

HELLENIC MEDITERRANEAN UNIVERSITY

DEPARTMENT OF ELECTRICAL AND COMPUTER ENGINEERING



BACHELOR THESIS

**IMPLEMENTATION OF A MOBILE APP
FOR PSYCHO-EMOTIONAL ASSESSMENT**

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ABSTRACT

Cancer is one of the most common chronic diseases, and the second leading cause of death in the developed countries. During treatment patients face several side effects, which are painful both physically and emotionally. This results to the need of seeking psychological support and constant monitoring of their psychological and physical condition. Diagnosis, follow-up and treatment, consist a great interest to the research field. The rapid development of the technology has significantly improved the treatment of cancer as its goal is early diagnosis and finding the right treatment. That process depends mainly on the type and the stage of the cancer and on the continuous monitoring of the patient throughout recovery. As technology and medicine evolve at a rapid pace, the need for better quality of life is growing. In this context the “mobile health” field is being added. This term refers to the variety of applications, which have been implemented for smartphones or wearables that are powered by user data. Such systems are either used exclusively by the patient as a personal health record or as an interface between the patients and the medical staff. This process aims in a model that focuses on the patient and the way they handle their health status. In this thesis we will deal with the implementation of a questionnaire of the mobile application MyPal, with which the user will rate his/her emotional state and then this will be visualized. Finally, special emphasis has been placed on the interface of the application, as well as in the usability, as it targets at the elderly and mostly patients are unfamiliar with mobile technology.

ΠΕΡΙΛΗΨΗ

Ο καρκίνος είναι μία από τις πιο διαδεδομένες χρόνιες ασθένειες, αποτελώντας την δεύτερη αιτία θανάτου στις ανεπτυγμένες χώρες. Κατά την διάρκεια της θεραπείας οι ασθενείς έρχονται αντιμέτωποι με αρκετές παρενέργειες, οι οποίες είναι επίπονες τόσο σε σωματικό όσο και σε ψυχοσυναισθηματικό επίπεδο. Απόρροια όλων αυτών είναι η ανάγκη για αναζήτηση ψυχολογικής υποστήριξης και η συνεχής επιτήρηση της ψυχολογικής και σωματικής τους κατάστασης. Η διάγνωση, η παρακολούθηση και η θεραπεία αποτελούν τεράστιο ενδιαφέρον για τον τομέα της έρευνας. Η ραγδαία ανάπτυξη της τεχνολογίας έχει βελτιώσει σημαντικά την αντιμετώπιση του καρκίνου καθώς στόχος της είναι η έγκαιρη διάγνωση, η εύρεση της κατάλληλης θεραπείας, η οποία εξαρτάται από τον τύπο καρκίνου και το στάδιο, και η συνεχής παρακολούθηση του ασθενούς καθ' όλη την διάρκεια της θεραπείας και της ανάρρωσης. Καθώς, λοιπόν, οι κλάδοι της πληροφορικής και της ιατρικής εξελίσσονται με ρυθμούς γεωμετρικής προόδου, η ανάγκη για καλύτερη ποιότητα ζωής γίνεται όλο και μεγαλύτερη. Στο πλαίσιο αυτό έρχεται να προστεθεί ο τομέας της «κινητής υγείας» (mobile health). Με τον όρο αυτό αναφερόμαστε στην χρήση εφαρμογών που έχουν υλοποιηθεί για κινητά τηλέφωνα (smartphones) ή για φορετές συσκευές (wearables), οι οποίες τροφοδοτούνται από δεδομένα τα οποία προέρχονται από τον ίδιο τον χρήστη ή μέσω αισθητήρων. Χρησιμοποιούνται είτε αποκλειστικά από τον ασθενή ως προσωπικοί φάκελοι υγείας είτε υπάρχει δυνατότητα αλληλεπίδρασης του ασθενούς με το ιατρικό προσωπικό. Η διαδικασία αυτή στοχεύει σε ένα μοντέλο που ως επίκεντρο έχει τον ασθενή και στον τρόπο με τον οποίο διαχειρίζεται την κατάσταση της υγείας του. Τα δεδομένα που αποθηκεύει ένας ασθενής ποικίλλουν. Για παράδειγμα, τις τελευταίες δεκαετίες έχουν δημιουργηθεί εφαρμογές, οι οποίες διαχειρίζονται πληθώρα πληροφοριών σχετικά με την υγεία του, την φυσική του κατάσταση, την συμπεριφορά του, την φαρμακευτική αγωγή που ακολουθεί καθώς και την ψυχο-συναισθηματική του κατάσταση. Ιδιαίτερη έμφαση δίνεται στο τελευταίο, δεδομένου πως ο καρκίνος είναι μία ασθένεια με τεράστιο ψυχολογικό κόστος τόσο για τον ίδιο τον ασθενή αλλά και την οικογένεια του. Οι

ψυχολογικές προκλήσεις οδηγούν στην ανάγκη για αναζήτηση ανακούφισης μέσα από σε συνεργασία με αρκετές ειδικότητες όπως ιατρικό προσωπικό, ψυχολόγοι κτλ.

Στο πλαίσιο αυτό, έρχεται να προστεθεί το ερευνητικό χρηματοδοτούμενο πρότζεκτ MyPal. Το MyPal έχει ως στόχο να παρέχει παρηγορητική φροντίδα σε ασθενείς που πάσχουν από κακοήθειες καθώς και στα άτομα τα οποία τους φροντίζουν. Πιο συγκεκριμένα, μέσω της καταγραφής δεδομένων από τον ίδιο τον χρήστη ή της οικογένειας του θα είναι σε θέση να προσφέρει μία σειρά από ενέργειες για την έγκαιρη παρακολούθηση συμπτωμάτων, να ενισχύσει τον ρόλο του ασθενούς σε αποφάσεις που αφορούν την φροντίδα του αναπτύσσοντας ένα μοντέλο το οποίο στοχεύει στον ενεργητικό ρόλο του ασθενούς στην φροντίδα του με στόχο την ενδυνάμωση του και την καλύτερη ποιότητα ζωής εν γένει.

Σε αυτήν την πτυχιακή θα ασχοληθούμε με την υλοποίηση ενός ερωτηματολογίου της κινητής εφαρμογής MyPal, όπου ο ασθενής θα βαθμολογεί την συναισθηματική του κατάσταση ανά βδομάδα. Το ερωτηματολόγιο που υλοποιήθηκε αποτελείται από πέντε (5) ερωτήσεις σχετικές με το στρες, την κατάθλιψη, τον θυμό, την θλίψη και το πόση βοήθεια χρειάστηκε την εκάστοτε εβδομάδα. Ο χρήστης μέσω μίας κλίμακας θερμομέτρου βαθμολογεί την συναισθηματική του κατάσταση από το μηδέν (0) έως το δέκα (10). Επιπλέον, θα είναι σε θέση να ανατρέξει σε προηγούμενες μετρήσεις του ή της εκάστοτε εβδομάδας που διανύει αφού το σύστημα μας αποθηκεύει τις μετρήσεις για κάθε μία από τις απαντήσεις του με σκοπό την καταγραφή ιστορικού. Καθώς μιλάμε για ασθενείς που πάσχουν από καρκίνο, αξίζει να αναφερθεί και η αποστολή ειδοποιήσεων / υπενθυμίσεων στον ασθενή με σκοπό να του υπενθυμίζει να ολοκληρώσει το ερωτηματολόγιο για την εβδομάδα στην οποία βρίσκεται αλλά και να συνειδητοποιήσει πως δεν είναι μόνος σε όλη αυτήν την διαδικασία που υποβάλλεται. Παράλληλα, το σύστημα δεν είναι αυστηρό ως προς τον χρήστη αφήνοντας του να κάνει περιθώρια λάθους και μη δημιουργώντας του σύγχυση. Τέλος, ιδιαίτερη έμφαση έχει δοθεί στην διεπαφή της εφαρμογής καθώς και στην ευχρηστία της, διότι απευθύνεται σε ηλικιωμένους και ως επί τω πλείστον μη εξοικειωμένους με την κινητή τεχνολογία ασθενείς.

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1 Introduction

Cancer is a chronic disease that constitutes a huge concern of research through the years since its first appearance. There are different types of cancer with the most common the breast cancer in the female population and the prostate cancer in men. [1] The most important and time-consuming process for cancer patients is to cope with the disease and learn how to take care of their health. To achieve this, they must discover new techniques about how to handle it, inform themselves about treatment's side effects and keep a balance between the life before and after cancer.

As medicine and technology evolve, the need for better quality of life becomes higher. Therefore, the whole care model of doctor – patient changes radically due to modern health system structure, that includes an active role of the patient who is responsible for their decisions [2]

Health care systems are formed on top of electronic applications which aim at an enhanced treatment through the remote monitoring by wearable applications or mobile phones. Patients use their cell phones in order to communicate with doctors. They exchange either medical or mental information. Efficient patient-clinician contact during the treatment is important for symptoms management and mental wellbeing. [3]

MyPal is a recently funded research project that targets on cancer patients in order to offer palliative care. MyPal harness technical advancements in digital health to support patients and clinicians through the implementation of advanced electronic patient-reported outcome (ePRO) systems that allow reporting data related to disease, treatment, quality of life (QoL) and the general well-being of cancer patients. Through this, the patient and his/her family acquire an active role in the treatment process. Furthermore, MyPal seeks to enable patients and / or their caregivers to identify and express the symptoms and health condition more precisely. Providing this knowledge to the healthcare specialists (such as doctors, psychologist etc.) throughout the whole time of the disease will brace the prospective of a patient-centered treatment and help the clinicians to figure out the treatment's efficacy. As a result, the medical staff understand better the concerns of patients and their caregivers offering them the palliative care they need. Clinical trial will be conducted in two separate patient populations, adults who suffer

from hematologic malignancies and children with solid tumor or hematologic malignancies, across the Europe. [4]

This thesis investigates a psych-emotional questionnaire and implements it as a mobile user-friendly application for elderly patients with malignancies, focused on their psycho-emotional evaluation by logging the responses of the questionnaire through a simple scale thermometer.

1.1 Cancer

Cancer is a disease characterized by abnormal cell growth and division. Cancer cells grow uncontrollably and form a tumor known as a malignant. The tumor gradually becomes larger and can invade adjacent tissues and organs. Cancer cells can also abandon the tumor and spread to other areas of the body. [5] Although survival rates are increasing, cancer is the number two leading cause of death. [6]

Various environmental and lifestyle factors can disrupt normal genes and turn them into genes that allow cancer to grow. Many genetic disorders that lead to cancer are the result of smoking, poor diet, long term sun exposure or exposure to carcinogens. Some genetic disorders are inherited. However, the presence of an inherited genetic disorder does not always mean it will result in cancer, although it is associated with increased risk of developing the disease. [7]

Also, some viral infections (Hepatitis B, Hepatitis C, HIV) maximize the risk of the disease. Scientists, however, have declared that there are factors that are individual and external. For example, excessive alcohol consumption, obesity, smoking etc. belong to individual factors. [8]

The external ones are those that do not have to do with people's lifestyle and habits. For example heredity, genetic predisposition, radiation, environmental pollution etc. [9]

Cancer can affect anyone, regardless of gender, nationality or age. Today millions of people around the world live with the disease or have cured it. [10] The earlier it's detected and treated, the better the chances of a successful treatment.

In conclusion, cancer is not a contagious disease, it does not spread to a healthy person.

1.1.1 Types of cancer

Tumors are either benign or malignant. Benign tumors, whose cells are surrounded by connective tissue, are not large, they do not invade the surrounding tissues and do not spread to other parts of the body. In general, they do not cause serious damage to the body, unless they put pressure on vital organs due to their size. In contrast, malignant tumors show a difference in morphology than normal. They invade in neighboring tissues and can transport to other parts of the body through the blood or lymph, forming other tumors. That phenomenon is called metastasis [5] Depending on the body area there is a specific type. Each cancer has different symptoms, different treatment and therefore, each type is considered a different case.

The most common cancer types worldwide for both women and men are for 2018 [11]:

- **Lung:** 12.3%
- **Breast:** 12.3%
- **Colorectal:** 10.6%
- **Prostate:** 7.5%
- **Stomach:** 6.1%

1.1.2 Causes of cancer

Mutations can cause cancer. Errors in DNA occur every time a cell divides and make two new cells of itself. That process happens in our body every day, but sometimes a mistake it is possible to happen, affecting a functional region of the genome, they called genes.

Apart from the genetic associations of cancer, a common risk factor is the daily lifestyle. Smoking, alcohol consumption and lack of physical exercise are activities that introduce harmful cancer-causing cells into the body, known as carcinogens. [8] [12]

Substances like tobacco and alcohol are dangerous habits, which are directly linked to cancer. Researches have shown that people who are chronic smokers are more likely to have oral cancer. The combination of tobacco and alcohol consumption has multiple

effects on the growth of certain types of cancer such as laryngeal, esophageal and liver.[13]

The abstinence of proper nutrition in modern lifestyle is a high-risk factor of developing cancer. Research has shown positive results in groups of people who followed the pattern of healthy diet. Protein intake help shield the body and reduce the substances that are responsible for gastric cancer. [14]

The habitat conditions are also responsible for the appearance of cancer. Environments with intense radioactivity affect the onset of the disease in a future time. Moreover, climate change and ozone depletion are factors that increase the temperature and consequently increase the absorption of the ultraviolet rays. [14][15] Exposure to the sun during the summer months is quite harmful to the human body. Continuous and extensive sun exposure is responsible for the development of skin cancer. Skin cancer is a common type of cancer, as it is the third common cancer worldwide. [16]

1.1.3 Cancer management

The next step after diagnosis is the implementation of the treatment. The planning of the treatment depends on the type, the stage of the disease but also the patient. There methods are:

- **Surgery:** is the process where doctors remove a piece or the whole tumor from patient's body. [17]
- **Radiation:** is the treatment that uses x-rays in order to fight the cancer cells. It is categorized as external beam and internal. The external is used by machines and the internal is the type of radiation that is added to your body through drugs. Both radiations are used for a specific part of the body. [18]
- **Chemotherapy:** is the treatment that substances like pills are used in order to fight the cell that grow fast. Sometimes it is a method that causes side effects such as hair loss, pain, dizziness, nausea etc. precisely because it attacks on cells that

grow quickly and can be healthy. Chemotherapy can be inpatient or outpatient. [19]

- **Stem Cell Transplant:** the procedure in which new stem cell take the place of the ones that destroyed from a cancer treatment. [20]
- **Hormone Therapy:** is the medication that slow or prevents the raise of cancer cells. [21]
- **Personalized Medicine:** is a concept of understanding that each person is a unique gene system. By that patients that belongs to a certain group may follow each one of them different treatment based on their genetic profile. [22]
- **Targeted therapy:** is a treatment that uses medication that aim to certain genes. Researchers recognize the genetic variations that make a tumor evolve in order to create a specific treatment. A target for this treatment will be a protein that found in the cancerous cells. When a mutation is detected, researchers create the drug that addresses to that certain mutation. [23]

All the above can cause fatigue, pain, exhaustion and psychological damage in the cancer patient's life. Treatments creation is a multidimensional process that combine medication as well as a long-term patient follow-up plan both medically and psychologically.

1.1.4 Cancer: The psychological perspective

Psychological effects are a common phenomenon for patients who suffer from chronic diseases and especially for cancer survivors. Cancer diagnosis may cause changes in emotional state since it involves a series of losses, a loss of self and life as one knew it until now. The patient who is diagnosed with cancer feels that has to deal with many issues. Not only the symptoms of the disease but also the side effects of the treatment. There are main changes that affect the mentality like the emotional swings, changes in the relation to himself / herself and the other around him / her and also changes in the appearance, possibly due to the side effects of the treatment or the symptoms of the disease. If the patient finds it hard to adapt, he / she is more likely to have psychological effects. The most common ones that need support are the poor quality of life, disorder in the social and interpersonal relationships, in sexuality and in workplace. [24]

After the therapy the person may feel sadness, anger, lack of joy. For some people these emotions diminish over time but for other may intensify. The treatment process can be aggravating for the patient. Mood swings, fatigue, pain, eating disorders, lack of interest for activities are result of the therapies. Understanding and recognizing a person's emotional state as well as monitoring how his or her emotional state is shaping helps in treatment management. Lack of diagnosis of the high rates of distress puts in danger the whole treatment and reduces the quality of life. Psychological tests are an important component of integrated cancer treatment. [25][26] The acceptance, the communication of these feelings with the family and the search for help from psycho-emotional interventions are part of the recovery of mental balance.

Cancer is a multidimensional and subjective disease, which means that every person fights it with different way. The role of psychology is very important and can facilitate the process of treatment with support to the patients and the care giver.

1.1.5 The impact of psycho-emotional empowerment

According to the European Network on Patient Empowerment, empowerment is a mechanism that helps people gain power by solving problems, making decisions, distinguishing medical and social care and self-management treatment. [27] Moreover, the World Health Organization describes the term of empowerment as “a process which gives people a great control on deciding and acting for their own health and should be treated as both individual and a mechanism of society”. [28]

Cancer patients often experience both physical and emotional side-effects that affect their daily life. When coping with a long-term disease, except from physical exhaustion, mood transitions can occur. Over the last decades, the empowerment of patients personally and emotionally is a key factor that related to quality of life. Involving a patient in the treatment planning process and equipping him / her with the appropriate educational material, so that can act properly in any situation makes him / her feel useful and gives a psychological boost.

In the past years, patients depended on the medical staff and did not the ability to inform themselves about the disease. Over the years, the classic model of patient – doctor has been changed and the health care became more personalized and patient centered. This new model includes the field of psychology, by introducing a term of empowerment in health care system.

The empowerment comes from a variety of valid information from specialists, the active role of the patients in clinical decisions, the psychological support, the learning processes of managing emotions and symptoms. It is essentially a process in which the patient is able to acknowledge and manage the condition that he / she is in. [29]

Empowerment also leads to the ability of the individual in self-management. Self-management contributes to the active role of the patient’s health. Patients with the necessary knowledge are able to prepare themselves emotionally. [30]

Nowadays, empowerment has been established in the biomedical applications as an approach which provide educational material related to clinical care in order to strength the decision making and the awareness [31] , interaction between patients and doctors

or caregivers, evaluation of the general mental health and well-being, drug recording and outpatient monitoring through wearables or data tracking. [32]

During the participation in the whole process from diagnosis until the end of the treatment, patients learn how to manage emotional transitions and the overall well-being.

1.1.6 Psycho-emotional mobile health tools

Chronic diseases have a major impact on mental health. Cancer has a profound psychological and psychosocial effect on both patients and their family that are followed by a series of alterations both physically and mentally, affecting person's life. Recognizing the fact that many cancer patients deal with emotional instability, for example rapid changes of mood, or psychopathological disorders, such as depression symptoms, is highly necessary for clinicians to offer coordinated and systematic oncological treatment psychological support. [33] During the whole process of cancer care individual and their family often share the need for mental and psycho-social support. Although that the needs of psychological instability is high, healthcare systems cannot always provide that kind of support to their patients and caregivers. [34]

Evidence from clinical research have shown that taking a caregiving role can be overwhelming and stressful. As a result that can cause effects in the care experience such as distress, health behaviors, mental disorders or/and physical illness. [35]

Although cancer is a disease that cause a lot to the mental health if the psychological treatments provided early and systematically can decrease the amount of stress and increase the quality of life of both cancer patients and their family. Research also points to a psycho-oncology significance in assisting people receive effective treatment. [36]

Furthermore, it is proposed that introducing the psycho-emotional management to patients immediately after diagnosis will help them recover from their stress and improve their quality of life by early detection. [36] [37]

Over the past few years, more and more mobile applications have been implemented including features with psychological parameters. Psycho-emotional tools can be divided into categories [38]:

- **Self-management:** Users record their own vital data and / or emotion condition.
- **Chat-bot apps:** Applications where patients having a conversation with a software system and seek for help about their mental health.
- **Emotional Tracking:** Users can record their emotions themselves or through wearables, interact with professional and receive support.
- **Skill Training:** They are apps for helping cope with disorders like anxiety and stress by specific techniques.
- **Supported care:** Users can interact with an expert in order to receive help.

Clinicians are moving towards to family-centered healthcare services as effective coping mechanisms that can assess the patient outcomes related to his/her well-being. MyPal recognize the importance of cancer care and the correlation of it with the well-being in general.

1.2 Mobile applications

With the massive rise of technology during the recent years the time where mobile devices are at the forefront of the global market has come. Mobile phones give us the opportunity for quick and easy access to websites and applications.

Due to this great demand, there is given space for technological development, in order to fill the needs of each service; therefore there is a corresponding mobile application for a specific necessity.

Mobile applications are small software programs with certain functionality that are designed to serve specific market demands. They are called mobile applications, because we can use them via our mobile phones, tablets or smartwatches. Thus, if a user wants to download an application, they can do it easily through the Google Playstore or the App Store (iOS).

Mobile applications can be classified into three well—defined categories:

- **Native Apps:** A Native application is an application that has been implemented in a specific way to "run" on devices with the corresponding operating system. For example, Android devices can run apps that are written in Android programming.
- **Hybrid Applications:** In this category, there is a combination of native and web applications. These applications are compatible with all mobile OSes.
- **Web Applications:** These are programs available to users through a browser, such as Opera / Google Chrome / Mozilla etc.

1.2.1 Mobile health

We live in the era where portable devices are equipped with features that a decade ago seemed impossible. The main reason that they are considered “everyday devices”, is the fact that they record and process data with great easiness. There are plenty of applications that have been designed for medical problems and due to that has been created the term mhealth. This term is referred to health services which are provided using portable devices such as mobiles, tablets or wearable devices, usually are used by doctors and/or patients for monitoring, collecting and sharing medical data and communication between health providers and patients. The ease of internet access, the portability and the fact that the majority of the population is familiar with the usage of a mobile device, are the crucial factors that compose a strong medical tool. [39][40]

Mobile health could boost the productivity of medical services and therefore could even upgrade the efficiency of the health care system. [3] mHealth applications continue to improve their features as the technology rises. [41]

Through their functionalities, mhealth applications can be imported in all the “steps” of the health system, such as the diagnosis or the tracking of the data. Because of its growth, it is now able to create a patient-centered model in the field of medicine, in which the patient is able to manage their own condition by monitoring the symptoms

and his vitals at any moment with the doctor's observation. [42] These services help the patients with self-management and self-monitoring practices in order to learn innovative ways to support their well-being. [43]

1.2.2 Utility of a mobile health tool

MHealth is a combination of economical and medical revolution that day after day change the health foreground. [44] Due to that all the medical data can be visualized on the phone screen of the patient without any paper processes including doctor's appointments for routine prescription. According to mobile health patients are allowed to have access in their health record from their mobile phones / tablets. [45]

By utilizing telehealth technology, physicians can keep up with patients. Every mhealth app targets on a different group of patients.

There are applications that stands for medical education, prevention, self-management, wellness and symptoms tracking especially for patients who suffer from chronic diseases. Applications from any of these categories keep vital, psycho-emotion or personal data that has a value for patients most of the times.

1.2.3 Mobile app services

Mobile technology is also widespread in medical staff, which uses telemedicine and e-health programs in order to inform the patients and their family, monitor their health condition, gather all the useful data remotely and create a follow-up with the treatment.

With mobile health, for each disease stage, there is the appropriate app that can help. There are certain features that distinguish m-health from the other apps. For example, mhealth applications have the ability to collect behavioral and vital data with great validity using surveys and questionnaires in order to implement them in psychological researches. [46]

Recent applications offer real-time recording data, as well as monitoring prescriptions. Remote monitoring aims at reducing the health cost and patient's self-condition

control. [46]

Furthermore, they aid in the empowerment of the patients, especially to those who cope with chronic diseases such as cancer, diabetes etc. Applications with features like communication and interaction abilities are considered helpful in the psychological upliftment of users, creating the feeling that they are not alone. [47]

All the mentioned services help in both physical and psychological patient's boost. Their goal is to introduce self-management of someone's health condition as well as improving their quality of life in general.

1.2.4 Mobile applications requirements for elderly

Elderly have more access to digital technology tools than before, such as smartphones or wearable devices. Worldwide research attention in older patient is high in order to implement a mobile application to meet their needs and requirements. [48] These individuals have different characteristics and the adaptation to the new technology is not always easy. However, MyPal project aims to open new possibilities for older people by introducing the mobile version in their daily life.

As we said, MyPal project focuses on a group of people who are not familiar enough with the mobile technology. It is known that many of older people use mobile phones for specific reasons such as calls or messages. [49] Results of research have shown that they feel that new mobile phones and their functionalities are unnecessary in their daily life and hard to use them, for example small button or small text sizes reading or touch screen are complicating and stressful actions. Also, a large percentage of them have become accustomed to the environment and navigation through older phones, considering the new adaptation and learning difficult. [50]

Elderly also worry about complicated components, system structure and not user-friendly application which make them unable to navigate and understand an app's functions.

Designing guidelines for older people that should be taken under consideration are [51]:

- **Reduction of confusion:** Each one of the components should have a meaning and their function should be very clear. Icons and symbols also need labels to be more comprehensible. Moreover, all the texts and size formats should be under consideration for example button, cards, texts etc.
- **Educational material:** Users need guidance in order to understand how to use all the features of an app.
- **Reminders and notifications:** Older people tend to forget to use an app every day or complete a questionnaire every week.
- **Features to minimize the error:** Strictly actions such as a disable button should not be part of an app for elderly, they need to feel comfortable by making a mistake and undo it.
- **Simple navigation:** A simple design is consisted by an easy navigation that do not require complex interaction.

Mobile applications for elderly should be stimulating and user-friendly. Designing a mobile application for elderlies is where simplicity meets technology. All the features should have a purpose. Avoiding a barrage of information is helpful in order to steer clear of confusion. There is an extra complexity in the ease of use for the elderly people, without misinterpretations. A simple interface should meet certain requirements. These are not defined by extra and distractive features, difficult navigation and hard usability because the target group in an application like that is people that do not have such experience with the mobile technology. [52]

1.3 Questionnaires

A questionnaire is a set of questions, which has been implemented in order to collect answers from a specific group of people. [53] Questionnaires help researchers into gathering useful data and improving the understanding of a study. They are widely used in the field of medicine and especially in cases with problems such as clinical errors. It remains one of the most efficient way to gather massive amounts of data. [54]

1.3.1 Questionnaires in healthcare

Healthcare services should be adapted to the needs of the patients as well as the requirements of the medical staff. Nowadays there are plenty types of questionnaires in the field of medicine each one for a different use. In most of the cases they are used for clinical trials or tests because they are the most effective way of gathering data from a variety of people with the minimum cost. [54]

Questionnaires target patients in order to help them speak up their thoughts and needs. There are written or online questionnaires that are confidential and allow patients to express their opinion or preferences in their treatment. Although there is data security and privacy, there are many patients who are ashamed to respond or do not trust sending feedback. [55]

On the other hand, employees are also submitted in that process. Similarly, requesting feedback from healthcare professionals to identify problems in the health system is a way of improving the healthcare environment, determining issues and delivering a better care.[56]

1.3.2 Types and categories

Questionnaires can be issued in a number of different ways such as:

- **Face to face:** the interviewer visits the responder in their home or workplace and collects all the data directly. This method requires a lot of time and data in order to get the required information. [53][57]
- **Telephone questionnaires:** Data collection is accomplished through the phone. The responder is usually unwilling to give a lot of information over a phone call. [57] Though, this method may be more flexible, the cost depends on the interviewer's time. [54]
- **Computer questionnaires:** Can be presented in online platforms. There is no pressure of time and answers might be more accurate. [57]
- **Email questionnaires:** The responders receive them through their e-mail account. They are able to complete them with no time pressure. The study can include a big part of the population, due to the fact that physical presence is not required and the geographical location does not matter. [57]

They can also be divided in two categories:

- **Qualitative method of research:** In this category, users are able to express their answers in their own words. For example "How much stress are you feeling at the moment?". We can understand that this type of research takes a long time to collect all the data needed and to extract the useful information due to the aim of analyzing a topic rather than measuring it. [58]
- **Quantitative method of research:** This method is used in order to capture numbers or strictly one-word answers. Typical verbal questions are used, for example "From scale 1 to 10 how much pain are you feeling right now?". By quantitative method, researches have a general picture of the topic. The data can be collected easier, however data loss can occur. [58]

1.4 Goals and objectives

The goal of this thesis was to implement a mobile application as part of the MyPal – mobile app, which targets on people who suffer from malignancies. In the context of clinical trials that will be conducted, the application will be used by older adults across the Europe during the pilots of MyPal that have not start yet due to the COVID-19 crisis. Patients will assess their psycho-emotional state as well as they will be able to keep a history record. The process of assessment is going to be through an emotional thermometer, which is a simple, easy and fast screening tool for detecting and tracking clinical mental disorders. Through the patient-reported outcomes MyPal proposes to establish the psycho-emotional management for both cancer patients and their caregivers. MyPal will highlight the value of well-being as well as the integration of the cancer patient and/or his/her caregivers in the treatment process emphasizing in patient-centered model. Finally, the designing of a simple and innovative user interface accomplishes the patient requirements, which are taken under consideration in order to meet the elderly needs.

2 Implementation

The implementation is done through the android studio environment. In order to develop the application, we needed to install Android Studio and add the Dart and Flutter plugins. The code is written in Flutter, which is based in Dart programming language. Flutter provides a faster and more flexible mobile app development than other frameworks. It also contains its own design including Material components for Android and Cupertino for iOS. Since everything is a widget, it makes it customizable. The most important about Flutter is the fact that allows the development of mobile native applications with a single codebase. This means that enables the implementation of mobile apps for both Android and iOS without extra code.

2.1 Architecture

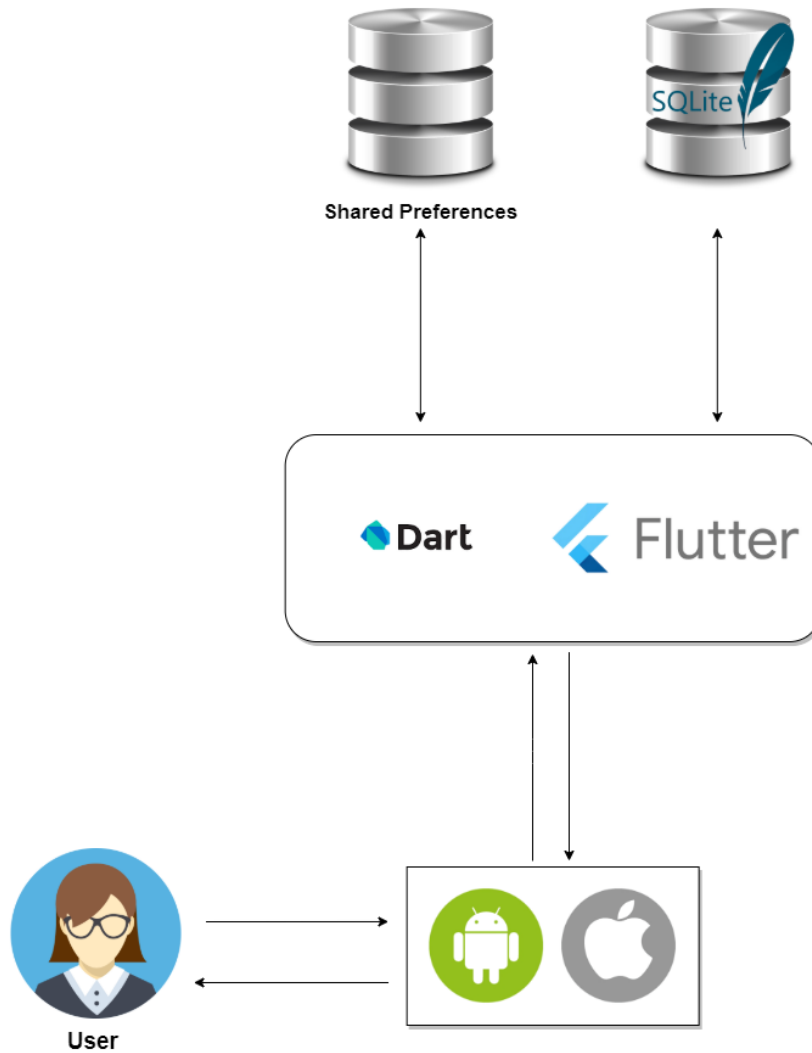


Figure 1. Architecture of application

Figure 1 represents the architecture of the application. The user can install MyPal via his/her mobile device, which runs on Android or iOS. The whole interface of the app is written in Dart and Flutter. The database connection is done through the SQLite for data storing and retrieving. Shared preferences are also used in order to display the data in the dashboard and to save the specific day of the last record in the database for later validation, even though when the app is terminated.

2.2 Android studio



Figure 2. Android studio logo

Android studio is the official development environment created by Google to develop mobile applications that run on android operating system. Android studio is a free and open-source program that embody a text editor where the code belongs. Libraries, a Gradle - based build system, emulator and code templates for easier programming. [59]

Android is consisted by four (4) levels [60] :

- **Linux Kernel:** is the lowest layer of the OS pyramid, which include the drivers in order to run the system such as Bluetooth, camera, audio etc.
- **Libraries:** the code that is needed in order to have specific application features and functions.
- **Android runtime:** provides a set of libraries that allow to developers to code in Java. Android runtime is in the same level with libraries.
- **Application framework:** provides various features to developers in order to use them in their applications such as notifications, location etc.
- **Applications:** is the highest level of the system. It contains all the applications of the system, such as Camera or Contacts that are already installed and other apps that the user wants to download

2.3 Flutter



Figure 3. Flutter logo

Flutter offers a free interface toolkit for native mobile development, web and desktop applications for Android and iOS devices. It is created by Google for flexible, easier, faster and innovative interfaces and services using less coding across all the operating systems. Flutter is not an object - oriented language. The main difference between Flutter and all the other mobile programming languages is that it is composed by widgets. Widgets are important building blocks and components for the user interface of an application. Flutter is also based on Dart and integrates with well-known tools such as android studio, IntelliJ IDEA and visual studio code.

2.4 SQLite



Figure 4. SQLite logo

The database of the system is implemented with SQLite, because is more flexible and the most common used databases for mobile programming. SQLite is a library that requires minimal support from the operating system and that makes it usable in many environments especially in mobile devices like android phones, iPhones etc. Is the most famous choice as a built-in local storage database. Moreover, is does not based on any server which means applications that use SQLite database read and write their data in files that store on disk and is not necessary any installation or other process that needs to be done.

2.4.1 Database setup

```
// this opens the database (and creates it if it doesn't exist)
_initDatabase() async {
  Directory documentsDirectory = await getApplicationDocumentsDirectory();
  String path = join(documentsDirectory.path, _databaseName);
  print(path);
  return await openDatabase(path,
    version: _databaseVersion,
    onCreate: onCreate);
}
```

Figure 5. Open the SQLite database

Figure 5 shows the first step of how to create a database by opening it and providing the path.

```
// SQL code to create the database table
Future onCreate(Database db, int version) async {
    await db.execute('''
        CREATE TABLE $table (
            $columnId INTEGER PRIMARY KEY,
            $columnDate STRING NOT NULL,
            $columnStress INTEGER NOT NULL,
            $columnDepression INTEGER NOT NULL,
            $columnAnger INTEGER NOT NULL,
            $columnDistress INTEGER NOT NULL,
            $columnHelp INTEGER NOT NULL
        )
    ''');

    print('$table');
}
```

Figure 6. Create table in SQLite

In order to store the data, we create a table as shown in figure 6, with the following code lines:

There are six (6) columns:

- **columnId:** The id of each insertion into the database
- **columnDate:** The date of each insertion with the format “year-month-day”
- **columnStress:** The value of stress
- **columnDepression:** The value of depression
- **columnAnger:** The value of anger
- **columnDistress:** The value of distress
- **columnHelp:** The value of help

2.5 Shared preferences

```
void saveStressNumber() async {  
    final SharedPreferences prefs = await _prefs;  
    prefs.setInt('savedNumber', stressValue );  
    _savedNumberStress = stressValue;  
    CurvePainter updateProfileInfo = new CurvePainter();  
    updateProfileInfo.loadNumber();  
}
```

Figure 7. Shared preferences storage of stress value

Shared preferences are a manner of storing local values in order to retrieve them later. This method uses a pair of keys–values to store locally the data. For example, in figure 7 the key is the “savedNumber” and the value that we want to save is the “stressValue”.

```
void loadNumber() async {  
    final SharedPreferences prefs = await _prefs;  
    _savedNumberStress = prefs.getInt('savedNumber') ?? 0;  
}
```

Figure 8. Shared preferences load of stress value

In figure 8, load method contains the key that already exists in the save method and returns a value. With the same way all the other values have been implemented such as depression value, etsum and the result of etsum (normal, mild, moderate, severe) in order to display these data in the dashboard screen. All this information exists even when the user terminates the application. Also, the day of the last insertion into the database has been locally stored for the checking validation in figure 23.

2.6 Flutter notifications

2.6.1 Local notifications setup

In the AndroidManifest.xml of the android app:

Requesting permission requires adding the following to the manifest:

```
<uses-permission android:name="android.permission.RECEIVE_BOOT_COMPLETED"/>
```

For the vibration pattern of an Android notification:

```
<uses-permission android:name="android.permission.VIBRATE" />
```

The <receiver> is needed to ensure notifications remain scheduled upon a reboot and after an application is updated:

```
<receiver  
  android:name="com.dexterous.flutterlocalnotifications.ScheduledNotificationBootReceiver">  
  <receiver android:name="com.dexterous.flutterlocalnotifications.ScheduledNotificationReceiver"  
  />  
    <intent-filter>  
      <action android:name="android.intent.action.BOOT_COMPLETED"/>  
      <action android:name="android.intent.action.MY_PACKAGE_REPLACED"/>  
    </intent-filter>  
</receiver>
```

After the setup of the manifest, we create a file named *proguard-rules.pro* in the path: *android/app*. Into the file we execute the command: `-keep class com.dexterous.**{*;};`

2.6.2 Local notifications implementation

```
FlutterLocalNotificationsPlugin flutterLocalNotificationsPlugin =  
FlutterLocalNotificationsPlugin();
```

Figure 9. Flutter local notification plugin

After the notification setup, the next step is to use the *FlutterLocalNotificationsPlugin* class as it is shown in figure 9. It offers functionality across channels for receiving local notifications. Moreover, the plugin will test the system to use the valid platform-specific implementation.

```
final MethodChannel platform =  
MethodChannel('crossingthestreams.io/resourceResolver');
```

Figure 10. Method channel

Notifications are exchanged via platform channels between the Flutter code and the client (Android or iOS hosts) and transmitted asynchronously.

```
var initializationSettingsAndroid =  
    AndroidInitializationSettings('app_icon');  
var initializationSettingsIOs = IOSInitializationSettings();  
var initSetup = InitializationSettings(  
    initializationSettingsAndroid, initializationSettingsIOs);
```

Figure 11. Initialization of settings

In figure 11 we initialize the settings for Android and iOS and then we setup (*InitializationSettings*) the plug-in configuration for both platforms.

```
Future<void> showWeeklyAtDayAndTime (  
    int id,  
    String title,  
    String body,  
    Day day,  
    Time notificationTime,  
    NotificationDetails notificationDetails,  
    {String payload}  
)
```

Figure 12. Notification function

In our project the *showWeeklyAtDayAndTime* function was used, as it is shown in figure 12, in order to display a notification at a specific date and time every week.

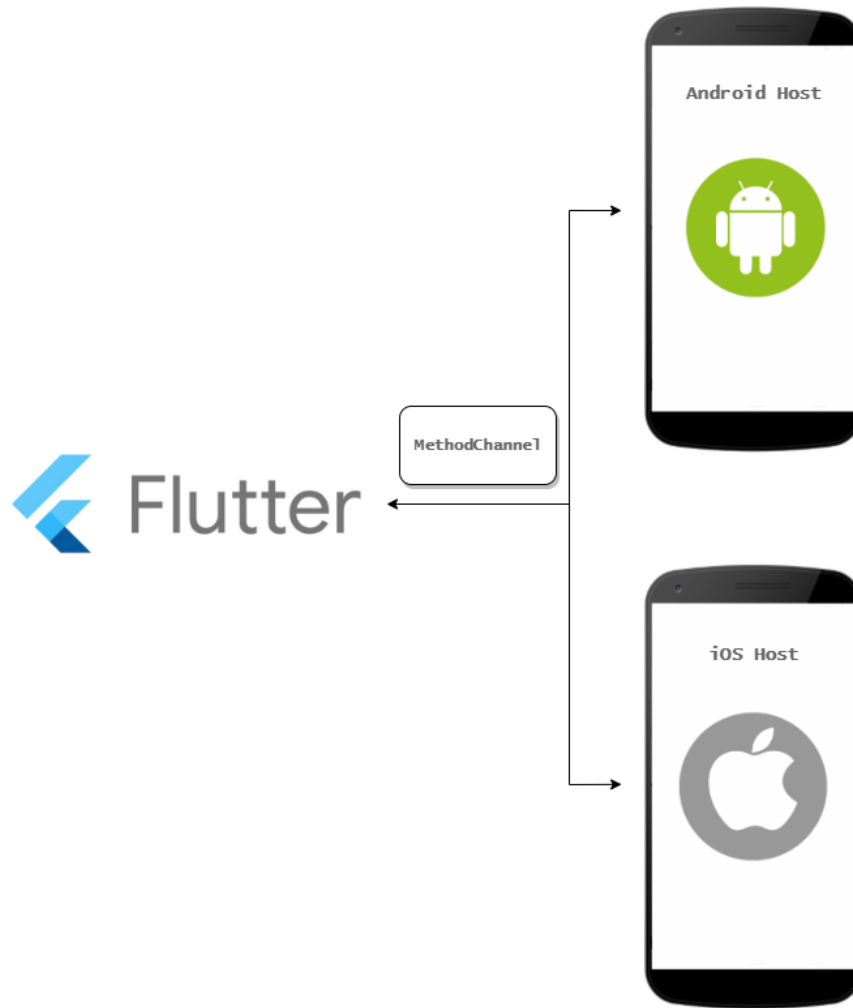


Figure 13. Notification Architecture

Figure 13 illustrates the process of how local notifications interact with the system. Messages are transferred between flutter code and the application (host) via channels. Through the MethodChannel (API) we deliver a message that corresponds to a specific call. MethodChannel Android (API) on Android platform and FlutterMessageChannel (API) on iOS platform are used to answer the call and send back data.

3 The Application

The application of this thesis motivates cancer patients to record their psycho-emotional status. The mobile implementation aims to create a more user-centered approach for psycho-emotional management. The users answer a series of questions about their mood through a scale thermometer. All values are stored locally for history record and outcomes. We also implemented the ability to monitor their psychological condition via the dashboard screen. Application interacts with users through weekly notifications.

3.1 Installation

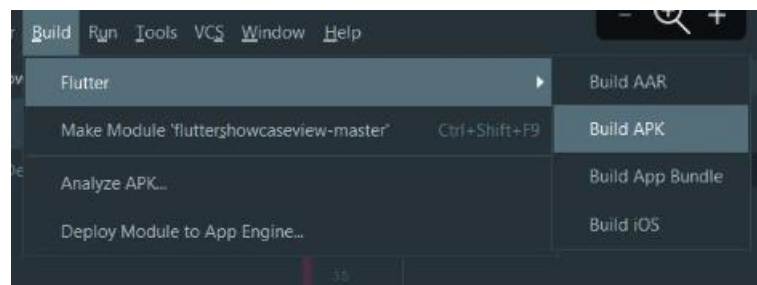


Figure 14. Build APK

To export our project from android studio we need to release the APK file.

When the build is done, the *app-release.apk* file has been created in the project folder in the following path: *applicationName/build/app/outputs/apk/release*.

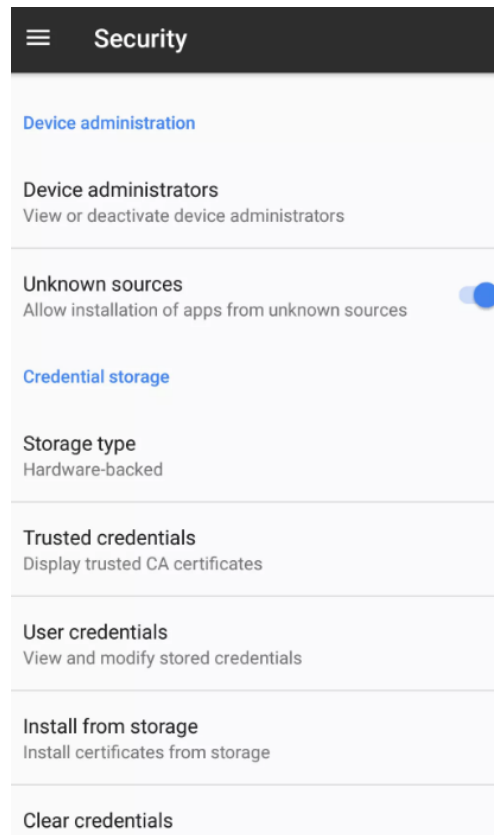


Figure 15. Android setup

Any apk that does not exist in a Store such as Google Playstore, is considered as an unknown origin to our mobile device. In order to install it, users can follow the next steps:

1. Settings
2. Security (or Lock screen and Security)
3. Unknown sources (enable it)

After the device setup that allows you to install unknowns apps, users need a way to find that apk file on their device in order to run it. Android phones usually lunch an app that is called *File Manager*. In case you do not have one, then go to Google Play and check for *File Manager*. After that installation, users will be able to locate the APK file.

3.2 User interface - Dashboard

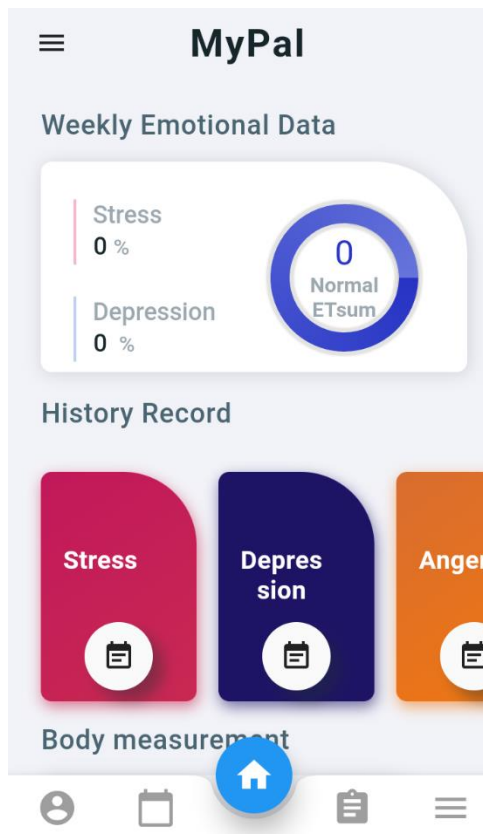


Figure 16. Dashboard screen

Figure 16 shows the dashboard, which is the main screen of the application. Dashboard contains the weekly data of the patient, the history records and a demo tour of cards with pseudo data. When the user opens the application for the first time the values on the screen are all zero until he/she completes the questionnaire. The percentages of the cards vary according to the patient's responses. Moreover, the application calculates the summary of the four moods (stress, depression, anger and distress) and creates a result (ETsum – Emotional Thermometer summary).

The result is categorized as:

- **Normal:** Etsum ≤ 9
- **Mild:** ETsum > 9
- **Moderate:** ETsum > 14
- **Severe:** ETsum > 20



Figure 17. History record tabs

Figure 17 presents the tabs of each emotion. User can tap on them and monitor the measurements of the current week or the history record since he/she started using the application.

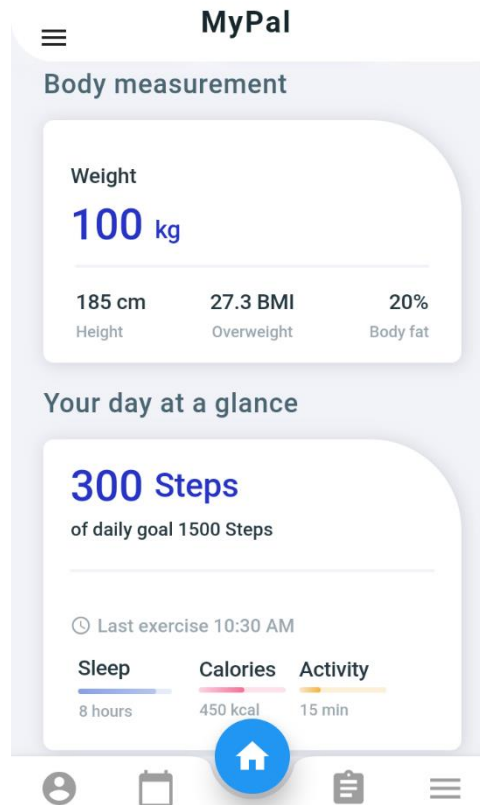


Figure 18. Synthetic data

In figure 18 there are personal data about body measurement and physical activity which are visualized in a demo tour. The data are synthetic. However, the option of monitoring the exercise through a wearable device was included in the prototype. In addition to the daily steps in the demo, there are also the hours of sleep as well as the calories of the diet and the duration of the exercise. Physical activity rates are associated with lower risks of cancer. The combination of exercise and proper nutrition constitute ways to protect and strengthen the body. Therefore, it was considered as an approach to connect that representation with a database adapted to real data, which will be recorded by a patient.

3.3 Navigation

Navigation between various screens and activities is an important part of user experience. Every application has a start and a destination. Components such as back and next buttons, app bars and navigation drawers are identified as proper navigation principles.

3.3.1 Navigation drawer

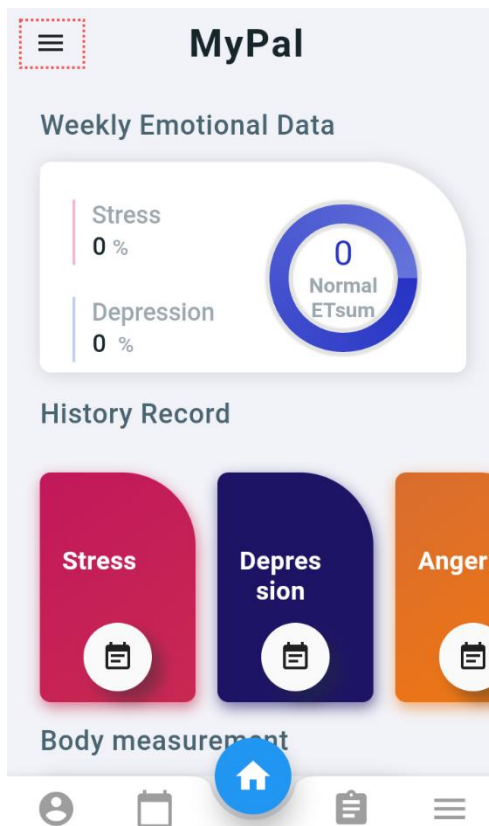


Figure 19. Navigation drawer button

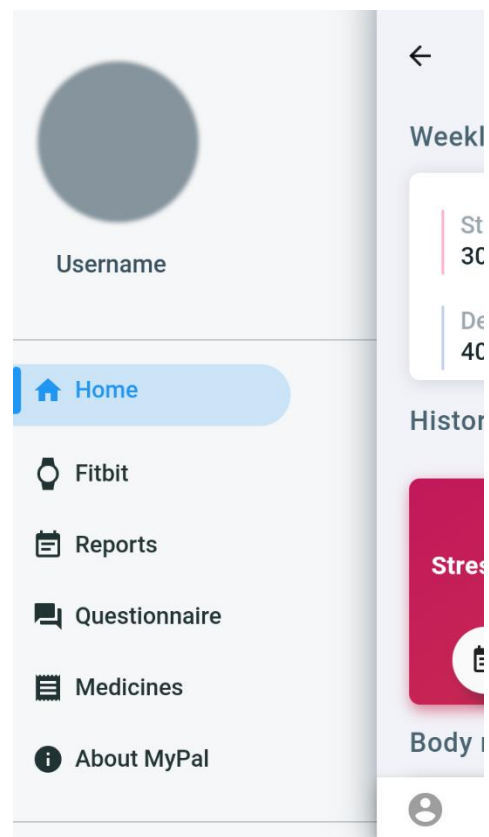


Figure 20. Navigation drawer menu

A navigation drawer is a list panel with options. It contains the most important features and gives access to activities that are most likely to be used. In figure 19 there is the button of the navigation drawer on the left of the dashboard screen. When the user presses the button, the menu in figure 20 shows up. Each item of the list has the corresponding activity. In this thesis, we focus on the option of questionnaires.

3.3.2 Bottom navigation bar

Bottom navigation bar is used for direct access in the main features of a mobile application. It is a user interface element that allows the switching between the main screens of the application and it makes the whole process easier with a single tap on a menu item. There are five main activities of our bottom navigation bar:

- User profile
- Calendar
- Home
- Medical reports
- Menu

In figure 21 we are going to focus on the menu screen, which is the main activity.

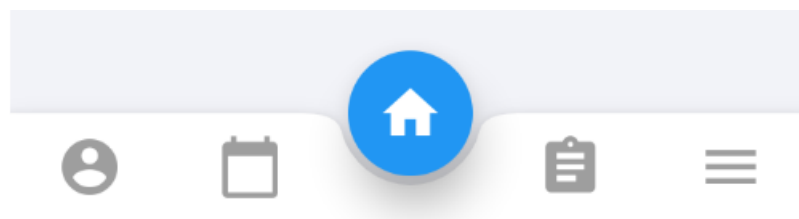


Figure 21. Bottom navigation menu

3.4 Menu

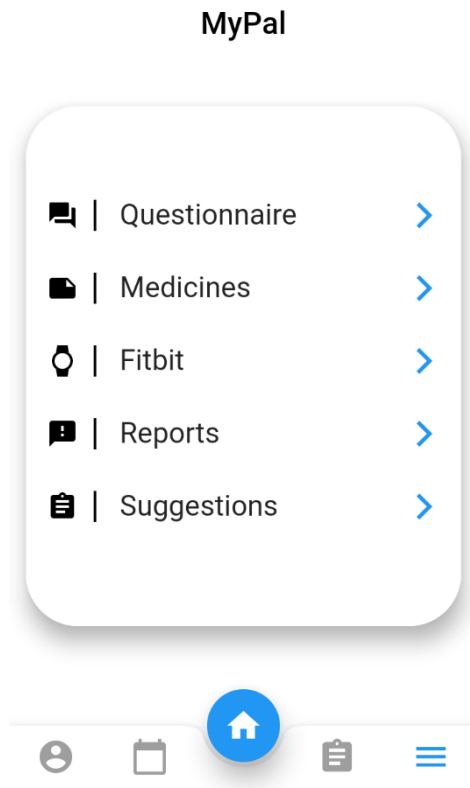


Figure 22. Menu

Menu screen is consisted by a card as we see in figure 22 which includes a list of five options, according to the prototype:

- Questionnaires
- Medicines
- Fitbit
- Reports
- Suggestion

Considering that this is the first time of running, the system will let the user go to the next activity for starting the questionnaire.

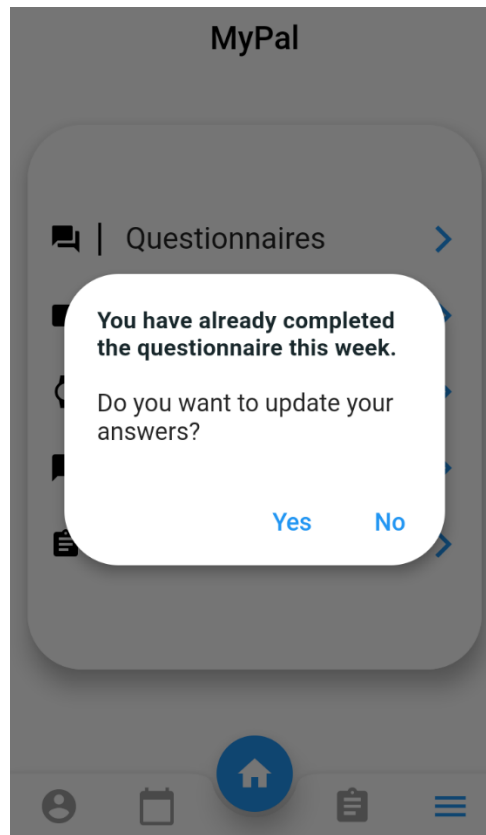


Figure 23. Update questionnaire

In case of second tapping on the *Questionnaire* option, considering that he/she has already completed the questionnaire in the same day or before the pass of a week, a pop-up notification informs the user that he has already done the weekly questionnaire. More specifically, we check the date validation and if the number of days is less than seven (7) since the last insertion in the database, the user can only update his/her current weekly measurements. Our system is not strict to the user and allows him/her to re-do the questionnaire.

3.5 Questionnaire

User measures the weekly emotions of stress, depression, anger, distress and how much help he/she needed. If a user selects a value from zero (0) to six (6) then the line inside of the scale thermometer remains its primary color, white. Otherwise, from seven (7) and above the line turns red indicating severity.

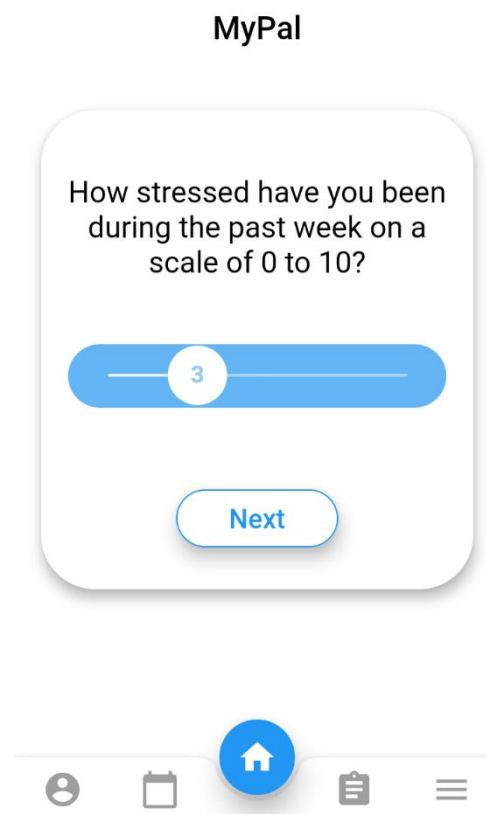


Figure 24. Stress measurement

User measures the weekly stress level. The *Next* button redirects him/her in the depression assessment.

MyPal

How depressed have you been during the past week on a scale of 0 to 10?

4

Next




Figure 25. Depression measurement

User measures the weekly depression level. The *Next* button redirects him/her in the anger assessment.

MyPal

How angry have you been during the past week on a scale of 0 to 10?



Next



Figure 26. Anger measurement

User assesses the weekly anger level. In figure 26, the user selected the value seven (7). The line of the thermometer turns red if a value is seven (7) and above. User presses the *Next* button and he/she is navigated in the distress assessment.

MyPal

How distressed have you been during the past week on a scale of 0 to 10?

8

Next



Figure 27. Distress measurement

User assesses the weekly distress level. *Next* button navigates him/her in the help measurement.

MyPal

How much help did you need during the past week on a scale of 0 to 10?

Save data



Figure 28. Help measurement

User assesses how much help he needed during the past week. After pressing the *Save data* button his/her answers are stored locally.

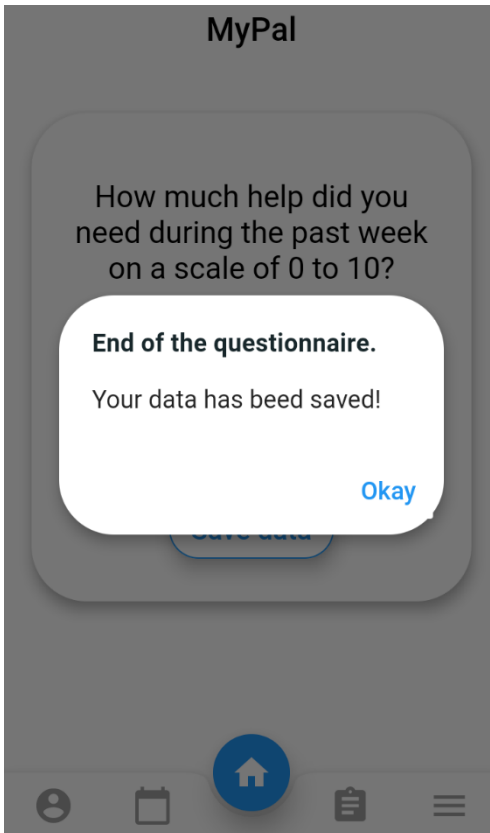


Figure 29. End of the questionnaire

When the questionnaire is completed, a pop-up message appears in the screen and the *Okay* button returns him/her in the dashboard screen.

3.6 User's data

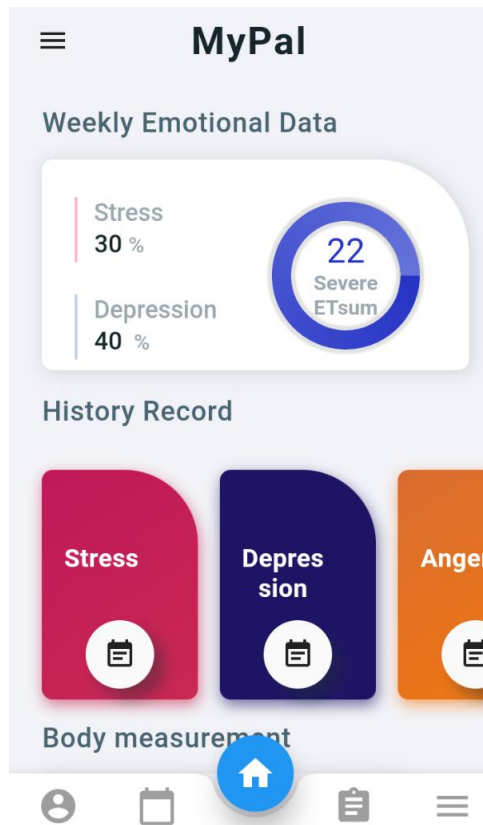


Figure 30. Display of the data

After a successful assessment of the weekly emotions, user can monitor the psycho-emotional answers by checking the history record.

3.7 History record

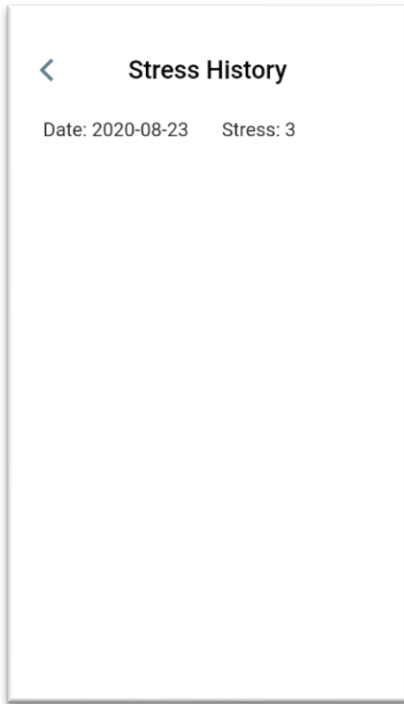


Figure 31. Stress history

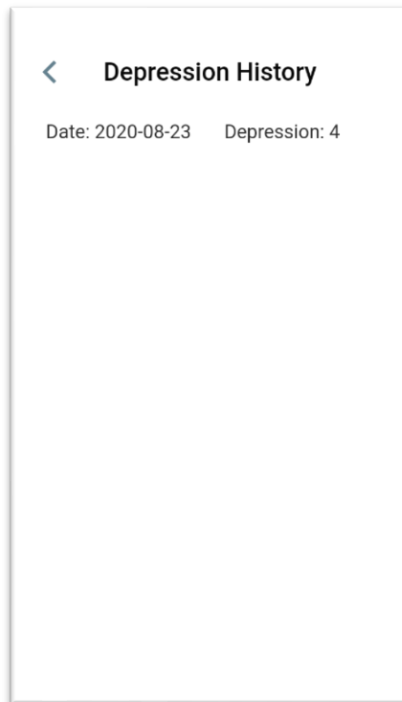


Figure 32. Depression history



Figure 33. Anger history

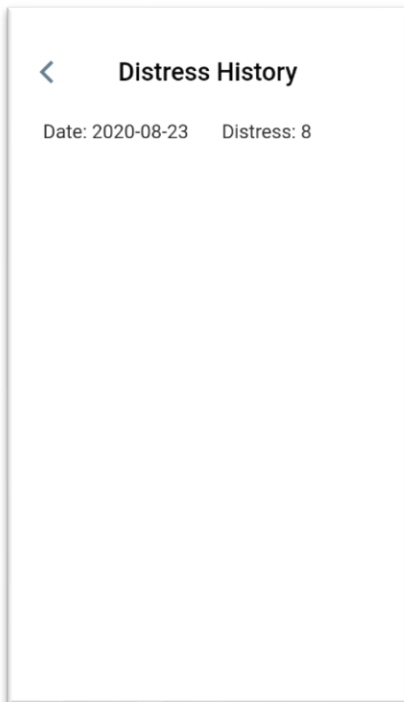


Figure 34. Distress history

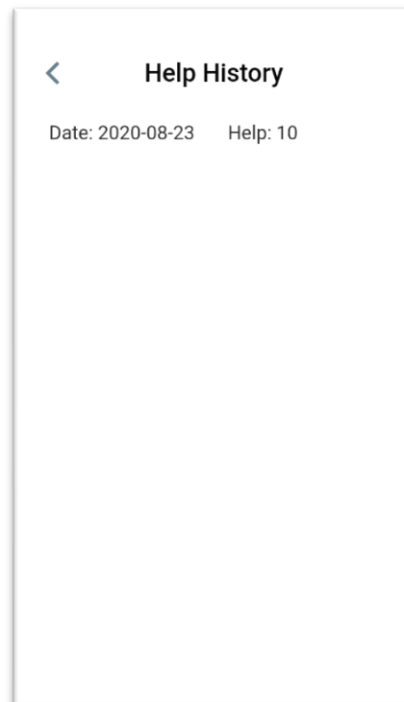


Figure 35. Help history

3.8 Weekly notification

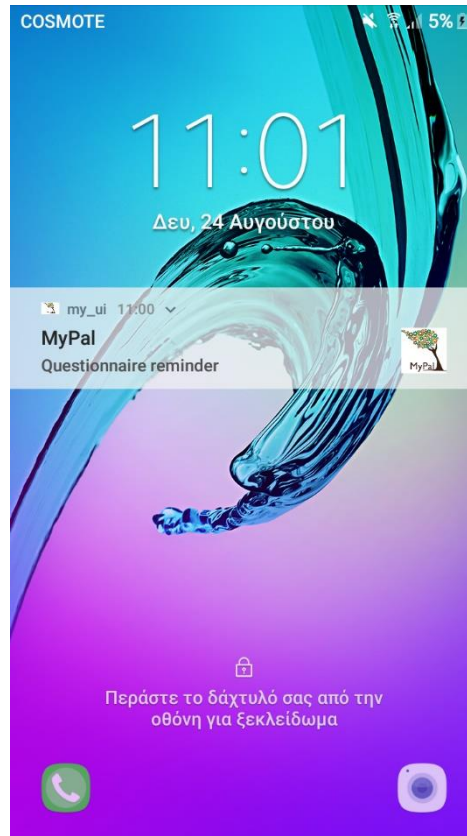


Figure 36. Weekly notification

Every Monday at approximately eleven (11:00 AM) o clock in the morning users receive a notification which reminds them to complete the questionnaire of the week.

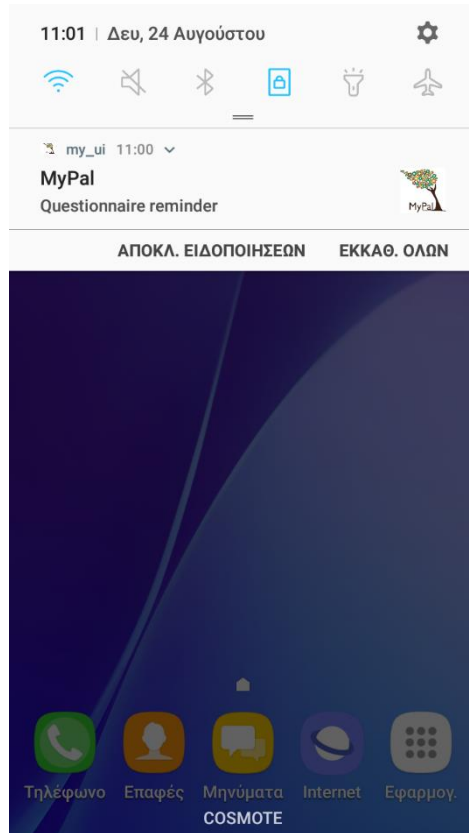


Figure 37. Notification title

In figure 37, users can drag down on the notification in the drawer to reveal the expanded view, which shows the weekly questionnaire reminder.

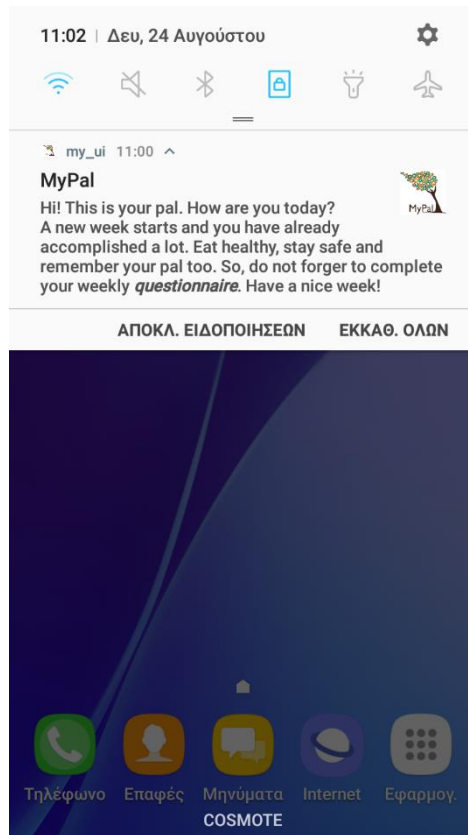


Figure 38. Notification context

Figure 38 shows the text of the notification. In the context of self-management and psychological support that message includes empowerment words as if it comes from a close friend. Finally, when users click on it, the application launches.

4 Discussion and conclusions

4.1 Discussion

The new standard for healthcare trials is the gathering of electronic data, which is gradually being used as a manner to help track and monitor patients outside the clinical environment. ePROs gather a wide variety of information based on medical data, mental health, well-being, physical activity, vital signals or even behavioral data. The data collection from the daily life, health, lifestyle and behavior of a patient helps in better practice of treatment. Studies also have shown that patients feel satisfaction when their needs taken under consideration for the care they receive.[61]

After the introduction of ePROs into the medical field, several advantages have identified. For example, the utility of electronic patient-reported outcomes is more effective than the usual medical records because there is no data loss of human error. Patients are more willing to record confidential and private information, in which they have easy access. [62] Studies also have shown that the use of PROs into the daily treatment of cancer patients has been linked with improved survival relative to normal treatment. [63] They have been identified as a significant tool for incorporating the needs and voice of patients in cancer care. When they are combined with the ongoing medical care, treatments decision and physician workflow they can be valuable. [64]

PRO data enable doctors to realize better the needs of the patients and understand them both as a person and a population. [65]

Recent healthcare challenges have expanded the need of ePROs in clinical practice. They constitute the key element of clinical trials and treatments. ePROs have tremendous potential to boost patient care in clinical oncology by enhancing patient provider contact, improving quality of life and survival. The utility of their data can alter the whole health system care into a patient-centered care and improve the planning of the clinical trials. [66] While mobile and wearable technologies continue to develop in the onset of the clinical science, ePROs are considerate as a tool which rise in value as the patient-centered concept gains more leverage.

4.2 Conclusions

To sum up, the development of e-health services is at its peak. The cooperation of IT with the health care systems brings positive results in terms of patient's control as they contribute to the recording of timely events and manage the whole process of their condition through reports and interactions. Today, there are many medical web and mobile applications that aim to be helpful for both doctors and patients but not all of them reach to be effective.

Patient's monitoring in the field of mHealth is defined as "the utility of mobile or wearable technology for managing, recording and treatment with outpatient care."

The mobile version of MyPal implemented for elderly patients with malignancies in order to assess their emotions with an easy-to-use mobile application. User does not have to register just to track their mood through a series of questions every week. The responds are stored locally, visualized in the dashboard screen and users can also monitor their history record through the application. Also, the system offers clarity in case someone who is not familiar with mobile technology to use it easily.

The system of the psycho-emotional assessment was going to be used as part of the MyPal project, which would begin the clinical trials in hospitals across Europe in May. Due to Covid-19, the consortium postponed the trials. At that moment we do not have results for the usability of the system from real group of patients, but there will be in the next months.

Although the mobile application has been implemented, there is the need to be properly tested in order to ensure that it is acceptable to patients, who are the end users. In our system since the application focuses on people who are not so familiar with the mobile technology, moderated testing would be an advised technique. That means that the most appropriate way of the evaluation should be in person and not remote, because we may not extract clear results. Patients through the laboratory research could be able to interact with the application, once they have been given strong guidelines for its use by a researcher. With this perspective, the researcher may record other additional data such as user's reactions and opinions about the system.

MyPal mobile version was implemented for cancer patients but its design with extra features and functionalities, that already exist in the prototype application, may be useful for people who want to store data about symptoms, emotional stability and medical data in general. Since mobile technology offer opportunities for prevention, treatment and follow-up care of patients' health, people should be more aware of mobile health's advantages in the management of their own diseases.

4.3 Future work

The application was designed exclusively for patients and the main purpose was to create a psycho-emotional evaluation through a scale thermometer, visualization of patient's data and a history record. However, in the prototype there are feature that can be integrated with the demo screens or tabs in the dashboard such as the physical exercise tracking through fitbit. Although the implementation was focused on the questionnaire and the interface representation, there are other features that could be added to make it more interesting such as:

- Recording of medical prescription
- Data security
- Direct patient-doctor contact
- Interaction with a chat-bot

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