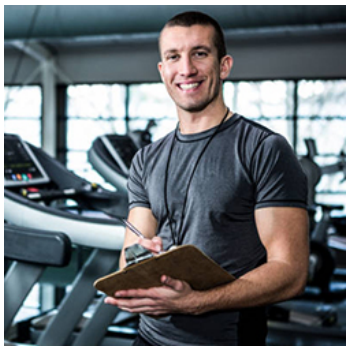

Figure 3.4: Paulo, a personal trainer.

Paulo is a thirty-three years-old personal trainer that has been working in a local Aveiro gymnasium for the last ten years. He is an excellent personal trainer. He is helping someone change their life triggers in him a will of getting better on his job, to get better, he is trying to improve the advice that he provides to everyone on the gym he works and increases their well-being get even better.
Around six years ago, Paulo had to deal with his first obese patient and his physical limitations. Since then, he has gained a particular interest in those types of patients and studied how he can help them in a safer and higher success rate to achieve their results in a gymnasium environment. He noticed that most of the obese patients were lacking the motivation to move. Paulo found that finding "cardio" sports such as football, handball, running, surfing, swimming, and many others that their patients would enjoy would make the process of losing weight much more comfortable. Paulo is still discovering new sports, and learning which sports are suited for each type of patients.
Motivation: Paulo wants to be a better personal trainer, and find new strategies to deal with his patients.

3.2 Scenarios

The following scenarios aim to present concept solutions to the challenges stated on the first chapter 1.2. Some of the following scenarios, consider the existence of some innovative devices that can be useful on the support to an obese patient evolution, such as a chair that takes measures every time a user sits on it, or a tabletop that can take measures from what is over it. These devices are being developed in collaboration with a research team from Aveiro's Institute of Telecommunications (IT).

3.2.1 Marta setups her tabletop

Marta is at home, installing her new mobile application that aims to help her with the obesity treatment. Curious as she is, she wants to use the full potential of it, and decided to proceed with the setup of a tabletop that helps her with her meals. The system asks her

to turn on the bluetooth of her phone and to selected the Obe Tabletop from the bluetooth devices list, and after a few seconds it informs her that the pairing was successfully completed and she can now start using her tabletop.

3.2.2 Marta eats her lunch at home

Around lunch time, after the application setup, Marta is still at home. She wants to make sure she eats the proper quantities of each of the food elements she has available, to that she starts the nutritional support system. Since she is at home, she selects voice interaction. The system starts by asking Marta to put the empty plate hover the tabletop. She takes a plate and places it over the tabletop and says "done". The system then asks Marta about what foods she has available to compose the meal. She has some stew chicken, rice and salad, so she answers: "stew chicken, rice, and salad". The system then suggests Marta that she starts adding rice to the plate. She puts two spoons of rice in the plate and the system responds with "you can put a little more". She pours two extra spoons of rice and the system says "Wonderful. That is OK for the rice. Now add some salad". She starts adding some tomato salad and glances at the screen and sees a little bar filling up. Oh, she is halfway of the quantity suggested by the system. She pours some more, and the system says "What a nice plate you are making! Now add some chicken". She then adds some chicken pieces until the system says it is enough. The system then shows her how she has been having balanced meals during the whole week. She feels happy about this and cannot wait to show this to her doctor Rita.

3.2.3 Marta eats her dinner at work

On the same day, at dinner time, Marta was in her working pause. She is as focused as ever, and wants to maintain her quality meals, however she is not alone and does not feel comfortable using the voice interaction mode on her current environment. She starts the nutritional support system, and selects 150g of chicken and 100g of rice to eat. The system answers to her action, with a "Great meal plan !" feedback. She is extremely happy with how easy it was to have all her meals on point during the whole day, and is starting to feel more confident with her treatment.

3.2.4 Marta eats lunch very fast

Marta then takes the tray with the plate to the living room table to eat her lunch. She is starving! When she finishes, she goes to wash the dishes and then, afterwards, she receives a notification from the system saying that one thing they should try is to experience eating slower and that the system can help, if she wants. She chooses "Yes" and the system says that they can start the next day, during lunch.

3.2.5 Marta trains herself to eat slower

After composing her meal the system suggests that they can try and take some more time to eat lunch. Marta really does not understand why this is that a big deal and chooses "why?". The system then informs her about the advantages of eating slower and how it impacts her condition. Ah, now she understands and sits in the living room to have diner and starts the system.

3.2.6 José forgets to track his day

José dedicated his Saturday to spend time his kids, which resulted in him not using the obesity support system. Lately, once he arrives home, he felt exhausted and decided to rest a while in his couch while watching TV. During that time, he remembers that he had forgot to track his whole day, to which he decided to open the system on his Smart TV and start registering his meals. José, feels relaxed and happy with his day while not compromising his health.

3.2.7 José uses his chair

At home, José during his breakfast, he has the habit of weighting himself while before the first meal of the day. To that he sits on his special chair that acts as scale, and proceeds to his obesity support system personal settings, and asks the application to start a new weighting process. The application provides him a feedback, with his new weight and a message "Wow, you're on the right way ! ". José, feels very confident, it has been years since his weight was so low, hes anxious to share the news with his personal trainer Paulo.

3.2.8 José follows his guidelines

At the gym, José was getting ready to train. To check his training plan provided by Paulo, he accesses the physical support system from his obese support application, and starts analysing which exercises he is going to perform on his training session. However, Paulo had left him a new exercise which he has never eared about called HIIT. Along with that exercise, the system has provided him the option to see more information about it. José then, selects see more, the system provides to him with a explanation saying that HIIT is a Hight Intensity Interval Training and he could do any exercise he wanted as long as it is divided between high intensity and resting intervals. José, proceeds with the training and by the end, feels shocked with how sweaty he is, leaving him with a sense of accomplishment.

3.2.9 José associates a health professional

José have decided to supplement his life with a touch of sports, to that he subscribed into a local gym and met Paulo, his new personal trainer. While, talking with Paulo, he told him that he is using a system that helps him with his treatment and that it has support for health professionals inclusion. Paulo, liked the idea and asked José, what he would have to do in order to be able to help José thought that system. José, told him that he only had to download the application and register as a doctor, Paulo did it and asked José how could he now associate him in the application. José showed him his physical support system, and the spot where he could send a invitation to a doctor by using the professional QR Code, he proceeded with the action and asked Paulo to show him his QR Code, he then pointed his phone at his QR Code and Paulo instantly received an notification saying "New association request". Paulo clicked on the notification, and was redirected to a screen with both acceptance or rejection options, he has clicked accept. José has then, received a new notification saying "Paulo is now your physical professional !". José now had Paulo associated as his Physical professional. Both of them, are excited to explore all the functionalities they can do as doctor and patient !

3.2.10 Paulo learns about the system

Later that day, Paulo was excited about his new obesity support system, and decided to explore it a bit more. At the beginning he was confused with some actions, however he quickly noticed the existence of a tutorial. He accessed it, and passed by all the features until his doubts were explained. He now knows the full potential of the system and is curious to see to his other patients reaction about it.

3.2.11 Paulo deactivates a module support

A few months later, after his introduction to the system, Paulo has been noticing that José motivation on his training sessions has been decreasing drastically. He decided to have a chat with him about it, in which José told him that lately he has been feeling pain while performing some exercises. While Paulo was hearing, he realized that all the exercises that José is complaining required an strong effort from his knees. He calmed him down and recommended him to have some rest from the trains. He also told him, that a likely cause to his pains would be overtraining. José agreed, so Paulo deactivated his physical support system while he would do some checkups.

3.2.12 Paulo shares José's problem

A few minutes later, Paulo have decided that it might be important for other doctors following José to know about his knee problems. To warn them, he accessed José information and left a note on a shared area by the medical team so they can understand that his performance can be temporarily decreased and that he has a pendent problem to be analyzed.

3.2.13 Rita acknowledges José problem

Rita, was at her office, planning José next appointment. When she accessed his information, she noticed that someone have left a note about a problem with him. Rita, changes José appointment plan, instead of the regular measurements, she have decided to do a knee checkup, so she can diagnoses if it is a severe problem rather than overtraining.

3.2.14 Rita schedules a new appointment

After José appointment planing, Rita had to schedule the appointment itself. To that she accesses José information, and selects the new appointment option, she then proceeds to select the date and confirms it. José then receives a notification, with the date for his appointments.

3.3 Requirements

Based on the described scenarios above and the help of a doctor and psychologist, it was possible to establish the following specific requirements for ObeOne 2.0 on the patient side.

- Account system creation, inherited from all the scenarios and generic problems found in the previous version (see section 2.3).
- Adoption of new input modalities such as speech, directly inherited from the scenario 3.2.3.
- Creation of a notification system, directly inherited from the scenario 3.2.9.
- Development of a settings area, indirectly inherited from the scenario 3.2.12.
- Ability to enable/disable sharing permissions, directly inherited from the scenario 3.2.11.
- Integration with other devices that can help within the treatment, directly inherited from the scenario 3.2.1.
- Access to the guidelines provided by responsible, directly inherited from the scenario 3.2.8.
- Adoption of a QR Code reader that would allow the association with doctors, directly inherited from the scenario 3.2.9.
- Identification of specific keywords that are present on the guidelines and provide educational support based on them, directly inherited from the scenario 3.2.8
- Restructure of main modules challenges, directly from the scenario 3.2.5.
- Restructure and redistribution of statistical module to the respective areas, inherited from generic problems found in the previous version (see section 2.3).
- Adoption of a more intuitive and friendly interface, inherited from generic problems found in the previous version (see section 2.3).

The described scenarios involve creating a system for the doctor(s) responsible for an obese patient that must address the following requisites.

- Account system creation, inherited from all the scenarios and generic problems found in the previous version (see section 2.3).
- Acceptance and of association invites, directly inherited from the scenario 3.2.9.

- Adoption of a QR Code base association method that allows the association request by patients, directly inherited from the scenario 3.2.9.
- Implementation of different roles with specific permissions among the the responsible, directly inherited from the scenario 3.2.9.
- Ability to see and edit information about a patient such as weight, directly inherited from the scenario 3.2.14.
- Defining the permissions a patient has over the application, directly inherited from the scenario 3.2.11.
- Creation of shared areas between responsible, directly inherited from the scenarios 3.2.12 and 3.2.13.
- Development of a area to write guidelines to a patient, directly inherited from the scenario 3.2.8.
- Possibility to schedule new on-office appointments,directly inherited from the scenario 3.2.14.
- Suggestion of educational information to patients, directly inherited from the scenario 3.2.8.

3.4 Conclusions

Understanding users and conceptualizing how the envisaged platform can influence their daily life, helping them to pursue their motivations, is a crucial step in designing technology for humans. In this context, this chapter started by analysing a set of Personas, directly connected with the problems domain – obesity –, and their motivations. Considering them, and the challenges identified previously, we then proposed a set of scenarios that illustrate how the assistive technology will be used. These, result from the reviewed literature, from feedback provided by different stakeholders, and from novel ideas being explored regarding assistive devices for the obesity context. The scenarios then play a key role in defining a list of requirements that will serve as grounds for the work presented in the following chapters.

Chapter 4

ObeOne Patient System Development

This chapter provides an overall description of the main steps of the adopted iterative UCD approach to address the requirements identified in the chapter (section 3.3) for the patient side of obesity support. Considering that ObeOne 2.0 is being developed considering a UCD methodology, this chapter is designed following the same flow, starting by a description of the overall concept and architecture, followed by a mockup design and evaluation stage, then by supporting the discussion of the concept with the stakeholders, and ending with an implementation and evaluation of a first iteration functional prototype.

4.1 Overall Concept and Architecture

Considering the requirements identified in the previous chapter (section 3.3), it was possible to define the needed infrastructures and organize an application architecture for ObeOne Patient system that is represented in the figure 4.1. Considering that ObeOne is a big long-term project, the planned architecture was thought thinking on the future and with a possible evolution path. Currently, only the firebase API is being used to communicate with the database, however, in the future the need for other support APIs to the logical modules might be necessary. Currently, the idea is to evolve the system with a very little or free cost, so, based on that, ObeOne is currently a "serverless" application.

The requirements presupposes the existence of at least three basic modules, Physical, Nutritional and Mental, that are planned to host a group of tasks and relevant information to users on theme, considering that there is a user notion on the application, there were

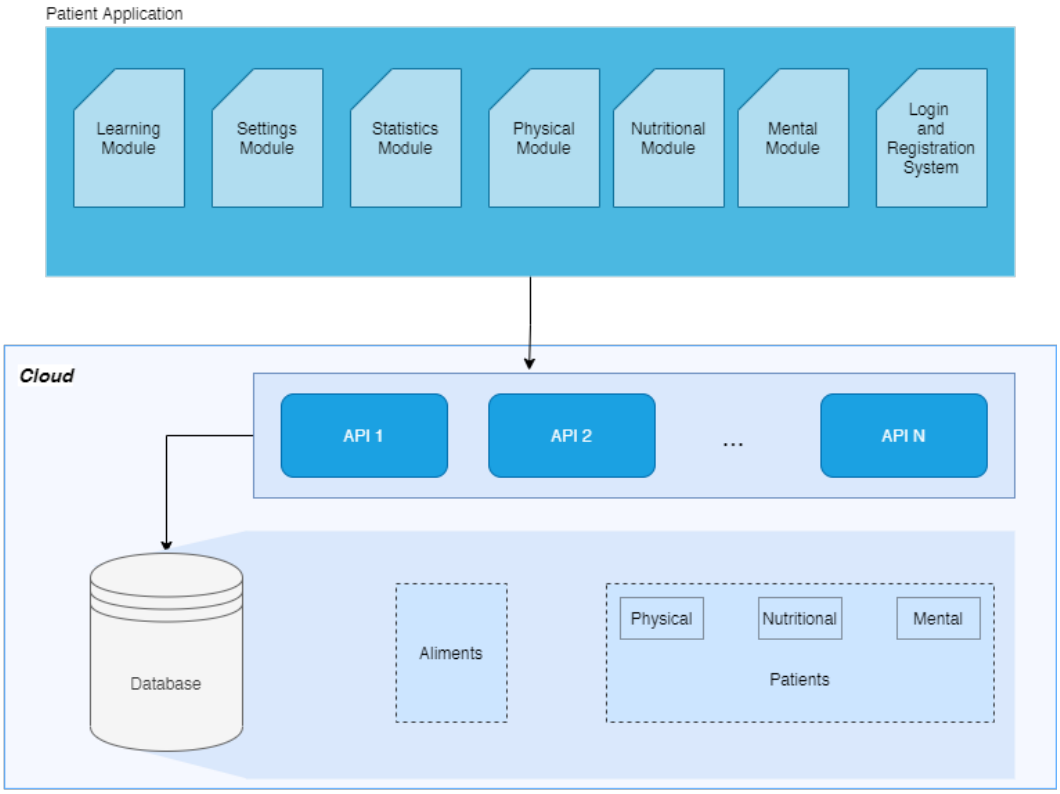

Figure 4.1: Overall architecture defined for ObeOne patient application composed by a database its collections that aim to support the several APIs that serve the information to the logical modules related with the planned implementation modules.

two options, to keep the application login free, which means, store all the data on the user phone or to develop a login system that would make use of a database, both approaches have advantages, while with the local approach, General Data Protection Regulation (GRPD) would not be an issue, it implies that the user can only make use of the application on one device and that for some reason he decides to wipe the application information or all the data from the phone, all the progress would be lost, the second approach is more prone to GRPD issues, however would allows users to login anywhere, considering that ObeOne is long-term effort and is very likely to possibly evolve into a Internet of Things (IOT) sector, having the versatility of a login anywhere would be more future-proof, considering this, a cloud based login system was the choice to the current architecture.

Although the nutritional module is part of the three base modules, it has a peculiarity, the requirements suggest the existence of meal tracking methods, such as the use of ObeOne tabletop. To make it possible, the application shall be able to access the nutritional information about the possible foods. The proposed architecture solves it by having a dedicated database table with the available aliments and their properties.

ObeOne is an application that aims to help obese becoming healthier. That concept implies the notion of progress. Providing patients the idea of the made progress is important and can improve user motivation if applied correctly. This reveals the necessity of a module that presents to users statistics on a set of relevant metrics on obesity treatment. The planned statistics module shall be able to access information from the three base models, infer part of the metrics from them and present it to the patients using a positive psychology approach.

Since ObeOne is planned to be a system with a cooperative side, choosing what users want to share becomes relevant. With that in mind, the architecture also predicts a settings module that would allow users to modify their sharing properties values on the database, which are later taken into consideration on the sharing logic.

Last but not least, teaching obese about obesity on first look sounds like a counter-census, however, is not. One of the causes of obesity and failed treatments is the lack of information about its dimensions. This architecture suggests the existence of a learning module that is planned to be nothing more than a collection of articles related to the diverse themes involved in obesity treatment such as training and nutrition. The presence of such a module implies the existence of a source to the articles. Again there could be taken two approaches, web-scrapping, which means that the articles would be taken from somewhere on the web or the directly production of the articles. The first approach would very likely result in copyright problems and lack of filter with the articles to be shown, so it was discarded. The self-production of articles implies an extra effort, however, it allows a source filter of the articles to be disposed of and avoid any possible copyright problem. To achieve that, the articles also have a dedicated table on the database.

4.2 Application mockup

The development of ObeOne is based in UCD, part of this methodology, refers to the continuous exploration and validation of ideas with increasingly refined prototypes, with a large role being played by initial mockups to validate major conceptual options before implementation. Having in consideration that ObeOne is a project that has a foundation that has already been validated and part of the problems found were due to his poor user interface implementation, low-fidelity prototypes will not be made. Instead, the first phase will use high-fidelity mockups created in Adobe XD, so that the system UI can also be evaluated along with the new features.

4.2.1 UI Proposal

This subsection will provide a detailed explanation regarding the design and development of a first iteration prototype.

The new version of ObeOne will follow the same dashboard principle as the old version. However, the new version will have incorporated an account system and solutions to the large majority of the requirements achieved in the previous chapter (section 3.3).

Considering that the first information a user shall see is a screen where he can either log in or register, forms shall be avoided since they can impact the first contact motivation when using the system. Considering that we cannot escape them, they shall be as short as possible. The left and center screen presented on the figure 4.2 respectively, illustrate the concept purposed for ObeOne 2.0.

Once a user is logged into the system, the dashboard concept will still be used. The modules will, however, be disposed in a more friendly and attractive way. The actual list visualization is very likely not the best approach. Instead, a grid visualization will be adopted as can be seen in the right screen from the figure 4.2. The dashboard content also had change since there was no point in having two modules with the same information. The terminology used also was not the best and is now with a more friendly approach.

There was also added a salutation and a quick tip on the top of the dashboard that when pressed lead to a full article about the subject approached on it. Finally, a notification icon on the top right corner was added to represent if the user has any association request from a doctor.

The information present in each module is going to be dependent on the purpose. However, the three dimensions modules can be follow the same pattern. Currently, all the dimensions only have a container with the challenges to be presented. The requirements predict patient-doctor associations. Together, with each of the dimension modules, since doctors can be characterized by the specialty they are practicing, would be a good place to find an association button. It was also stated that the statistical module was too confusing, so the statistics that directly refers to the activities performed to a dimension shall be represented among the challenges and the rest of the information regarding it. The proposed interface design is illustrated into the figure 4.3, where all the modules are presented. In some cases, there is the possibility for special actions to appear, for example, the use of a tabletop that acts as a scale and helps patients to register and healthy meal by providing feedback to them about the best spot in quantity for each specific food, a place intended for them has also been thought as possible to see in the center screen from the figure 4.3. Relatively to where

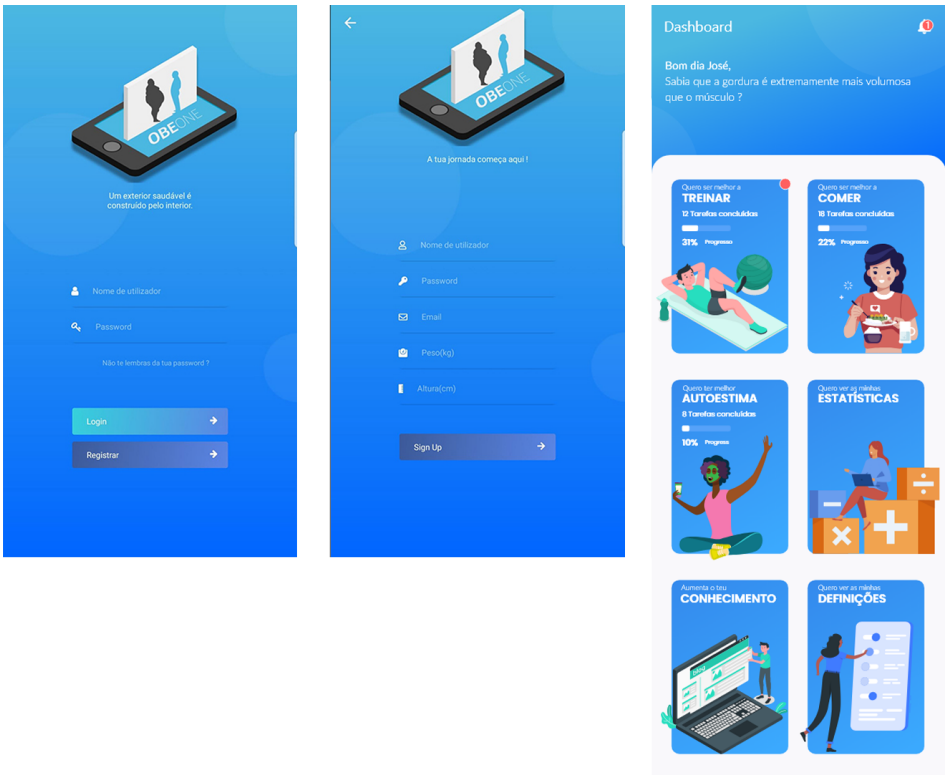

Figure 4.2: At left, patient login page composed by the a small form that allows users to login. On the center, registration screen with a quick form that allows new registers on the system. On the right, the first page users see when they login with a button to a notifications page, a quick tip and a dashboard composed by all the modules a user can navigate to.

doctors can share a patients treatment, it can be seen as a list of actions, has shown in the figure 4.3 left screen, that can be considered a special feature since there may exist modules where this section may not be needed.

The next module aims to provide patients with information regarding their overall progress and various areas directly connected with obesity, such as weight, body fat, and IMC. It is called the statistics module.

Along with the qualitative information represented in each area, clicking on them will reveal a chart with more precise information about their progress as illustrated in the figure 4.4. The whole application was designed considering the mental side of patients. Since it has been proven that having too much quantitative information could harm the motivation levels along the process, the idea was to try to hide them as much as possible behind qualitative measures that never have a pejorative side, which means that they only vary from good to very good.

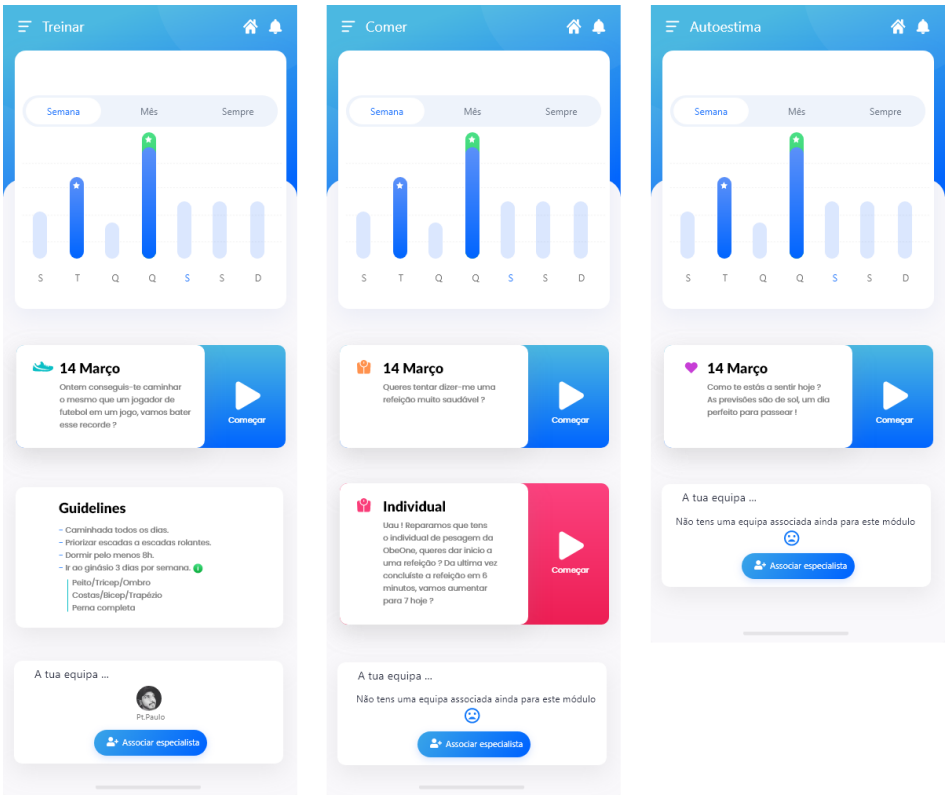

Figure 4.3: At left the physical module, with a overall chart of the performance on the module, a container for a task description and associated play button, another for potential guidelines given by the medical team, and finally a doctor association button. On the center, the same skeleton but for nutritional, being the main difference the existence of a container dedicated to the meal registration. On the right, the same skeleton again, but regarding the mental health context.

The left screen in the figure 4.5 aims to increase the knowledge that patients have about health in general and obesity derivative areas such as nutritional and physical areas. As possible to see in left screen from the figure 4.5, a list alongside an image that is directly related to the thematic of the article is made available for users consultation. They can access this module from three distinct places, they can access it from the dashboard such as the other screens, from the daily tip that is present on the top of the home screen, and from certain guidelines that can have a link to specific articles related with them.

Finally, a module that was missing on the first versions of ObeOne, a settings module. This module allows users to connect devices to the application, such as the ObeChair, change their sharing permission settings, and alter their current weight and height, this module proposal interface is illustrated on the left screen from the figure 4.5.

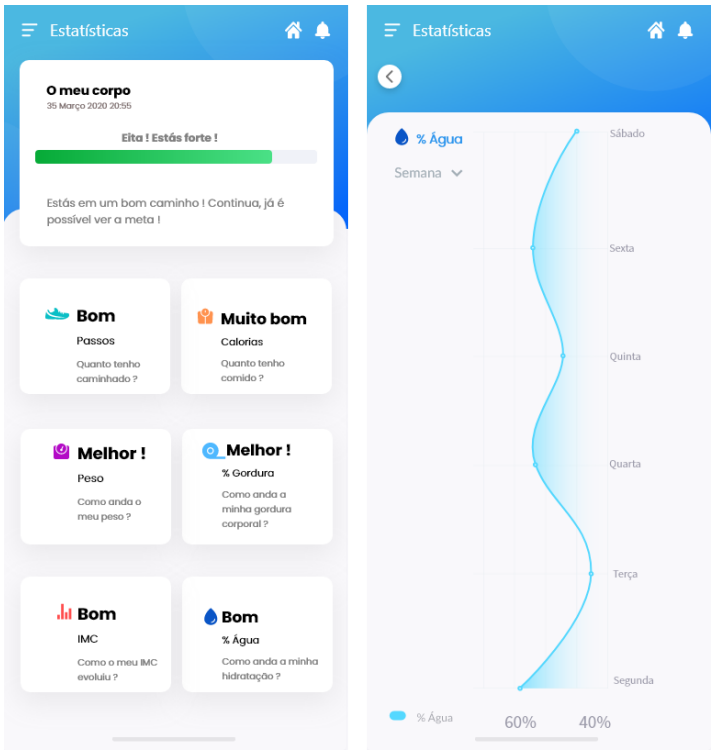

Figure 4.4: On left, the statistics module, with a overall progress bar about the patient progress and several indicators that are useful in the obesity context. On the right, a indicator chart screen.

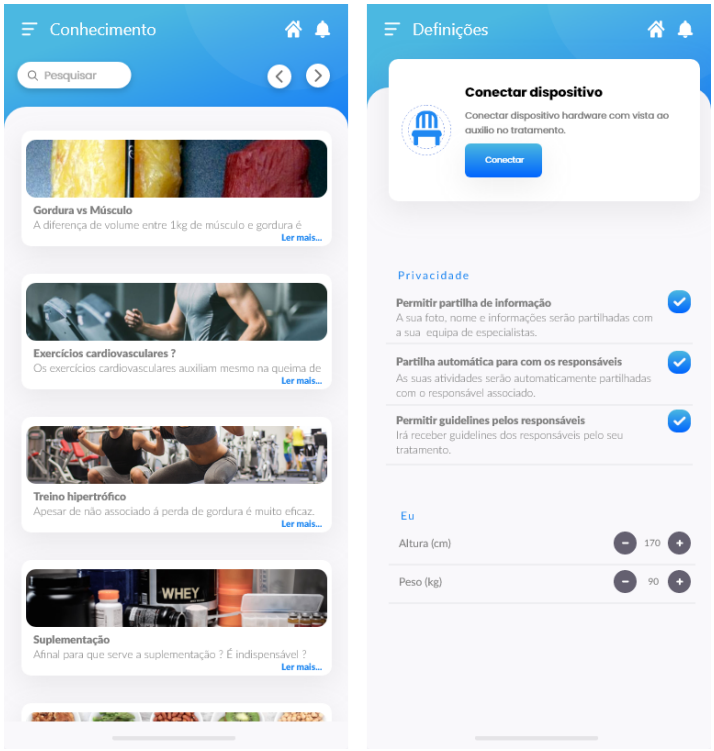

Figure 4.5: On left, the purposed educational module composed by a list of articles regarding health aspects. On the right, the settings module, composed by a place to integrate new hardware devices with the system and permission settings.

From all the modules, it must be possible to navigate to any other module without returning to the dashboard. It shall also be possible to have a shortcut that allows patients to navigate to the dashboard. The prototype uses a sandwich button on the top left corner that allows navigation to other modules and a home icon on the right corner that allows a quick navigation to the dashboard. Also on the left side, there is present a bell icon that the goal is to act as a notification alert, on an application such as ObeOne where there must establish relationships between Doctor-Patient, there is the need of a relationship request and his subsequent acceptance, this icon alerts patients to a new association request that they can decide if they accept or no by turning into red.

4.2.2 Evaluation

Having a design concept done, the next phase according to the UCD methodology wis Evaluation, to that there were used two types of evaluation, a focus group to collect feedback from two health professionals and a heuristic evaluation with 4 potential users.

4.2.2.1 Focus Group

During the prototype development, several aspects were considered related to the human-machine relationship. In order for those aspects to be validated, there was planned a focus group with a psychologist and an obesity doctor to discuss the following topics:

- Current prototype state, both doctors have agreed that the strategies used were very favorable, however, two features have awakened special interest, they were the possibility of association with doctors and the use of positive psychology in all the actions.
- How shall activities be suggested, the second topic has the goal of understanding how patients shall be asked to, for example, perform a physical challenge. We concluded that the best option was to keep everything passive, which means that there would not be any notifications or pop-ups that would request patients to perform a challenge.
- The relevance of mental support and if really requires a mental based module. Psychological support is one of the main requirements on ObeOne, understanding the best options to address it was also one of the themes during the discussion, the conclusion was that although it does not seem a big deal, having a dedicated mental support screen will very likely improve the chance of a healthy mind, however, all the application shall continue to follow methods such as positive psychology and qualitative over quantitative units.

- Voice-assisted actions, this theme has the goal of understanding if voice-assisted actions are something well seen by the scientific community and if they can affect patients motivation. There had not been concluded an answer to this theme. Although this type of approach can improve patients motivation, there is still a high resistance when using this method, either due to privacy issues or because a method that was supposed to improve the speed on how actions are performed has the opposite effect actions even slower.

- How should doctors receive information from the patients, it was required to define how and which information shall doctors have access to and to detect possible privacy constrains, at the end, it was agreed that doctors shall have access to the number amount of tasks performed in each module, weight and height however, on the patient side they shall be have to choose if they want that information to be shared with their medical team or no.

4.2.2.2 Heuristic Evaluation

A heuristic evaluation consists of having a set of persons who will perform an examination in an application interface and judge it according to a set of pre-defined heuristics. Jakob Nielsen's along with Rolf Molich developed a set of 10 heuristics in 1990 that would become the standard heuristics for user interface design, the Nielsen heuristics.

ObeOne will make use of Nielsen heuristic for user interface evaluation purposes. A set of 4 participants all of them with at least basic knowledge about Nielsen Heuristics and the evaluation process were asked to perform this evaluation. During the evaluation, each examiner was asked to mark any found usability issues according to a severity scale in a range from 0 to 4, in which 0 defines a no usability problem and 4 consists in a very severe issue. The used severity scale and an explanation of all the heuristics used can be seen in the Appendix 7.1.

4.2.2.3 Results

Considering the stakeholders answers, it was possible to find problems to be addressed on the functional versions of ObeOne. The following charts represent the overall severity of the errors founds at each of the evaluated heuristics, being the maximum a severe problem, that is represented by a value 4 and the number of participants also 4.

Table 4.1: Patient heuristic evaluation table with the results of the number of errors and severity from the four participants, on which the severity was assessed considering a scale from 0 to 4, where 0 means the non-existence of a problem and 4 the existence of at least a severe problem. The represented severity consists in the overall severity of the errors found regarding heuristic context.

Patients application heuristic evaluation table								
	E1		E2		E3		E4	
	N	S	N	S	N	S	N	S
Visibility of system status	0	0	0	0	0	0	1	2
Match between system and the real world	1	1	1	3	0	0	4	4
User control and freedom	0	0	0	0	0	0	1	3
Consitency and standards	1	1	1	1	0	0	1	2
Error prevention	0	0	1	2	0	0	0	0
Recognition rather than recall	1	1	0	0	1	2	0	0
Flexibility and effiency of use	1	1	0	0	0	0	0	0
Aesthetic and minimalist design	1	1	1	1	1	1	1	2
Recognition, diagnose and recover from errors	0	0	1	2	0	0	0	0
Help and documentation	1	2	1	2	0	0	1	2

N - Number of errors, **S** - Errors severity

It is possible to notice that the most severe problems reside on compatibility with the real world and help. The stakeholders have justified the found problems with the following list of aspects:

- Hard to understand the information from the charts on the statistics area.
- Lack of the homepage button on the menu.
- Non-inclusion of feedback to user actions.
- Hard to understand what each chart on the top three main modules represents.
- Non-existence of a tutorial to beginners.
- Lack of the possibility to collapse the dashboard buttons.

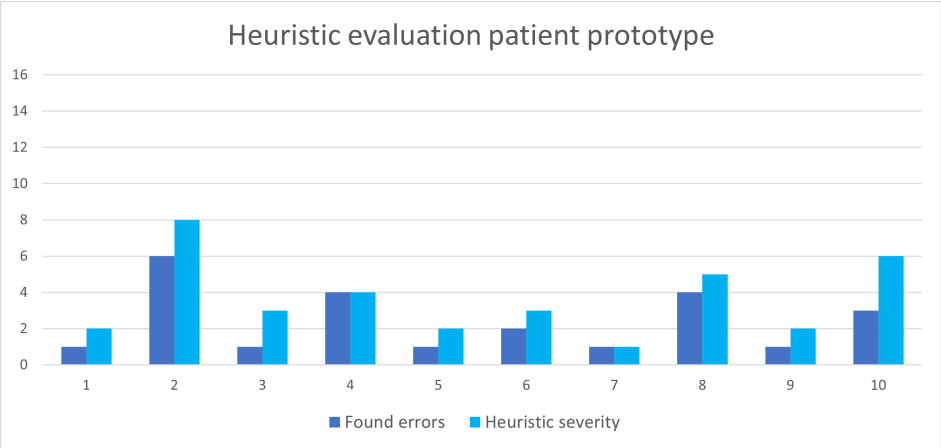

Figure 4.6: Aggregated number of errors and severity from all the participants along the ten Nielsen Heuristics taken in consideration in a range from 0 to 16, where 0 means the non existence of any problem and 16 the report of very severe problems by all of the participants.

4.3 Current functional version

This section will describe the process of development from the first functional prototype of ObeOne. It will be possible to see all the requirements that have to arise from the heuristic evaluation and more technical features that have been planned to be addressed on this first iteration.

By the end of this iteration, a new evaluation will be made, and consequently the results from it will be analysed to find new requirements for a future iteration.

4.3.1 Requirements

The first functional version of ObeOne was planned to have both applications communicating with each other, which means that by the end of this iteration, it shall be possible for an upcoming doctor application to be easily integrated. This is only possible by finding solutions to all the problems that have resulted from the prototype evaluation and creating the back-end support for all the features that the application is supposed to have.

4.3.2 Process

The development process from the ObeOne patient application was supposed to be based on the previous version done last year, however, with the evolution of the application to the new prototype, the progress that could be reused was very little. By the end, the only reused material was the project skeleton and the same programming language, which was React Native, mainly due to the versatility that it provides when developing applications to Android and iOS.

The newer application requires a strong front-end effort. The first steps were to recreate all screens using the same design identity that was validated from the prototype, due to React Native large community, it was possible to find a diverse number of libraries that acted as a support to this procedure, such as packages that help drawing charts, menus, and other UI/UX elements that were present in the project. For all the work to be easily manipulated by all the screens and both applications, a component methodology was used where all the elements that could be reused were packed into a component that means that the code for it only has to be written once.

On the previous version back-end, a local SQL database was used. This type of databases are not suited for applications that require an account system, so instead, the newer version of ObeOne makes use of Google Firebase database, which is a non-relational database that matches perfectly the necessities that the system represents.

During the development of the application, the need for periodical execution from a function emerged, to that, there has been decided to make use of Cloud Functions, that is a serverless framework that stores code in Google cloud and execute it according to with a trigger that is programmed for example with database access.

The applications whole development was done according to a serverless approach that represents exactly the advantages that ObeOne system requires, which were the ease of deployment, the zero initial costs, and extra time for UX purposes.

4.3.2.1 Problem solving

According to the previous evaluation, it was possible to divide the found problems into two distinct groups, being the first related with more functional actions composed by the following list.

- Non-inclusion of confirmation feedback to the creation tasks.

- Non-existence of a tutorial to beginners.

To solve the functional problems found, there was added feedback to a large number of tasks, especially to destructive actions. There was added a new screen with a slider that appears on the first access of a user to the application with a quick tutorial about it, this screen can also be accessed after by clicking a button on the top right corner of the application as can be seen by the images below.

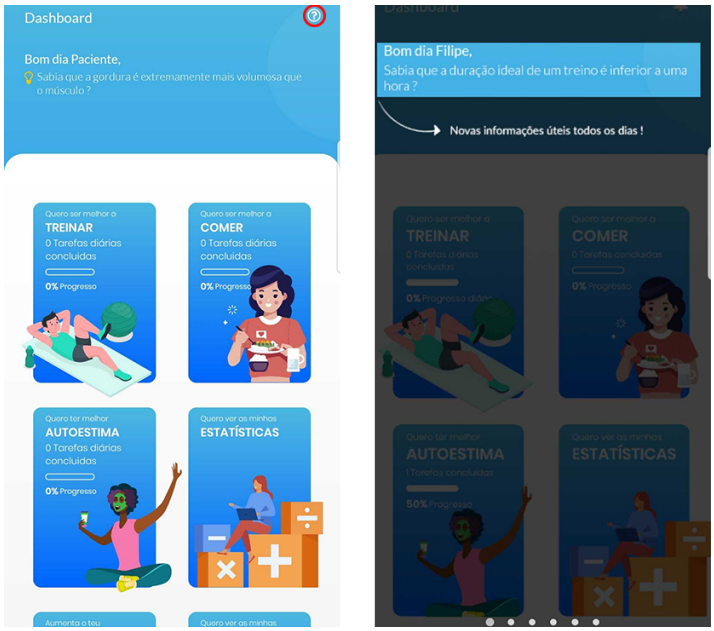

Figure 4.7: Addition of a tutorial button to the dashboard on the left screen and tutorial screen concept on the right screen.

The second group of problems reflect interface design problems and is composed by the following list

- Hard understanding of the charts on statistics area.
- Lack of the homepage button on the menu.
- Hard to understand what each chart on the top three main modules represents.
- Lack of the possibility to collapse the dashboard buttons.

There were made efforts on the three first points from the problems found. Regarding the fourth issue, it can be addressed by providing users with a customization option and was not considered high priority at this point, and postponed to a future iteration.

Considering this, to solve the first problem, the charts screen was redesigned and evolved into a modal as possible to see on the left screen from the figure 4.8, with a standard chart and a short description of what the users see and how it can be interpreted. The second one was simply to add one more item to the sandwich menu on the top left corner and is illustrated at the center from the figure 4.8. However, the third problem was more complex, and although there was no solution to it, the graph area has been slightly refactored into a more traditional bar graph that can be seen on the right screen from the figure 4.8. The figure 4.8 illustrate the found solutions.

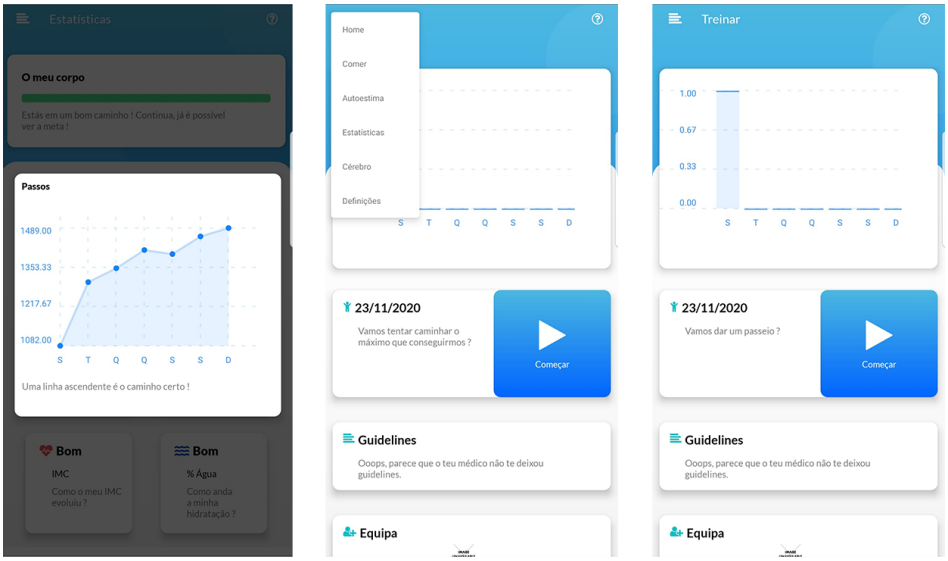

Figure 4.8: On the left, redesign of the metrics charts from statistical area. On the center, the sandwich button implementation. At the right, the implementation of the dimensions performance chart.

Along with the problems solved, the mock-up was also converted to a functional prototype, which can be seen in more detail in the Appendix 7.2.

4.3.3 Evaluation

To identify problems and uncovered opportunities among the functional version, it was decided to make use of Usability Testing combined with a thinking aloud methodology. In this methodology, the participants were requested to execute tasks such as traditional usability tests, however, they shall do it while they verbalize their thoughts and planned actions to

move on the tasks.

4.3.3.1 Usability Testing

In order to proceed with the usability testing, it was asked to five participants with different levels of knowledge regarding the use of mobile applications to execute the following set of nine tasks, (support documentation for the evaluation available in Appendix 7.4).

1. Find ObeOne use manual and count the number of modules present in ObeOne.
2. Find the first suggested task on physical module.
3. Find the given guidelines by the doctor regarding mental health.
4. Find where it is possible to proceed with meal registration and the current possible foods to be chosen.
5. Find where it is possible to consult the water percentage estimate.
6. Find the third educational article available on the system.
7. Find the current state of the automatic sharing permissions with the doctors.
8. Perform a doctor association using the given QR Code.
9. Experience the voice iteration input when registering a meal.

Those were then marked with their overall evaluation into how easy the task was in a range from one to five, where one is an arduous task and five an effortless task. During the execution of the tasks, there were made notes about the user usage regarding the system, and the following set of metrics was registered, Appendix 7.6.

- Number of clicks.
- Task conclusion.
- Execution time.
- Confusion existence.
- Existence of errors.
- Help request.

- Ease of use, following the same range as stated above.

Once all the tasks were performed, the participants were also asked to fill a after tasks questionnaire regarding the satisfaction with the system, (Appendix 7.5). For that purpose, we made use of QUIS, that is a measurement tool designed to collect the subjective satisfaction level with the human-computer interface. This tool targets direct aspects such as screen factors, terminology and system feedback, learning factors, system capabilities, technical manuals, on-line tutorials, multimedia, voice recognition, virtual environments, internet access, and software installation.

4.3.4 Result analysis

According to the results from the evaluation, it was possible to draw graphs that indicate the percentage of ease of use from a participant point of view, the ratio of completed tasks, error ratio, and ease of use from an observer point of view.

The first indicator to analyze is the ease of use on participant and observer points of view.

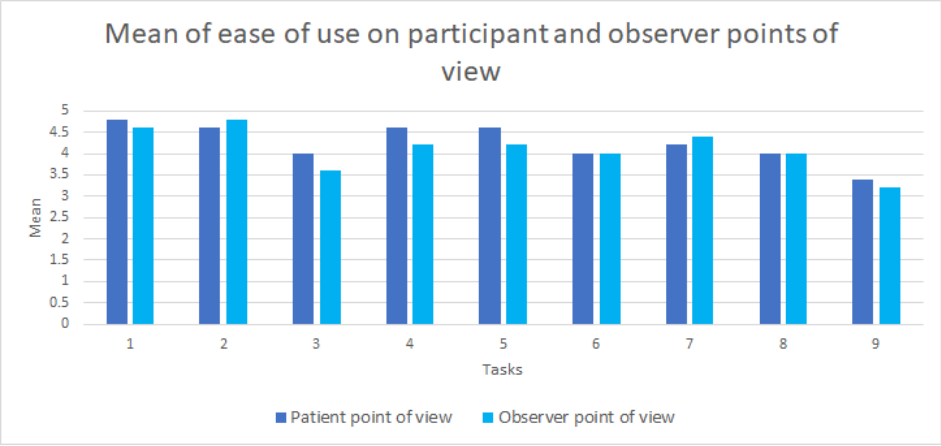

Figure 4.9: User evaluation of the first functional patient prototype: Bar chart regarding the mean ease of use at each of the tasks presented to the participants on both the participants and observer points of view of the patient application where 0 means an very hard task and 5 an very easy task.

According to the figure 4.9, it is possible to see that the ease of use among both points of view does not have a significant deviation, however, in most cases, the observer attributed a lower level of ease use. It is also possible to notice that there is not a significant deviation

among the tasks. In general, all the tasks were easy to be executed being the lowest, task 9 (Experience the voice iteration input when registering a meal), rated with around 3.8 out of 5 on the patients point of view.

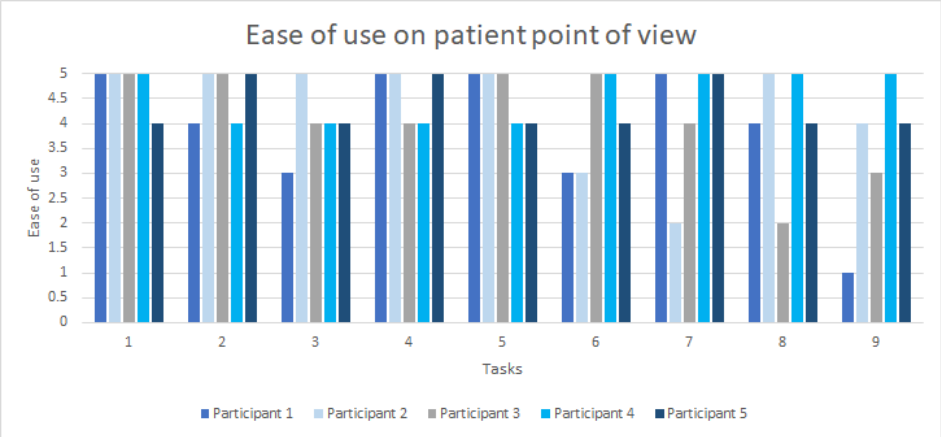

Figure 4.10: User evaluation of the first functional patient prototype: Bar chart illustrating the ease of use from each of the participant to the nine tasks they were asked to execute from the patient application where 0 means an very hard task and 5 an very easy task.

By having a closer look at the given ratings by the participants, according with the figure 4.10, it is possible to notice that, for example, on the first task, there was only a user that had not classified the task as very easy, however on the last task there is one participant that has classified it as being very easy but another one as a difficult task, which can represent some vulnerability on the functionality that is being tested on task nine.

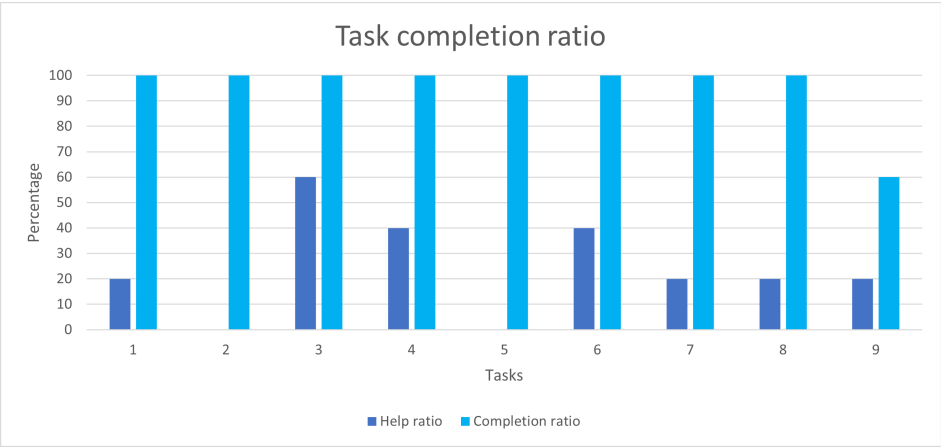

Figure 4.11: User evaluation of the first functional patient prototype: Completion ratio at each of the tasks regarding the patient application in a scale from 0 to 100,where 0 indicates a low completion/help request and 100 a high completion/help request.

The task completion indicator provides information about the percentage of persons that have completed the task. According to the chart presented in figure 4.11, all the tasks were completed. However, there was only a 60% completion ratio in the last task, which reinforces the thesis that there might be some functional vulnerability. Even though eight of the nine tasks were all completed, there was one task with a high percentage of help requests, which was task 3. This happens due to the nomenclature used to identify the mental module. Most of the participants think that the educational module is mental and kept trying to execute the wrong modules task until they asked for help.

Figure 4.12: User evaluation of the first functional patient prototype: Bar chart illustrating the relation ratio between the number of tasks executed without errors and the tasks that were executed or not with errors from patient application where 0 means the non existence of errors and 100 errors reported by all of the participants.

When combined with the completion ratio analyzed above, the error ratio provides information that allows the inference of the existence of aspects that can mislead participants. A deep dive into the chart in the figure 4.12 suggests that, for example, on task number three, there might be an aspect that is making participants perform it wrongly. However, they notice it and can recover from it since the completion ratio was 100%, however, when looking at task 9, there is represented an error of 40% that is the same percentage missing on the completion ratio, crossing this data allows the conclusion that there is an unknown condition on the last task that is leading to a fatal error that is not allowing the completion of it.

Last but not least, the post-task questionnaire based on QUIS,(support documentation for the questionnaire available in 7.5) allowed the draw of the chart presented in the figure 4.13, which represents the mean score obtained from it. It was possible to notice that the worst aspect of the current prototype was the lack of clear messages that help in how to solve any problem that might occur during the application usage. Given this score, the application

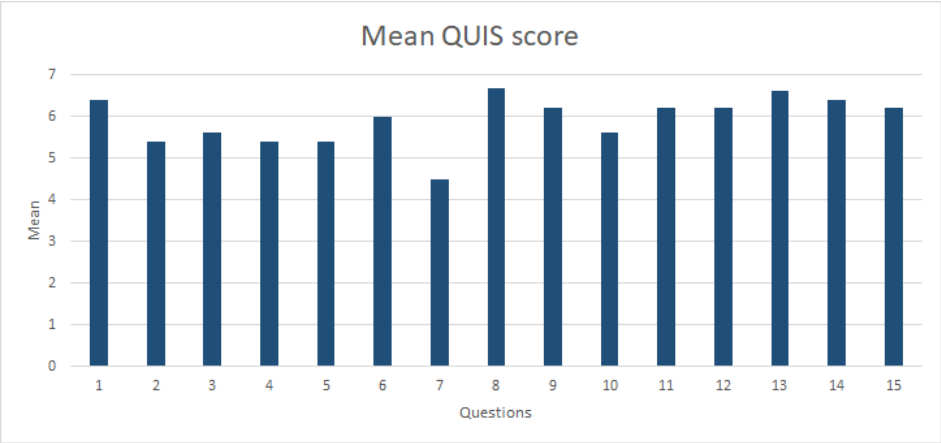

Figure 4.13: User evaluation of the first functional patient prototype: Mean score registered at each of the questions presented into the questionnaire presented to the participants regarding the patient application where 0 means a terrible experience and 7 an great experience.

presents a good level of usability. From the thinking aloud approach and the questionnaire notes, it was possible to identify the following list of aspects that can be improved:

- Improve the nomenclature used to identify each module. The current names are the source of confusion, especially when accessing the mental module.
- Interface wise, some aspects can be improved, such as the font size and weight.
- The voice interaction functionally on meal registrations also has a large room for improvements. Currently, some unidentified conditions prevent it from working properly.
- Redesign on the tutorial, in some smartphones, the slide dots are not visible, making the screen look like a blocking screen, preventing users from proceeding due to the lack of information provided by the system.

4.4 Conclusions

Analyzing the list of requirements, it was possible to identify the need for two applications depending on the user role (section 3.3). In this context, this chapter started by presenting an architecture that would allow patient requirements to be addressed. Considering it, and the requirements identified previously, there has been made a conceptualization of a set of features

that aim to be solutions to the identified problems, in the form of an Adobe XD prototype. Then, to validate them, we have evaluated them using a focus group with two clinicians and Nielsen Heuristics with a group of 4 experts, that have resulted in a set of refined requirements and the validation of most of the concept and features of the purposed system. In the next iteration, we decided to take the application to a functional level by replicating the previous validated mockup into a functional version and developing new features aiming to address the newly identified problems from the previous evaluation. This version of the application has been then, submitted to a series of usability tests that aimed to validate the patient application performance in a user point of view. The evaluation results were than analysed, from them it was possible to have an early usability evaluation by non obese participants, leading the application to a state where it is ready to be tested by patients, for example, in the context of focus groups so discussion is promoted, that will then very likely result in a new set of requirements for an future iteration.

Chapter 5

ObeOne Doctors System Development

This chapter follows the same overall structure as chapter four, but focusing on the development of the ObeOne doctors application. Unlike the patient application, this one must be done from scratch since the previous ObeOne version did not have any work directly addressing the health professionals. While the professionals that can provide support to the obese patient can include non-doctors, the expression "Doctor's Application" is used, for simplicity, throughout this chapter. This application also follows a UCD approach with the document structure reflecting the accomplished iterations.

5.1 Overall Concept and Architecture

Like in the patient application, based on the collected requirements it was possible to propose an architecture that aims to solve the doctor system requirements, as depicted in the figure 5.1.

Unlike the patient application, currently, the doctors application require a low amount of modules. Both applications share the same login/registration systems as the only difference is where the user is created. A settings module is planned to have basically the same functions as the one present in the patient application, this module has one particularity, which is the existence of a QR Code that uniquely identifies the doctor, with the goal of performing a request associations. Finally, a module that have as goal the presentation of the associated list of patients. In this module, it shall be possible for the doctors to consult details about a patients routine, schedule new appointments, write information about the patient that will be

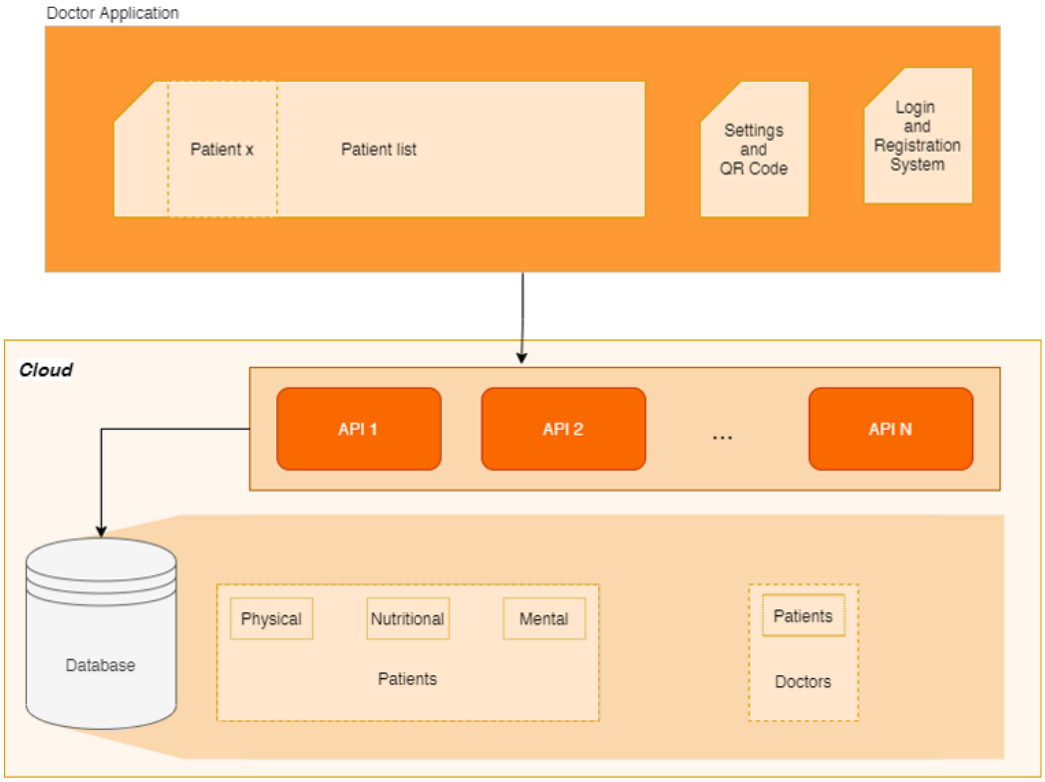

Figure 5.1: Overall architecture defined for ObeOne doctors application composed by a database and his collections that aim to provide support to the several APIs that serve the information to the logical modules related with the planned implementation modules.

shared with the other clinicians, and provide patient guidelines. To achieve that, this module consults and writes information into the patients and doctors tables in the database .

5.2 Application mockup

On the doctors side, there was nearly no work done since there was just a screen with a form and a button that would create a QR Code for a specific patient. The first phase of this applications development passes by developing a prototype that meets all the requirements involved in its specification.

5.2.0.1 UI Proposal

The following subsection provides a detailed explanation of the strategies used to solve all the requirements stated above with the resource of a high-fidelity prototype.

Since this application was nearly nonexistent, a low-fidelity prototype would be suitable for it. However, since there were elements that could be reused from the patient application, the effort that a low-fidelity prototype would require would be very similar to a high-fidelity one. Considering this and the advantages that derive from this type of prototypes, such as the ability to use them in closer to final version way, were more than reasons to advance into a high-fidelity prototype without making first use of a low-fidelity one.

The landing and registering pages on both systems were the same, so they will not be explained here since they have already been addressed in the previous chapter (section 4.2.1).

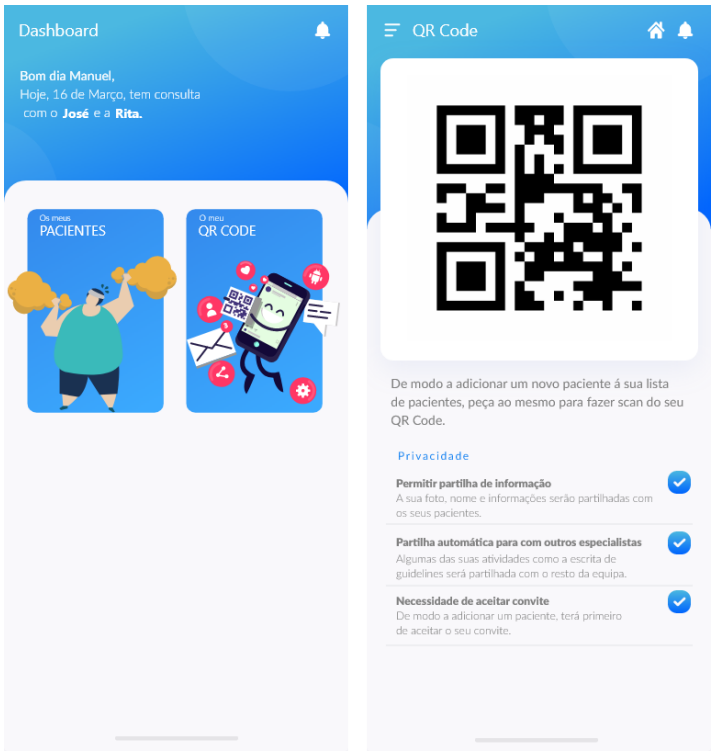

Figure 5.2: At the left, the home page from doctor application composed by the list of appointments for the day and a dashboard. On the right, the QR Code and settings module composed by a a list of permission settings and a QR Code for associations between patients and doctors.

The first screen illustrated in the figure 5.2 is what users see when they log in and is composed by a grid dashboard. Starting from the top, it is possible to notice a bell icon on the right corner, which will have its color changed when it is an association request pendent.

The next element is a quick text that presents to users their next appointments and with who they are, acting as reminders to doctors.

On the dashboard itself, there are currently present two modules, a patient module, where doctors can see all their associated patients, and a settings plus QR Code module.

By clicking the QR Code option, there is present a unique QR Code that has the goal of identifying the professional, which can be seen in the figure 5.2. Along with it, there are also a set of settings that allow health professionals to customize the information to be shared and how the doctor-patient association shall work.

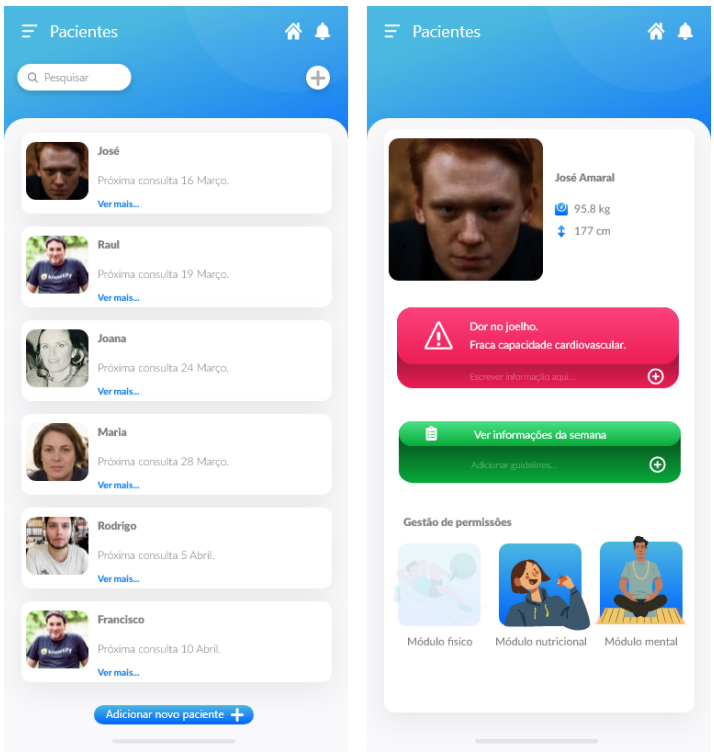

Figure 5.3: At the left, the screen that allows doctors to navigate through their associated patients. On the right, a patient information, a shared area for problems, a container for guidelines, and three buttons that aim to enable or disable the dimension modules from a patient.

On the patient module, there is a list of the associated patients with a small amount of information about them, as it is possible to see in the first screen presented in figure 5.3. There shall be two text areas that can act as input regarding each patient, one for guidelines and the other for shared information. Certain doctors shall also have the possibility to control which dimensions a patient has access to, translating into 3 toggle buttons which can be seen on the right screen from the figure 5.3.

5.3 Evaluation

With the mockup for the doctor application done, it was time to evaluate the work done. To that, the same approach used in patient application was followed, that is, a focus group and a heuristic evaluation.

5.3.1 Focus Group

Although overall the patient application feedback was very favorable. There was not given many information regarding the doctor application. Both health professionals agreed with the used approach. Other than that, the given feedback were mainly addressing minimal UI/UX aspects, such as the lack of back buttons and the nomenclature used.

5.3.2 Heuristic Evaluation

The approach followed on the Heuristic evaluation was the same as in the previous application. Four persons that have experience performing heuristic evaluations were asked to evaluate the doctor's application considering Nielsen's Heuristics and classifying the severity of any violation within a scale from 0 to 4, in which 0 defines non-existence of a problem and 4 a severe problem. The used severity scale, heuristics, and explanation about them can be found in the Appendix 7.1.

5.3.2.1 Results

With all the answers, it was possible to develop the following table, with the number of errors found and the severity attributed to them.

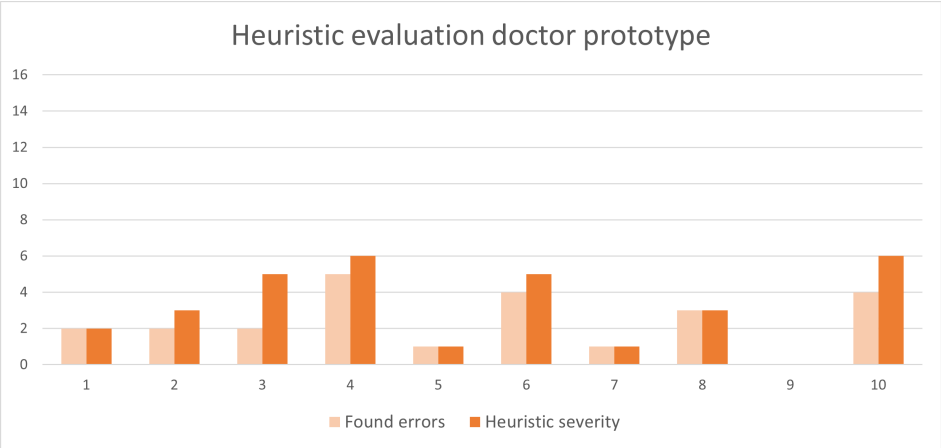

Figure 5.4: Aggregated number of errors and severity from all the participants along the ten Nielsen Heuristics taken in consideration in a range from 0 to 16, where 0 means the non existence of any problem and 16 the report of very severe problems by all of the participants.

Table 5.1: Doctor's application heuristic evaluation table with the results of the number of errors and severity from the four participants, on which the severity was assessed considering a scale from 0 to 4, where 0 means the non-existence of a problem and 4 the existence of at least a severe problem. The represented severity consists in the overall severity of the errors found regarding heuristic context.

Doctor's application heuristic evaluation table								
	E1		**E2**		**E3**		**E4**	
	N	**S**	**N**	**S**	**N**	**S**	**N**	**S**
Visibility of system status	0	0	2	1	0	0	0	0
Match between system and the real world	1	1	0	0	0	0	1	2
User control and freedom	0	0	0	0	1	2	1	3
Consitency and standards	1	1	2	1	1	2	1	2
Error prevention	1	1	0	0	0	0	0	0
Recognition rather than recall	2	2	1	2	1	1	0	0
Flexibility and effiency of use	1	1	0	0	0	0	0	0
Aesthetic and minimalist design	0	0	0	0	2	1	1	2
Recognition, diagnose and recover from errors	0	0	0	0	0	0	0	0
Help and documentation	2	2	1	2	0	0	1	2

N - Number of errors, **S** - Errors severity

Considering the table and the chart on the figure 5.4, it is possible to notice that the most severe problems reside on heuristic four related to the pattern consistency, and on heuristic ten that is related to the presence of help and documentation. The Stakeholders justified the severity with the following list of problems.

- Lack of button descriptions on the patient area.
- Lack of the homepage button on the menu.
- Non-existence of a tutorial for beginners.

5.4 Current functional version

This section aims to describe the development of the current version of ObeOne Doctor's application. By the end of this iteration, it shall be possible for the system to support at least a basic version of the envisaged requirements.

5.4.1 Requirements

This application acts as the second part of the patient application. It shall work together with the patient version. The goal is to present a solution to all the requirements found in chapter 3 and heuristic evaluation problems.

5.4.2 Process

Unlike the patient application, there was no previous work that could provide the overall design foundations for the doctors application, which means that the application to be developed shall be made from scratch independently from the used tools. To keep coherence with the previous version and due to the suitable advantages that react native has, such as large community, cross-platform, and reusable components, it was the chosen framework for the development of the doctors application. Just like the first application, there is a strong front-end effort required, however, due to the possibility of reuse from previous components built in react native, there were certain elements that could be reused from the first application, such as the login screen and dashboard components.

Since it was decided to use a firebase real-time database on the patient application, the same database will be reused in the patient application context. The needed tables will be added to the already existing database.

ObeOne Doctor's application follows the same serverless approach as the patient application due to the lack of costs and yielding extra time to dedicate to UI/UX features.

5.4.2.1 Problems solving

Although the problems revealed by the heuristic evaluation could be grouped just like on the patient application, the number of found problems was much smaller, which does not justify this division. The only interface issue found was the lack of a homepage button on the sandwich menu, which has already been addressed on the patient application. The same methodology has been used to solve the problem of this application.

The other found problems were the lack of an initial tutorial that, such as the previous problem, has already been addressed on the patient application, therefore, the same solution can be applied to the doctor's application. The second functional problem found, is due to the lack of information on the buttons that were supposed to enable/disable patient modules, it was hard to understand their propose. The mockup version of the doctor's application, also did not have planned a place where doctors could consult the patient performance at each module during the week, at the moment, guidelines can only be added as a whole to patients however that might not be the best approach since on the end there would be a mix of guidelines regarding all the dimensions, it would make sense to group them under a new screen for each of the dimensions, to that, the old button that would only allow the enable/disable of a module would become a button to a new screen. Another of the missing aspects was the ability to schedule new appointments. There has been added a button that would pop up a calendar and allow doctors to execute this type of procedure. All the challenges can be seen in the figure 5.5.

The remaining screens were replicated from the mock-up and can be seen with more detail in Appendix 7.3.

5.4.3 Evaluation

According to the UCD cycle, the next phase shall be evaluated with a functional prototype ready. In order to discover the issues and non covered aspects, this application is going to make use of usability tests such as the patient application. In this text, the participants

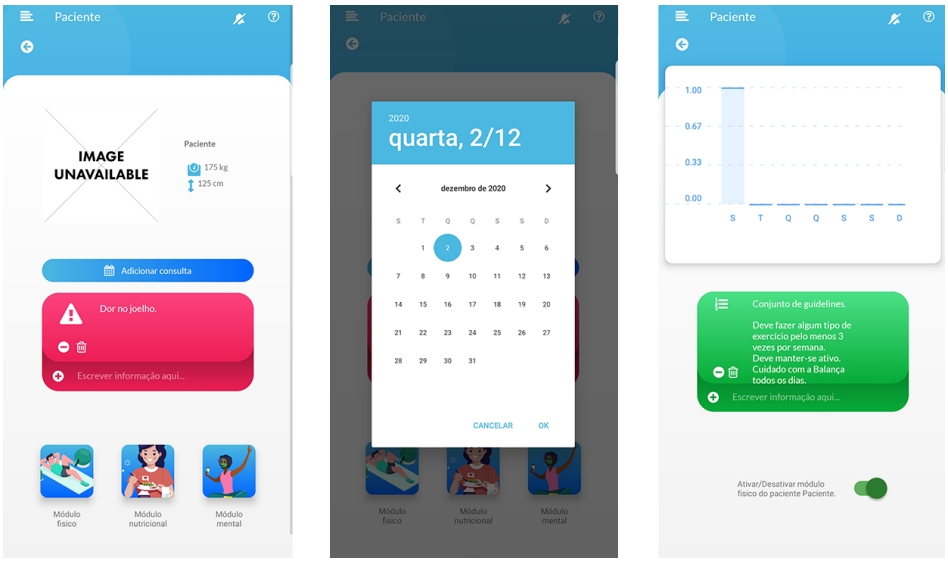

Figure 5.5: At the left, the redesigned patient area now with a place to schedule appointments and new functions to the dimension buttons. At the center, the calendar that has the goal of scheduling appointments. On the right, the new screen developed to control each of the dimension modules.

will be asked to perform a set of six tasks, Appendix 7.7, and evaluate them on a scale from 1 to 5, where 1 represents an very hard task and 5 an very easy task, while the execution of the tasks, the participants will be asked to verbalize what they are thinking, and there will be taken notes about the problems and performance among all the tasks, Appendix 7.9, once all the tasks are executed, the participant will be asked to fulfill a questionnaire based on QUIS, Appendix 7.8.

Like in the patient prototype, five participants with different levels of knowledge using mobile applications were asked to perform the evaluation. The considered metrics were the percentage of ease of use from a participant point of view, the ratio of completed tasks, error ratio, and ease of use from an observer point of view.

5.4.4 Result analysis

This subsection will present a series of graphics along with a detailed explanation and interpretation. The first chart to be analyzed, is the ease of execution from the different tasks from a participant and observers points of view.

Analyzing the chart presented into the figure 5.6 that represents the ease of use from each participants point of view, it is possible to understand that all the tasks were marked as elementary tasks being the lowest mean ranked task marked with a 4.

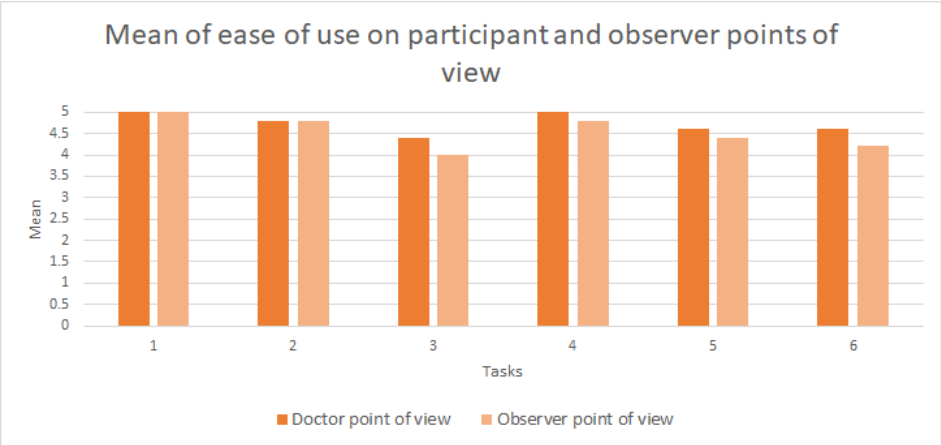

Figure 5.6: User evaluation of the first functional doctor's application prototype: Bar chart regarding the mean of use at each of the tasks presented to the participants on both participants and observer points of view of the doctor's application where 0 means an very hard task and 5 an very easy task.

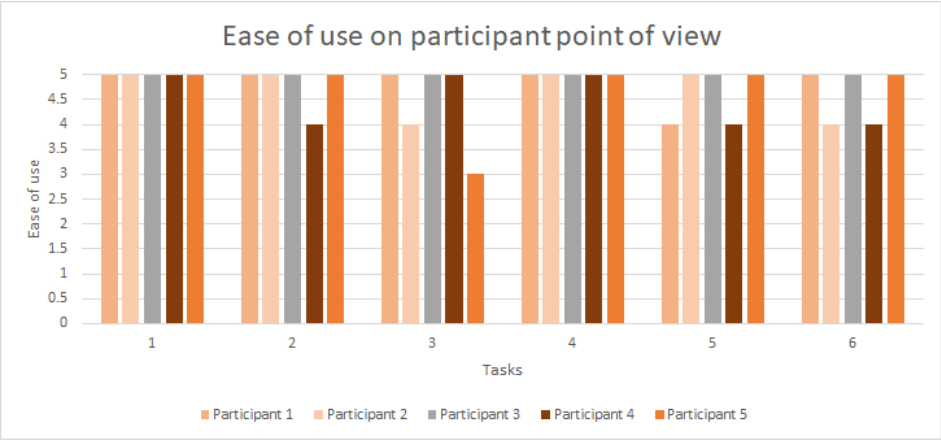

Figure 5.7: User evaluation of the first functional doctor's application prototype: Bar chart illustrating the ease of use from each of the participant to the nine tasks they were asked to execute from the doctor's application where 0 means an very hard task and 5 an very easy task.

The figure, 5.7, allows some considerations to be taken. For example, it is possible to notice that the fifth participant marked all the tasks except the third to be very easy to use. He had problems either finding where he could execute the task, or any execution problem occurred meanwhile. It is also possible to see the third, fifth, and sixth tasks were not all marked at the maximum. The think-aloud methodology allowed us to identify the problems found on these tasks, which was the lack of knowing where to navigate to execute the task on the third and fifth, and the non-understatement of the QR Code purpose on the last one.

Unlike the patient application, on this application, even thought in some of the tasks

Figure 5.8: User evaluation of the first functional doctor's application prototype: Completion ratio at each of the tasks regarding the doctor's application in a scale from 0 to 100, where 0 indicates a low completion/help request and 100 a high completion/help request.

help was requested all of them were successfully completed as possible to see in the figure, 5.8. Most participants have not had any problems executing any of the tasks.

Figure 5.9: User evaluation of the first functional doctor's application prototype: Bar chart illustrating the relation ratio between the number of tasks executed without errors and the tasks that were executed or not with errors from doctor's application where 0 means the non existence of errors and 100 errors reported by all of the participants.

Has a reflection from the analyzed metric previously, the figure 5.9 illustrates the error rate committed, from it, it is possible to notice that the number of committed errors was very low, with only two participants having errors on the third task. Both of them occurred due to the lack of notion regarding where they could see the association requests.

Once all the tests were done, the participants were asked to fill a QUIS based question-

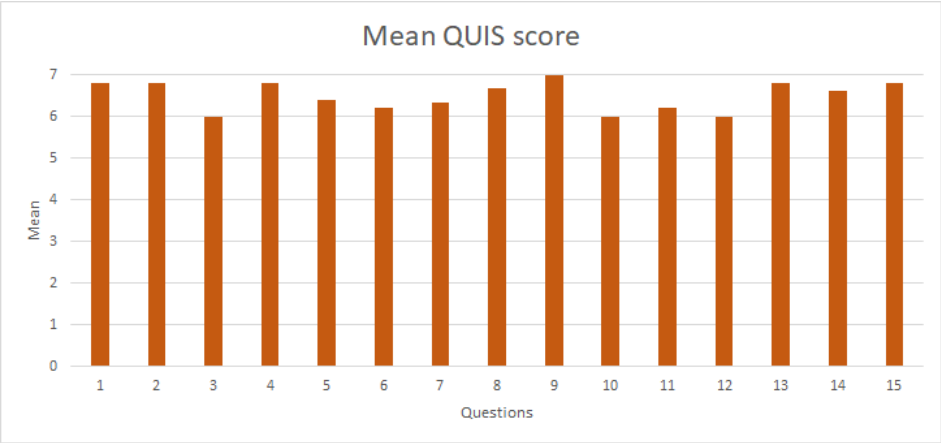

Figure 5.10: User evaluation of the first functional doctor's application prototype: Mean score registered at each of the questions presented into the questionnaire presented to the participants regarding the doctor's application where 0 means a terrible experience and 7 an great experience.

naire. From the answers it was possible to draw the chart presented in the figure, 5.10, which made possible to see that all the topics covered by QUIS questionnaires have reached an good score, being the lowest one 6 out of possible 7, meaning that all the score occurrences achieve at least 85% of the maximum possible score, which can be interpreted as a successfully designed interface.

These results allow an important conclusion about both applications, since both of them were designed using the same design identity and methodology, and considering that overall the results were better on the second evaluated application, this could mean that the participants quickly evolved and learned how to make use of the application. The experience that they have acquired on the test from the first application allowed them to have a better performance on the second.

5.5 Conclusions

From the preceding chapters, there was identified the need of a system composed by two applications, the previous chapter explained the process of developing the patient application, the improvement of the doctor–patient relationship implies the doctor requirements previously identified, 3.3 to also be addressed. In this context, this chapter, has started by presenting an architecture that would act as ground for the need features to be developed. Considering it, there have been conceptualized solutions to the majority of the identified problems in the form of an Adobe XD prototype. Then, a evaluation phase has then been run making use

of a focus group and Nielsen Heuristics to identify possible problems from which resulted a new set of requirements. The validated features have been replicated to a functional version, and new ones were developed to fill the identified gaps from the previous evaluation. The application was submitted to user evaluation and the results were then analyzed, resulting in the concept approval and some new identified problems. At this point the system became fully usable, a evaluation from all the work done is presented in the next chapter.

Chapter 6

Conclusion and Future Work

6.1 Overall results

Obesity is often called the pandemic of the 21st century. This condition has the particularity of aggravating and lead to an enormous set of other diseases. This work aimed to propose new methods that support obese patients and doctors in improving the treatments quality.

Having as base the first version of ObeOne together with other similar mobile applications that promote weight loss, it was possible to understand which were the potential opportunities and context of use from this mobile sector and the problems that those solutions try to solve.

In this dissertation, we present a system that aims to provide potential approaches to tackle some of the problems found on the support given to obese patients and doctors through two mobile applications. Both of the applications were developed considering an UCD approach, composed by analysis, design and evaluation of mock-ups until a functional prototypes were reached, as possible to see in Appendix 7.2 and Appendix 7.3. While, at the onset of this work, a direct access to obese patient feedback was planned, current limitations that derived from COVID-19 made it hard to accomplish and, therefore, we tried, as an alternative, to capitalize on the access to a psychiatrist and and psychologist with wide experience in working with these patients. This enabled obtaining some important characteristics of these patients through the professionals as proxy.

The mock-ups evaluation allowed the overall applications concept and planned features to be validated and to early diagnose ideas that would be very likely not to have success, considering that this project is a continuous work, it was possible to have a magnificent

understatement of the problems that have to be solved which allowed for the early mock-ups to already address a large part from all of them.

Currently, ObeOne is a materialization of a set of ideas that resulted by thinking out of the box regarding the weight loss process. All of this ideas have been validated by a series of tests and developed considering a modern and appealing interface that has been built all-around mental aspects and positive psychology with the goal of decreasing early demotivating chances. A first concept for voice interaction when registering meals to a more natural and potentially quicker way of interaction with the system was also made part of the system, allowing new grounds to be explored. Last but not least, a new infrastructure concept that aims to provide a large set of features and enhance the quality of doctor-patient, doctor-doctor relationship and clinicians workflow in general for instance respectively, an area where doctors can specify a set of guidelines that shall be followed by the patients to achieve success at each of the dimensions involved, a place where all the doctors involved in the treatment of patient have a common area where they can share important information about their patients and the possibility to schedule appointments on the application that will trigger a reminder on the application on the appointment day, were all the main aspects that have been thought and materialized into the form of a proof of concept.

In conclusion, the work made can be positively evaluated. The goals defined on 1.3 were accomplished. As for the requirements in section 3.3, there has been made work on the majority of them. Nevertheless, it is important to notice that the voice interaction and tabletop are only elementary proofs of concept due to time constraints.

Considering this, the development of this project allowed several aspects to be learned. Firstly, it modified our notion of obesity. Obesity is a much deeper problem than it looks and requires support in diverse fields commonly underestimated, such as psychological counseling.

The ideal treatment for obesity is still only a mirage. The effort needed to achieve almost effortless treatments in mHealth approaches to obesity is still very large. Still, ObeOne does his part on making it a bit more realistic and easy to handle.

6.2 Future work

Although ObeOne is already usable, there is still a large room for improvements, and it is still possible to have complete support on all of the dimensions. Some features shall be improved, new functionalities added, and a stronger verification among real users done. The following list of features can be enhanced, improving the overall system :

- Considering the current state of the system, it would benefit from tests and discussion with real users to understand the next steps to be done and have a final validation from the ideas purposed.
- Currently, there is the only functionality that allows voice interaction and is quite limited since it is only a proof of concept. Migrating both applications to a full Multimodality scenario would have a great impact on the overall system.
- The integration with new devices can be enhanced. There is currently an integration with ObeChair, and a proof of concept with ObeTabletop, which had awakened a strong interest by the clinicians. Developing a standard base for all devices to be added easily would also be a great improvement.
- Each patient has a different routine, which is very likely to affect the treatment. Collect data from a patients routine to create user profiles would allow the, for example, the recommended task pool to be different among different patient profiles.
- ObeOne at the moment is divided into two applications, one destined for doctors and the other for patients. However, there is no benefit to having two applications instead of one with the roles and privileges concept implemented. For example, a user with a patients role could only access screens related to patients, and however, if a user has the role of doctor, he could access all the doctors screens even though he has logged in the same place as the patient.
- Providing notifications to users regarding water intake, active time, or calories ingestion will allow users to have an extra reminder for a certain type of tasks that are important on this type of treatment.
- Considering that part of the system is now based on the cloud, this elevates privacy issues, investing in the user security mechanisms such as ciphers and data anonymization is a must before the application is released to audience universe.

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Chapter 7

Appendix

7.1 Nielsen heuristics

Avaliação Heurística

Escala de classificação A seguinte escala representa o grau de gravidade correspondente para com cada erro de usabilidade encontrado.

1. Não existe qualquer problema.
2. Problema cosmético, deve ser corrigido apenas se houver tempo de sobra.
3. Problema pequeno, problema que deve ser resolvido com baixa prioridade.
4. Problema grande, problema que deve ser resolvido com média prioridade.
5. Catástrofe, problema que deve ser resolvido com muita prioridade.

Heurísticas de avaliação As seguintes heurísticas (Heuristicas de Nielsen), permite classificar a interface e experiência de uso de ambas as aplicações, de modo a proceder à avaliação deve começar por ler as heurísticas a serem usadas, navegar livremente pela aplicação e quando se sentir pronto para responder, avaliar cada uma das heurísticas se possível juntamente com um comentário referente à mesma.

1. **Visibilidade do estado do sistema**
   Explicação: Esta heurística permite classificar o conhecimento que o utilizador tem sobre o seu estado na aplicação, ou seja, onde se encontra e que opções tem.

2. **Compatibilidade entre o sistema e o mundo real**
   Explicação: O sistema apresenta uma linguagem comum para com o utilizador.

3. **Liberdade e controlo do utilizador**
   Explicação: Permite avaliar se o utilizador tem em todos os momentos controlo total sobre as ações que executa sobre o mesmo.

4. **Consistência e padrões**
   Explicação: Permite caracterizar a consistência entre ecrãs e correspondência de ações.

5. **Prevenção de erros**
   Explicação: Permite avaliar se um utilizador antes de cometer algum tipo de erro é prevenido pela aplicação de o fazer.

6. **Reconhecimento em vez de memorização**
   Explicação: Permite avaliar se o sistema adota uma abordagem onde é dada preferência ao reconhecimento de informação do que à sua memorização.

7. **Eficiência e flexibilidade de uso**
   Explicação: Permite avaliar se a interface é útil independentemente do tipo de utilizador que se encontre a usá-la.

8. **Estética e design minimalista**
   Explicação: Esta heurística avalia a presença de informação de ruido não relevante para o uso da aplicação.

9. **Ajudar utilizadores a reconhecer, diagnosticar e recuperar de erros**
   Explicação: Permite avaliar quando um utilizador cometeu um erro e se é fornecida informação que auxilie na sua recuperação.

10. **Ajuda e documentação**
    Explicação: Permite avaliar se o sistema fornece ajuda caso o utilizador precisa de alguma.

7.2 Patient functional version

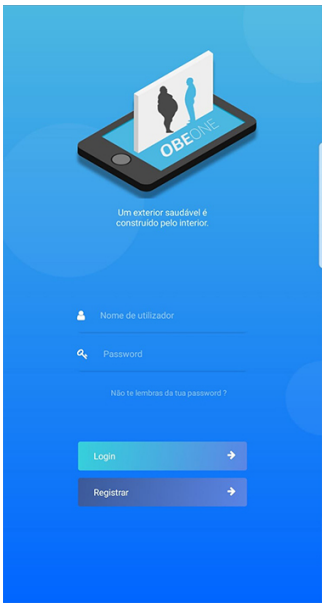

Figure 7.1: Login screen,.

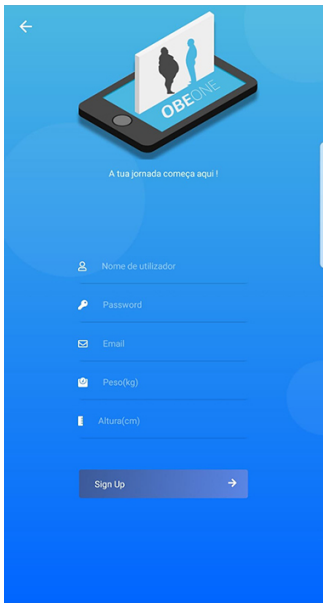

Figure 7.2: Register screen.

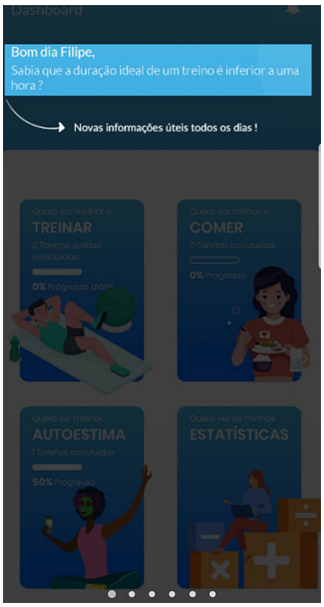

Figure 7.3: Tutorial screen.

Figure 7.4: Dashboard screen.

Figure 7.5: Dashboard screen scrolled.

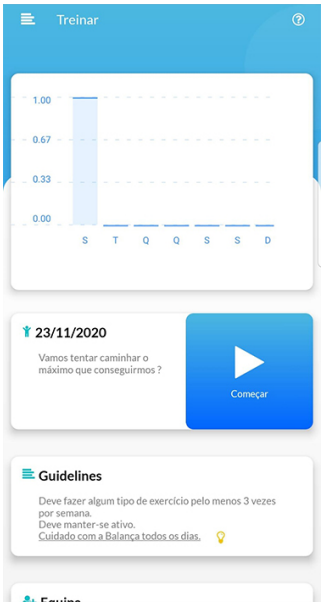

Figure 7.6: Physical module screen.

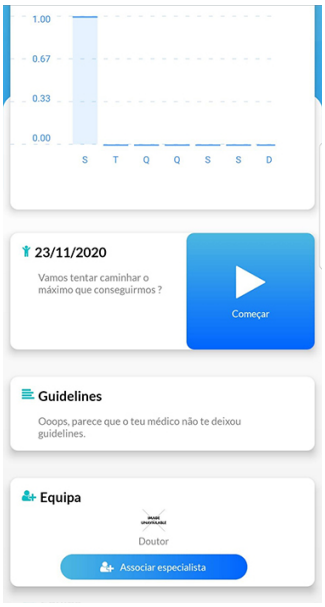

Figure 7.7: Physical screen scrolled.

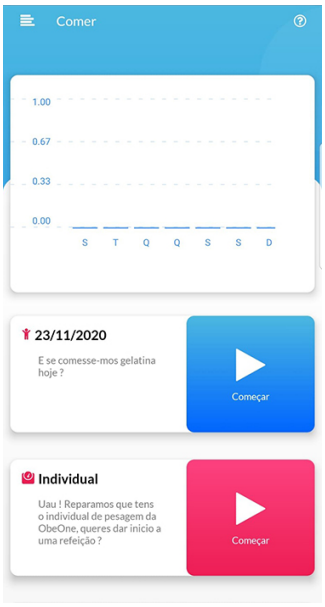

Figure 7.8: Nutritional screen.

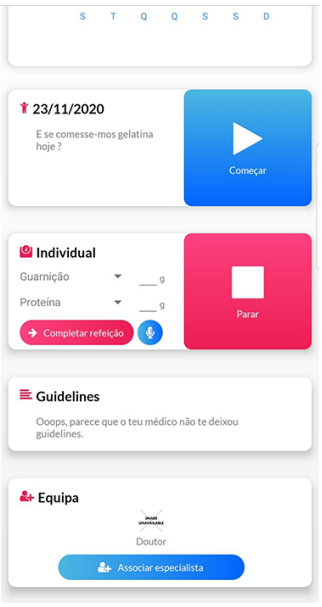

Figure 7.9: Nutritional screen scrolled.

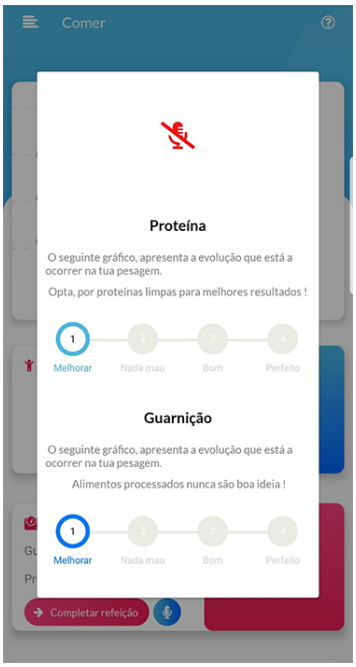

Figure 7.10: Voice iteration modal.

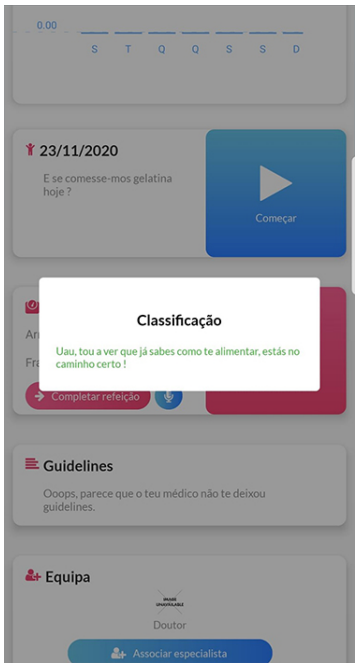

Figure 7.11: Meal classification modal.

Figure 7.12: Doctor association modal.

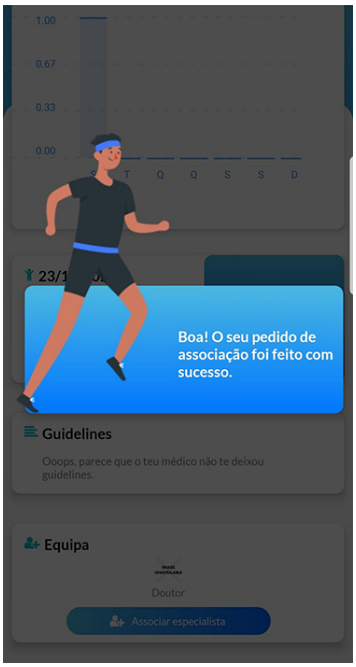

Figure 7.13: Doctor association feedback.

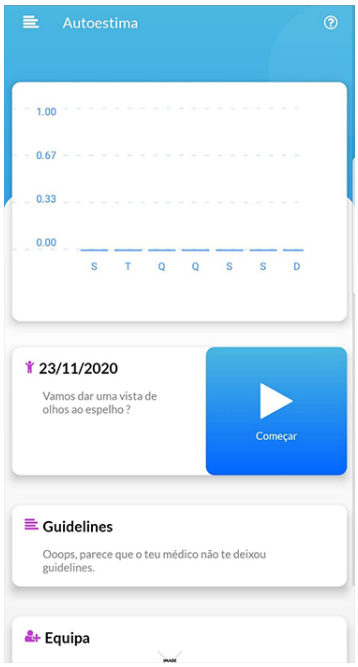

Figure 7.14: Mental module screen.

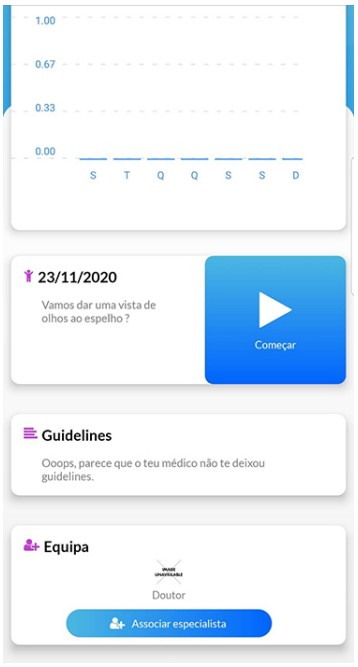

Figure 7.15: Mental screen scrolled.

Figure 7.16: Statistics screen.

Figure 7.17: Indicator graph.

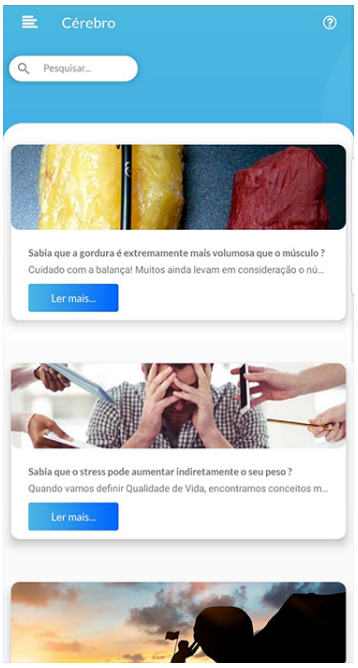

Figure 7.18: Articles screen.

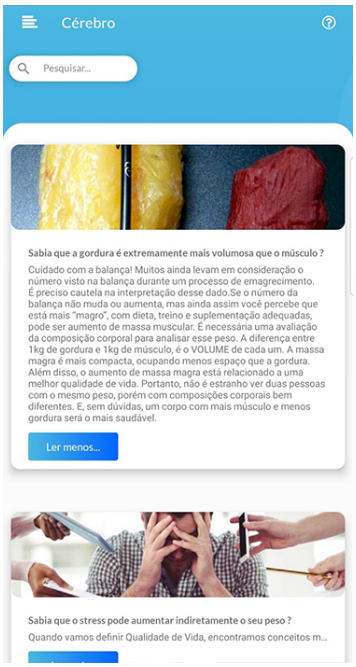

Figure 7.19: Expanded article.

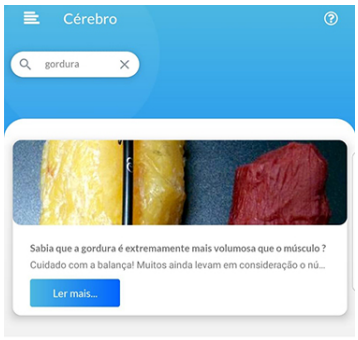

Figure 7.20: Searched article

Figure 7.21: Settings screen.

7.3 Doctor functional version

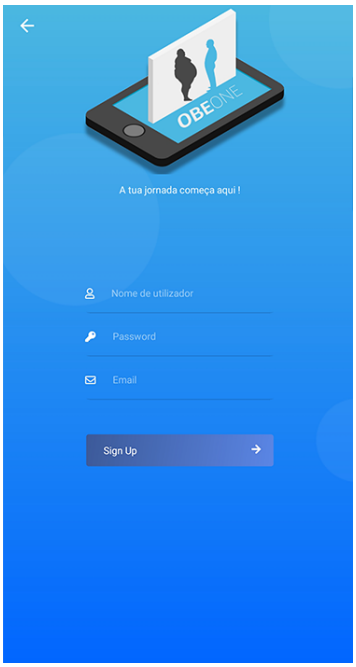

Figure 7.22: Register screen.

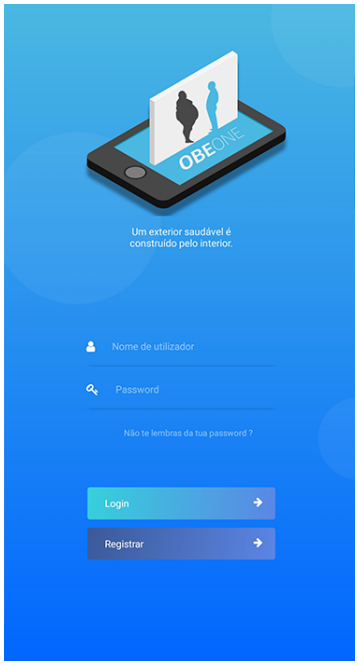

Figure 7.23: Login screen.

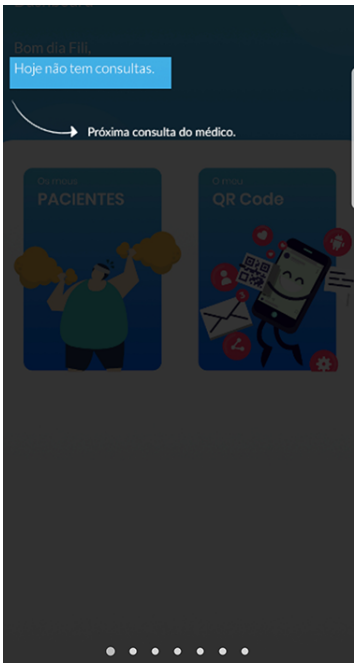

Figure 7.24: ObeOne Doctor application tutorial.

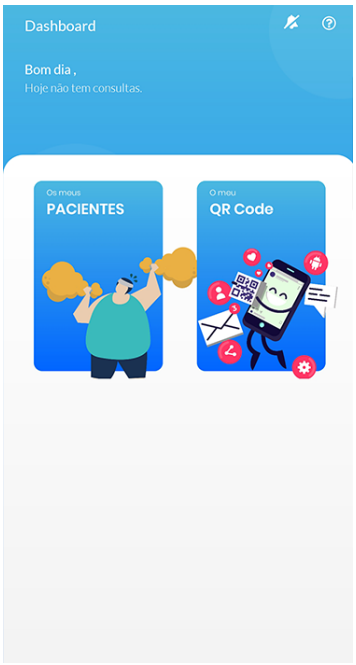

Figure 7.25: Doctors dashboard.

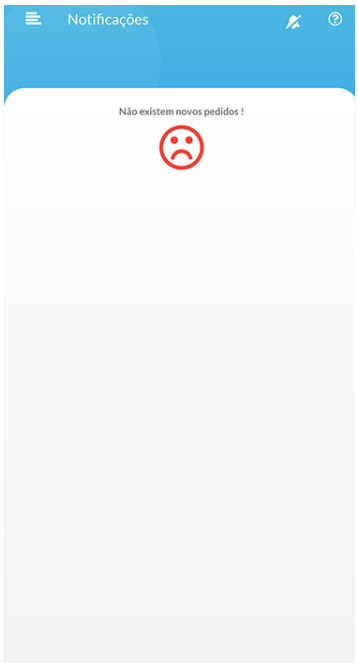

Figure 7.26: Dashboard without any new notification.

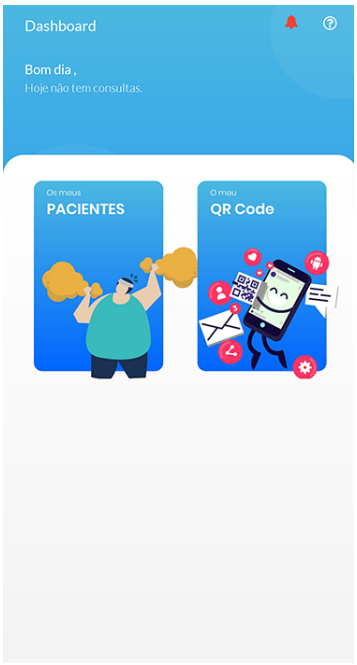

Figure 7.27: Dashboard with new notification.

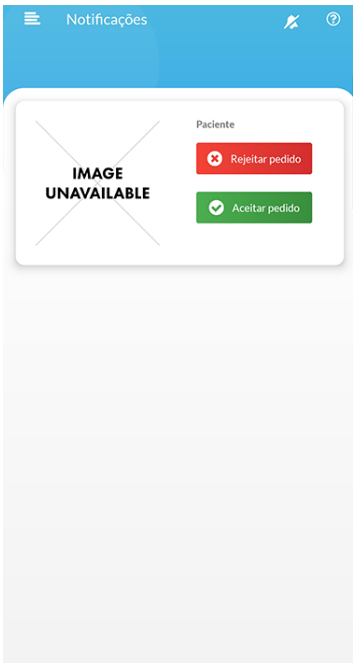

Figure 7.28: New association request..

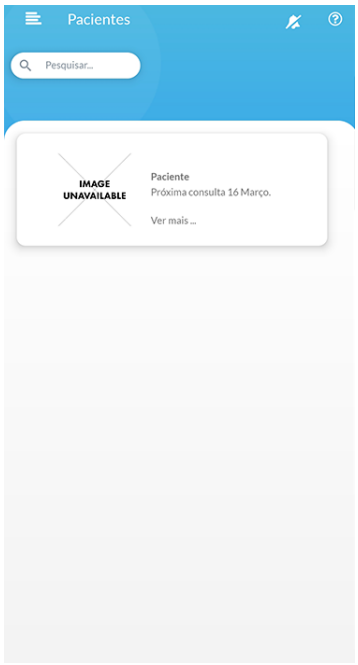

Figure 7.29: Patient list.

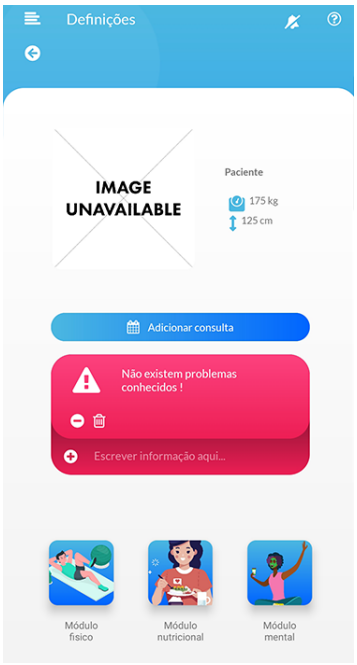

Figure 7.30: Patient information.

Figure 7.31: Appointments calendar.

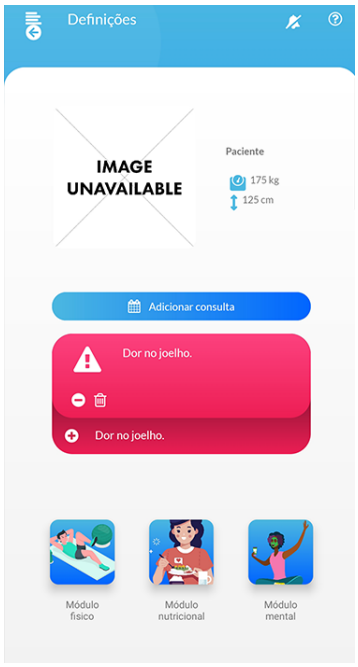

Figure 7.32: Addition of a problem.

Figure 7.33: Problems delete.

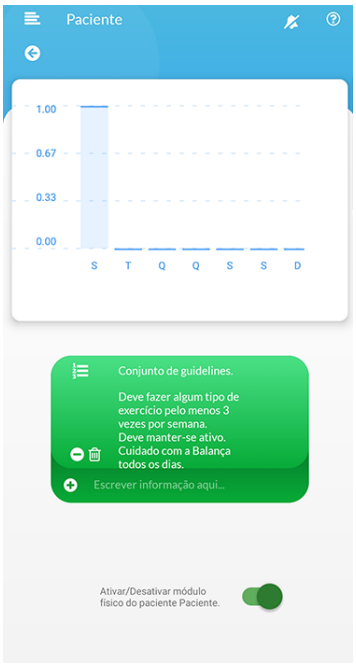

Figure 7.34: Physical dimension.

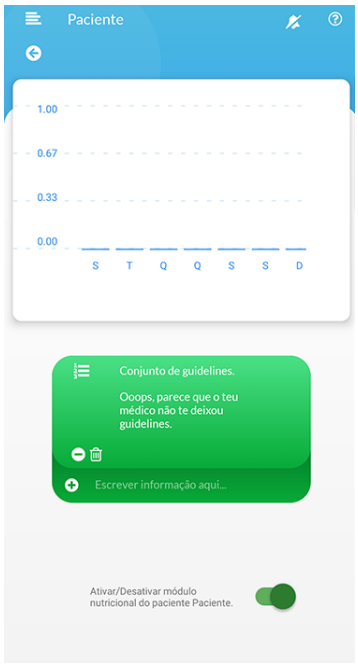

Figure 7.35: Nutritional dimension.

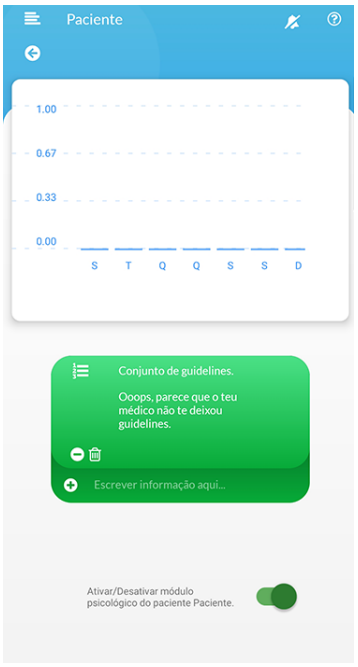

Figure 7.36: Mental dimension.

7.4 ObeOne patient application tasks

OBEONE
Teste com utilizadores

Objetivo: Navegar pelo ObeOne tendo em consideração todo o fluxo possível.

Tarefa 1	▪ Encontrar tutorial de utilização da ObeOne. ▪ Quantos módulos tem a ObeOne? --- Nada fácil | 1 | 2 | 3 | 4 | 5 | Muito fácil
Tarefa 2	▪ Qual é a primeira tarefa sugerida a nível físico? --- Nada fácil | 1 | 2 | 3 | 4 | 5 | Muito fácil
Tarefa 3	▪ Quais são as *guidelines* dadas pelo médico no módulo que visa a saúde mental? --- Nada fácil | 1 | 2 | 3 | 4 | 5 | Muito fácil
Tarefa 4	▪ Encontrar onde é possível usar o individual que permite fazer o registo da refeição a ser feita. ▪ Quais são os alimentos disponíveis? --- Nada fácil | 1 | 2 | 3 | 4 | 5 | Muito fácil
Tarefa 5	▪ Encontrar onde é possível consultar a estimativa de percentagem de água no corpo. Qual é a mesma? --- Nada fácil | 1 | 2 | 3 | 4 | 5 | Muito fácil
Tarefa 6	▪ Qual o terceiro artigo com caracter educacional a ser disponibilizado pelo sistema? --- Nada fácil | 1 | 2 | 3 | 4 | 5 | Muito fácil
Tarefa 7	▪ Qual é o estado da permissão para partilha de conteúdos automaticamente com o médico? --- Nada fácil | 1 | 2 | 3 | 4 | 5 | Muito fácil

Tarefa 8	▪ Faça a associação entre paciente e médico. Para isso, use o seguinte QR Code que lhe irá ser fornecido no momento da tarefa. --- Nada fácil 1 2 3 4 5 Muito fácil

Tarefa 9	▪ Experimente usar o modo de interação por voz no módulo nutricional, com a proteína Frango e o acompanhamento Arroz. As medidas serão automaticamente simuladas durante o processo. --- Nada fácil 1 2 3 4 5 Muito fácil

7.5 ObeOne patient application questionnaire

ObeOne

Questionário Pós Tarefas

Instruções: Agradecemos a sua colaboração na realização deste estudo, que tem por objetivo avaliar a *Interface de Utilizador* da ObeOne e, consequentemente, tentar melhorá-lo seguindo os critérios de *Usabilidade*.
A sua colaboração constitui um fator importante para o êxito desta avaliação, por isso solicitamos-lhe o preenchimento deste questionário, cujos dados serão usados com total anonimato apenas para fins científicos.

1. Dados pessoais

NI de utilizador: _____

(assinale com uma cruz as opções correctas)

Género: ☐Feminino ☐ Masculino

Idade: _____

2. Opinião geral sobre o sistema

Após a utilização do sistema e tendo em conta a sua avaliação final, assinale com uma cruz o círculo que melhor reflecte a sua opinião em relação à utilização do sistema. Caso considere que estas quantificações não são aplicáveis, escolha NA.

2.1. Opinião sobre a utilização do sistema *(assinale com uma cruz a opção que melhor corresponde à sua posição)*

No geral, estou satisfeito com o sistema.	Discordo totalmente	○○○○○○○	Concordo totalmente	NA
O sistema é de fácil utilização.	Discordo totalmente	○○○○○○○	Concordo totalmente	NA
Fui capaz de concluir as tarefas de forma rápida.	Discordo totalmente	○○○○○○○	Concordo totalmente	NA
Sinto-me confortável ao usar o sistema.	Discordo totalmente	○○○○○○○	Concordo totalmente	NA
Foi fácil de aprender a utilizar o sistema.	Discordo totalmente	○○○○○○○	Concordo totalmente	NA
Eu acredito, que consigo ser mais produtivo ao usar este sistema.	Discordo totalmente	○○○○○○○	Concordo totalmente	NA
O sistema devolveu-me mensagens de erro claras, que me mostram como resolver o problema.	Discordo totalmente	○○○○○○○	Concordo totalmente	NA
Quando cometi erros, o sistema permitiu-me recuperar de forma rápida e fácil	Discordo totalmente	○○○○○○○	Concordo totalmente	NA
A informação fornecida é clara.	Discordo totalmente	○○○○○○○	Concordo totalmente	NA
É fácil de encontrar a informação que preciso.	Discordo totalmente	○○○○○○○	Concordo totalmente	NA
A informação fornecida é fácil, ajudando-me a completar as tarefas.	Discordo totalmente	○○○○○○○	Concordo totalmente	NA
A organização da informação em cada ecrã é clara.	Discordo totalmente	○○○○○○○	Concordo totalmente	NA
A interface deste sistema é agradável.	Discordo totalmente	○○○○○○○	Concordo totalmente	NA

O sistema tem todas as funcionalidades e capacidades que eu esperava.	Discordo totalmente	○○○○○○○	Concordo totalmente	NA
No geral, estou satisfeito com o sistema.	Discordo totalmente	○○○○○○○	Concordo totalmente	NA

Se pretender pode deixar aqui outros comentários sobre a utilização do sistema:

_____
_____

3. Comentários finais

(Se tiver comentários finais, deixe-os aqui)

_____
_____

7.6 ObeOne patient application observer table

NI de utilizador: ______________________

OBEONE Guião do Observador

Tarefa	Nº cliques	Completou a Tarefa?	Tempo Máximo / Tempo observado (mm:ss)	Cometeu erros?	Sentiu-se perdido?	Solicitou ajuda	Grau de facilidade observada 1 – Nada Fácil 5 – Muito Fácil
1		Não / Sim	2m :____	Não / Sim / Muito	Não / Sim / Muito	Não / Sim / Qual	1 2 3 4 5
2		Não / Sim	2m :____	Não / Sim / Muito	Não / Sim / Muito	Não / Sim / Qual	1 2 3 4 5
3		Não / Sim	2m :____	Não / Sim / Muito	Não / Sim / Muito	Não / Sim / Qual	1 2 3 4 5
4		Não / Sim	2m :____	Não / Sim / Muito	Não / Sim / Muito	Não / Sim / Qual	1 2 3 4 5
5		Não / Sim	2m :____	Não / Sim / Muito	Não / Sim / Muito	Não / Sim / Qual	1 2 3 4 5

6		Não Sim	**2m** :____	Não Sim Muito	Não Sim Muito	Não Sim Qual	1 2 3 4 5
7		Não Sim	**2m** :____	Não Sim Muito	Não Sim Muito	Não Sim Qual	1 2 3 4 5
8		Não Sim	**2m** :____	Não Sim Muito	Não Sim Muito	Não Sim Qual	1 2 3 4 5
9		Não Sim	**2m** :____	Não Sim Muito	Não Sim Muito	Não Sim Qual	1 2 3 4 5

Observações

_____

_____

7.7 ObeOne doctor application tasks

OBEONE
Teste com utilizadores

Objetivo: Navegar pelo ObeOne tendo em consideração todo o fluxo possível.

Tarefa 1	▪ Encontrar tutorial de utilização da ObeOne. ▪ Quantos módulos tem a ObeOne? --- Nada fácil | 1 | 2 | 3 | 4 | 5 | Muito fácil
Tarefa 2	▪ Tem alguma consulta hoje? --- Nada fácil | 1 | 2 | 3 | 4 | 5 | Muito fácil
Tarefa 3	▪ Aceitei o pedido que fez previamente. ▪ Quantos pacientes tem? --- Nada fácil | 1 | 2 | 3 | 4 | 5 | Muito fácil
Tarefa 4	▪ Encontrar onde é possível ver os problemas do Paciente José. ▪ Quantos problemas o mesmo tem ? --- Nada fácil | 1 | 2 | 3 | 4 | 5 | Muito fácil
Tarefa 5	▪ Encontrar onde é possível adicionar *guidelines* ao paciente para o módulo físico. ▪ Qual é o estado do módulo? --- Nada fácil | 1 | 2 | 3 | 4 | 5 | Muito fácil
Tarefa 6	▪ Encontrar o seu QR Code de associação. ▪ Qual é a função do mesmo? --- Nada fácil | 1 | 2 | 3 | 4 | 5 | Muito fácil

7.8 ObeOne doctor application questionnaire

ObeOne

Questionário Pós Tarefas

Instruções: Agradecemos a sua colaboração na realização deste estudo, que tem por objetivo avaliar a *Interface de Utilizador* da ObeOne e, consequentemente, tentar melhorá-lo seguindo os critérios de *Usabilidade*.
A sua colaboração constitui um fator importante para o êxito desta avaliação, por isso solicitamos-lhe o preenchimento deste questionário, cujos dados serão usados com total anonimato apenas para fins científicos.

1. Dados pessoais

NI de utilizador: _____

(assinale com uma cruz as opções correctas)

Género: ☐Feminino ☐ Masculino

Idade: _____

2. Opinião geral sobre o sistema

Após a utilização do sistema e tendo em conta a sua avaliação final, assinale com uma cruz o círculo que melhor reflecte a sua opinião em relação à utilização do sistema. Caso considere que estas quantificações não são aplicáveis, escolha NA.

2.1. Opinião sobre a utilização do sistema *(assinale com uma cruz a opção que melhor corresponde à sua posição)*

No geral, estou satisfeito com o sistema.	Discordo totalmente	○○○○○○○	Concordo totalmente	NA
O sistema é de fácil utilização.	Discordo totalmente	○○○○○○○	Concordo totalmente	NA
Fui capaz de concluir as tarefas de forma rápida.	Discordo totalmente	○○○○○○○	Concordo totalmente	NA
Sinto-me confortável ao usar o sistema.	Discordo totalmente	○○○○○○○	Concordo totalmente	NA
Foi fácil de aprender a utilizar o sistema.	Discordo totalmente	○○○○○○○	Concordo totalmente	NA
Eu acredito, que consigo ser mais produtivo ao usar este sistema.	Discordo totalmente	○○○○○○○	Concordo totalmente	NA
O sistema devolveu-me mensagens de erro claras, que me mostram como resolver o problema.	Discordo totalmente	○○○○○○○	Concordo totalmente	NA
Quando cometi erros, o sistema permitiu-me recuperar de forma rápida e fácil	Discordo totalmente	○○○○○○○	Concordo totalmente	NA
A informação fornecida é clara.	Discordo totalmente	○○○○○○○	Concordo totalmente	NA
É fácil de encontrar a informação que preciso.	Discordo totalmente	○○○○○○○	Concordo totalmente	NA
A informação fornecida é fácil, ajudando-me a completar as tarefas.	Discordo totalmente	○○○○○○○	Concordo totalmente	NA
A organização da informação em cada ecrã é clara.	Discordo totalmente	○○○○○○○	Concordo totalmente	NA
A interface deste sistema é agradável.	Discordo totalmente	○○○○○○○	Concordo totalmente	NA

O sistema tem todas as funcionalidades e capacidades que eu esperava.	Discordo totalmente	○○○○○○○	Concordo totalmente	NA
No geral, estou satisfeito com o sistema.	Discordo totalmente	○○○○○○○	Concordo totalmente	NA

Se pretender pode deixar aqui outros comentários sobre a utilização do sistema:

_____
_____

3. Comentários finais

(Se tiver comentários finais, deixe-os aqui)

_____
_____

7.9 ObeOne doctor application observer table

NI de utilizador: ______________________

OBEONE Guião do Observador

Tarefa	Nº cliques	Completou a Tarefa?	Tempo Máximo Tempo observado (mm:ss)	Cometeu erros?	Sentiu-se perdido?	Solicitou ajuda	Grau de facilidade observada 1 – Nada Fácil 5 – Muito Fácil
1		Não ☐ Sim ☐	2m : ____	Não ☐ Sim ☐ Muito ☐	Não ☐ Sim ☐ Muito ☐	Não ☐ Sim ☐ Qual ☐	1 2 3 4 5
2		Não ☐ Sim ☐	2m : ____	Não ☐ Sim ☐ Muito ☐	Não ☐ Sim ☐ Muito ☐	Não ☐ Sim ☐ Qual ☐	1 2 3 4 5
3		Não ☐ Sim ☐	2m : ____	Não ☐ Sim ☐ Muito ☐	Não ☐ Sim ☐ Muito ☐	Não ☐ Sim ☐ Qual ☐	1 2 3 4 5
4		Não ☐ Sim ☐	2m : ____	Não ☐ Sim ☐ Muito ☐	Não ☐ Sim ☐ Muito ☐	Não ☐ Sim ☐ Qual ☐	1 2 3 4 5
5		Não ☐ Sim ☐	2m : ____	Não ☐ Sim ☐ Muito ☐	Não ☐ Sim ☐ Muito ☐	Não ☐ Sim ☐ Qual ☐	1 2 3 4 5

6		Não Sim	**2m** :____	Não Sim Muito	Não Sim Muito	Não Sim Qual	1 2 3 4 5

Observações

_____

_____