



A HOME-MONITORING SYSTEM FOR HYPERTENSIVE PATIENTS

Team 2

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1. Brief description of the pathological condition

Hypertension is traditionally defined as systolic blood pressure (BP) of ≥ 140 mmHg and/or diastolic BP of ≥ 90 mmHg in a medical setting.

It is possible to classify hypertension into three stages: pre-hypertension, stage 1 and stage 2. The presence of other cardiovascular diseases can influence its classification. Notably, systolic BP has a greater influence than diastolic BP. With systolic BP of ≥ 130 mmHg and/or diastolic BP of ≥ 80 mmHg, hypertension is a major risk factor for cardiovascular disease, affecting over 1.2 billion people globally.

2. Aim

The aim of our project is to develop a comprehensive system for the home monitoring and in-hospital follow-up of hypertensive patients, with the overarching goal of improving their overall care and quality of life.

Our system is designed to allow continuous monitoring of several biological parameters relevant to hypertension, such as blood pressure, heart rate and activity levels, using wearable technologies.

The featured functionalities of our system serve multiple purposes such as for both patients and healthcare providers, our system facilitates remote monitoring and follow-up, reducing the need for frequent hospital visits while ensuring that patients receive timely medical attention when necessary. Ultimately, our system aims to improve health outcomes for hypertensive patients by enabling proactive management, early intervention and continuous monitoring of their condition.

Every actor of the system, whether it's the hypertensive patient themselves, their caregivers, or healthcare professionals, will find our system useful for different reasons. For hypertensive patients, our system offers an opportunity to take an active role in managing their health providing them the ability to continuously monitor vital parameters. This not only helps them become more aware of their health status but also encourages them to adhere to prescribed treatment plans more closely, thus improving overall health outcomes. For caregivers, our system offers a sense of security and that they can intervene promptly in case of detected anomalies. Finally, for doctors, our system represents a valuable tool to optimize the care of hypertensive patients. It provides them with detailed, real-time data on patients' health status, enabling them to make informed decisions, develop personalized treatment plans, and allocate available resources efficiently. Additionally, doctors can access a weekly report summarizing our patients' information through the automatic data collection system.

3. Context analysis table

Source	Findings
<p>Self-reported questionnaires for assessment adherence to treatment in patients with cardiovascular diseases</p> <p>Aldona Kubica, Agata Kosobucka, Piotr Michalski, Tomasz Fabiszak, Mirosława Felsmann</p>	<p>Despite the presence of effective treatments, adherence to long-term therapies for chronic illnesses in developed countries averages only 50%, according to WHO.</p> <p>No universally accepted "gold standard survey" exists for medication adherence assessment. Indirect methods like questionnaires, pharmacy registers, and electronic devices are used, but reliability varies.</p> <p>Various scales like MMAS, SEAMS, HBCS, BMQ, ACDS, TAQPH, MBG, and ASRQ have been developed to assess adherence and identify barriers. They help understand factors influencing adherence, like therapy acceptance and patient-professional cooperation.</p>
<p>Interaction between trouble sleeping and depression on hypertension in the NHANES</p> <p>Yingjie Cai, Manshuang Chen, Weixia Zhai and Chunhui Wang</p>	<p>Hypertension, marked by high blood pressure, is a significant risk factor for cardiovascular disease, affecting billions worldwide. A study examined over 30,000 participants, finding those with hypertension had higher rates of smoking, diabetes, stroke, trouble sleeping, and depression. The study suggests a combined impact of sleep issues and depression on hypertension, stressing the need to address psychological well-being and sleep in managing hypertension. However, the study's reliance on self-reported data and its cross-sectional design limits its ability to establish causation or rule out bidirectional relationships.</p>
<p>Association between psychosocial stress and hypertension: a systematic review and meta-analysis</p> <p>Mei-Yan Liu, Na Li, William A. Li & Hajra Khan</p>	<p>Hypertension is challenging to manage and leads to heart and vascular damage.</p> <p>Occupational stress, including high workload and low control, raises blood pressure; lower socioeconomic status correlates with high and less responsive blood pressure; anxiety and depression are bidirectionally linked with hypertension risk. Behavioral factors like smoking, alcohol, inactivity, and poor diet contribute to hypertension.</p> <p>Data showed that psychosocial stress was associated with an increased risk of hypertension and hypertensive patients had a higher incidence of psychosocial stress compared to normotension patients.</p>
<p>Treatment of hypertension: The ESH/ESC guidelines recommendations</p>	<p>The goal of anti-hypertensive treatment is to reduce the excess cardiovascular mortality and morbidity associated with chronic high blood pressure (BP). Lifestyle changes can help prevent hypertension and lower BP. These include salt restriction, moderate alcohol consumption, increased intake of vegetables, fruits and low-fat dairy products, weight loss, regular exercise,</p>

<p>Cesare Cuspidi, Marijana Tadic, Guido Grassia, Giuseppe Mancia</p>	<p>and smoking cessation. However, the BP-lowering effects of non-pharmacological treatments are less than those of drug therapy.</p> <p>Anti-hypertensive treatment often starts with monotherapy, but if BP control is not achieved, additional drugs may be necessary. Combining two drugs from different classes can reduce BP more than increasing the dose of a single drug. If a two-drug combination at full doses doesn't achieve the target, a different two-drug combination can be considered, or a third drug can be added.</p>
<p>Systemic Hypertension</p> <p>William J. Elliott, MD, PhD</p>	<p>Cardiovascular (CV) disease will become the most common cause of death and hypertension, one possible cause, will be its most common reversible risk factor.</p> <p>It is shown that hypertension is related to: ageing, in addition if it appears in younger ages the probability of developing CV diseases increases; gender, in fact men tend to have it earlier, but after 70 the rate of women that have hypertension is higher and they are more probable to suffer from CV problems.</p> <p>A parameter to consider is the pulse pressure in elder people and the systolic/diastolic BP in young people.</p> <p>Cuff for the arm is the most useful method to measure BP, used at home, office and hospital. Home BP readings are typically lower than measurements taken in the traditional medical environment, even in normotensive subjects. Persons who routinely measure BP at home probably have a better prognosis than do those who do not.</p> <p>Firstly, lifestyle modification is recommended. This can be achieved by lowering the sodium intake, increasing the physical activity, losing weight in high BMI people, modifying the alcohol intake, ceasing smoking and the tobacco consumption. If this treatment is integrated with a drug therapy the effectiveness increases. Usually, a combination of pharmaceuticals is used to enhance the performance. A low dose of thiazide (a diuretic) is a solid base for additional therapy.</p> <p>There are different situations that need specific attention and treatment: extremes of age, pregnancy and extreme BP values.</p>
<p>Home Blood Pressure and Telemedicine: A Modern Approach for Managing Hypertension During and After COVID-19 Pandemic</p>	<p>Hypertension often remains undiagnosed, leading to acute cardiovascular events such as heart disease and stroke, in fact approximately 35-40% of treated hypertensive patients fail to achieve recommended therapeutic targets. Home BP Monitoring (HBPM) has emerged as a valuable tool in hypertension management, offering benefits such as increased disease awareness, enhanced medication adherence, and personalized treatment strategies, especially during the COVID-19 crisis.</p> <p>However, the widespread adoption of telemedicine faces challenges, including disparities in internet access and</p>

Barbara Citoni, Ilaria Figliuzzi, Vivianne Presta, Massimo Volpe1, Giuliano Tocci	technological resources, particularly in underserved communities. Despite these challenges, integrating telemedicine and HBPM represents a promising approach to improve hypertension management.
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4. Main assumptions

- The general practitioner suspects that the patient suffers from hypertension, therefore they suggest them to go to a specialist which will evaluate whether to include them in a monitoring program.
- The patient is self-sufficient or they have a caregiver to assist them.
- The program is based on the use of an application, which can also be opened as a web page.
- The local health authority has the resources to provide the needed devices to the subjects that do not already possess them.
- When the patient exits the program because their condition has improved, it is assumed that they will continue going to the general partitioner.
- If the patient deceases, their data is kept in the system for research purposes for 10 years, along with all the other patients who exit the program, highlighting the cause of their exit.
- By technician we refer to many different specialists which can solve eventual issues, analyze data, manage the software.

5. Textual description

In the following section, there are eight textual descriptions that explain the inclusion in the monitoring program and the functionality of the developed software.

TITLE	FIRST VISIT
DESCRIPTION	The patient displays concern over recent symptoms monitored with medical device and previous visit (not specialized for hypertension), so the patient, suggested from the general partitioner, makes an appointment for monitoring hypertension
OBJECTIVE	Patient's health evaluation for the profile set up
MAIN ACTOR	DOCTOR
PRECONDITION	The patient goes to the doctor office for their first visit
POSTCONDITION	The patient obtains the credentials for the login to the app and needed devices
BASIC SCENARIO	<ol style="list-style-type: none">1) The doctor logs into their account with their credentials (username and password)2) The doctor conducts the objective examination on the patient (measures heart rate, blood pressure, respiratory rate...)3) The doctor defines the diagnosis, pointing out only hypertension disease4) The doctor adds a new patient to their list5) The doctor creates a profile for the patient into the system, defining their credentials6) The doctor inserts the anamnesis data regarding the patient into the patient's profile: personal data, contact information, current and past medical history, family medical history, lifestyle factors (activity, smoke, alcohol, diet), current drugs, information about specialists the patient is currently seeing (nutritionist, psychologist, cardiologist)7) The doctor inserts the data into the patient's profile8) The patient downloads the app on the device9) The doctor provides the login credentials to the patient10) The patient logs into the app with the credentials11) The doctor asks if the patient has the needed devices (watch for monitoring sleep and hearth rate, sphygmomanometer, device connected to the internet)12) The patient answers positively13) The patient associates the app to the watch14) The doctor provides the general guidelines regarding the diet (in particular the recommended amount of salt and coffee to assume daily), lifestyle and the use of the devices15) The doctor defines initial treatment and uploads it on the app, explaining to the patient the drugs to take and the relative doses16) The doctor writes prescriptions17) The doctor and the patient schedule the follow up visit together

ALTERNATIVE SCENARIO	<p>3.a. The patient does not have hypertension</p> <ol style="list-style-type: none"> 1. The patient is excluded from the program <p>3.b. The patient has additional pathologies other than hypertension</p> <ol style="list-style-type: none"> 1. The doctor suggests a further visit with the needed specialist 2. The doctor gives a temporary treatment to the patient 3. The patient leaves the office and the account is not created 4. The patient makes an appointment 5. The specialist visits the patient 6. The specialist sends the results to the patient and the doctor 7. The doctor views the results 8. The doctor makes an appointment with the patient to finalize the process <p>5.a. The system does not work</p> <ol style="list-style-type: none"> 1. The doctor alerts the technician 2. The technician solves the problem 3. If the system still does not work, the doctor writes data on paper and then enter it into the system <p>10.a. Issues with the login</p> <ol style="list-style-type: none"> 1. The doctor alerts the technician 2. The technician solves the problem 3. If the problem remains, reschedule another appointment <p>11.a. The patient answers negatively</p> <ol style="list-style-type: none"> 1. The patient lists the devices they do not have 2. The doctor passes the list to the local health authority 3. The local health authority provides the devices on the list to the patient <p>13.a. Incorrect association</p> <ol style="list-style-type: none"> 1. The doctor alerts the technician 2. The technician solves the problem 3. If the problem remains, reschedule another appointment
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TITLE	FOLLOW UP VISIT
DESCRIPTION	During a follow-up visit for hypertension, activities are conducted to ensure the patient's ongoing health and well-being, also assessing the results of the treatment
OBJECTIVE	Update data on the app and adjust the treatment
MAIN ACTOR	DOCTOR
PRECONDITION	The patient goes to the doctor office for their follow up visit
POSTCONDITION	The patient obtains new prescriptions
BASIC SCENARIO	<ol style="list-style-type: none"> 1) The doctor logs into their profile 2) The doctor selects the current patient 3) The doctor checks whether the patient has experienced any side effects during the treatment 4) The doctor conducts the objective examination on the patient 5) The doctor inserts the data into the patient's profile 6) The doctor checks for other pathologies 7) The doctor analyses the evolution of the pathology to assess whether the treatment is working

	<ul style="list-style-type: none"> 8) The doctor adjusts the patient's treatment (extend the treatment, provide a lighter treatment, provide a different treatment, provide more strict guidelines) 9) The doctor asks the patient whether they want to continue the program 10) The patient answers positively 11) The doctor and the patient schedule the following visit together and add it to the calendar of the app
ALTERNATIVE SCENARIO	<ul style="list-style-type: none"> 1.a. The system does not work <ul style="list-style-type: none"> 1. The doctor alerts the technician 2. The technician solves the problem 3. If the system still does not work, the doctor writes data on paper and then enters into the system 3.a. The patient has had some side effects <ul style="list-style-type: none"> 1. The doctor writes the relative side effects in the treatment section of the app 2. The doctor takes account of it in pt.8 6.a. The patient has additional pathologies other than hypertension <ul style="list-style-type: none"> 1. The doctor suggests a further visit with the needed specialist 2. The doctor gives a temporary treatment to the patient 3. The patient leaves the office 4. The patient makes an appointment 5. The specialist visits the patient 6. The specialist sends the results to the patient and the doctor 7. The doctor views the results 8. The doctor makes an appointment with the patient to finalize the process 10.a. The patient answers negatively <ul style="list-style-type: none"> 1. The doctor excludes the subject from the program (the profile remains in the data server for 10 years, then it is automatically deleted)

TITLE	DATA COLLECTION
DESCRIPTION	Utilizing a hypertension monitoring app daily can significantly enhance treatment efficacy. The app enables real-time tracking of key parameters such as blood pressure readings, medication adherence and lifestyle factors. For this reason, every day the patient must insert data in the app
OBJECTIVE	Monitor the patient's health status
MAIN ACTOR	PATIENT This scenario can be done also by the CAREGIVER if the patient is not auto-sufficient, using the patient's credential
PRECONDITION	The patient has taken the first visit, has the credential and the needed devices
POSTCONDITION	Data is sent to the system
BASIC SCENARIO	<ul style="list-style-type: none"> 1) The patient opens the app <p>Data is displayed on the interface divided into five parts</p>

	<ul style="list-style-type: none"> ○ Fixed section: collects personal data, contact information ○ Flexible section: information about lifestyle factors, heart rate, blood pressure, sleep, the optional notes and the doctor's feedback ○ Treatment section: the patient can visualize their treatment and the consistency of medical intake ○ Educational section: in this area the patient can watch some videos about the hypertension or read guidelines, like the one regarding meals ○ Appointment section: in this area the patient can request an additional appointment independently the follow-up visit <ol style="list-style-type: none"> 2) The watch continuously monitors the hearth rate 3) The watch monitors the quality of sleep 4) The patient inserts the data about the physical activity done during the day, choosing from specific options (none, < 30 min, 30 min – 1 h, 1-2 h, > 2 h) 5) The patient chooses what type of activity they have done from a list: anaerobic, gym, hiking, running ... 6) The patient inserts the data regarding how much the patient has followed the guidelines of meals, selecting from specific values (0=none, 5=completely) 7) The patient inserts how much cigarettes he smoked during the day 8) The patient measures his blood pressure with the sphygmomanometer 9) The patient inserts the values of the sphygmomanometer in the app 10) The patient waits 5 minutes and repeat the previous two pt. 11) The patient skips the possibility to leave some free notes 12) The patient views the weekly notes leaved by the doctor 13) The patient follows the education program, watching videos or reading guidelines regarding hypertension, lifestyle ... 14) The device sends an alert in case of alarming data
ALTERNATIVE SCENARIO	<ol style="list-style-type: none"> 2.a Technical issue with heart rate monitoring <ol style="list-style-type: none"> 1. The patient alerts the technician 2. The technician solves the problem during a call or coming to the house 3.a Technical issue with sleep quality monitoring <ol style="list-style-type: none"> 1. The patient alerts the technician 2. The technician solves the problem during a call or coming to the house 8.a Difficulties to take this measure by themself <ol style="list-style-type: none"> 1. The patient calls a caregiver 2. The caregiver comes and helps him 11.a The patient wants to make some note <ol style="list-style-type: none"> 1. The patient leaves some free notes 13.a Do not have the necessity

	1. The patient skips this section
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TITLE	REQUEST OF AN APPOINTMENT
DESCRIPTION	Requesting an appointment through the phone offers convenience and flexibility to the patients managing hypertension. This streamlined process minimizes the waiting times and facilitates prompt intervention and management of hypertension-related concerns
OBJECTIVE	Schedule an appointment with the doctor
MAIN ACTOR	PATIENT
PRECONDITION	The patient does not feel well
POSTCONDITION	The patient schedules a visit with the doctor
BASIC SCENARIO	<ol style="list-style-type: none"> 1) The patient opens the app 2) The patient access to the section of the app dedicated to scheduling an additional appointment 3) The patient selects the preferred time and date among those available 4) The patient adds an explanation regarding why they need a visit 5) A notification is sent to the doctor 6) The doctor confirms the proposed time and date 7) The patient receives the notification regarding the confirmed appointment 8) The previously scheduled visit is cancelled
ALTERNATIVE SCENARIO	<p>3.a There are no available slots</p> <ol style="list-style-type: none"> 1. The next visit will be the previously scheduled one <p>6.a The doctor does not agree to the new appointment</p> <ol style="list-style-type: none"> 1. The next visit will be the previously scheduled one

TITLE	MONITORING DATA
DESCRIPTION	A website that consolidates patient data for monitoring by the doctor proves invaluable in managing hypertension effectively. This approach enables doctors to track progress and identify trends during patient's treatment
OBJECTIVE	Monitor patient's health status at the same time
MAIN ACTOR	DOCTOR
PRECONDITION	The doctor opens the website weekly
POSTCONDITION	Data are sent to the system
BASIC SCENARIO	<ol style="list-style-type: none"> 1) The doctor logs in on the website Data is displayed on the interface divided into two parts <ul style="list-style-type: none"> ○ Fixed section: collects personal data, contact information, hospital information ○ Patients section: list of following patients with full name and initial data of the hypertensive diagnosis 2) The doctor selects the patient 3) The doctor visualizes the patient data (weekly report) Data is displayed on the interface divided into three parts

	<ul style="list-style-type: none"> ○ Fixed section: collects personal data, contact information, current and past medical history, family medical history ○ Flexible section: there is the weekly report of all the daily information given by the patient through the app (lifestyle factors, heart rate, blood pressure, sleep) and the optional notes leaved by the patient ○ Treatment section: the doctor can visualize the diagnoses, the treatment that the patient is following, the possible side effect and the consistency of medical intake <ol style="list-style-type: none"> 4) The doctor monitors the patient's health 5) The doctor leaves some free notes, given feedback about patient's health during the exanimated week
ALTERNATIVE SCENARIO	<ol style="list-style-type: none"> 1.a Connection error <ol style="list-style-type: none"> 1. The patient calls the technician 2. The technician solves the problem during a call or coming to the office 4.a Alarming data <ol style="list-style-type: none"> 1. The doctor calls the patient 2. The doctor checks personally the patient's health 3. The doctor inserts the result of this examination in the app

TITLE	CREATION OF DOCTOR PROFILE
DESCRIPTION	The technician initiates the creation of the doctor's profile within the software interface. This process entails inputting relevant professional information and configuring access permissions
OBJECTIVE	Every doctor has their own verified account
MAIN ACTOR	TECHNICIAN
PRECONDITION	The software is developed. The doctor wants to participate in the program, so they contact the technician
POSTCONDITION	The doctor gains access to the software platform with their new profile
BASIC SCENARIO	<ol style="list-style-type: none"> 1) The technician logs in 2) The technician creates a profile for the doctor into the system, defining their username and password 3) The technician inserts the doctor's full name, contact information, medical qualifications, the hospital in which they work and its relative information 4) The technician configures access permissions, specifying the areas of the software the doctor can access and any limitation 5) The technician verifies the information entered and confirms the creation of the doctor's profile 6) The doctor receives an email with their login credentials and instructions on how to access the platform

ALTERNATIVE SCENARIO	<p>2.a The technician encounters any errors or missing information during profile creation</p> <ol style="list-style-type: none"> 1. The technician contacts the doctor for clarification or updating the profile accordingly
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TITLE	CREATION OF SIDE EFFECTS ANNUAL REPORT
DESCRIPTION	An emerging trend in hypertensive patient care involves the management of drug treatment side effects through monitoring protocols
OBJECTIVE	Define a trend for side effects intake in hypertensive patients
MAIN ACTOR	TECHNICIAN
PRECONDITION	Some patients are experiencing side effects from the treatment
POSTCONDITION	Doctor receives the annual report
BASIC SCENARIO	<ol style="list-style-type: none"> 1) The technician logs in 2) The technician views the data of all patients (anonymously) in the program that have reported some side effects during the treatment 3) The technician collects all the side effects grouped by drugs code 4) The technician does some natural language processing to analyse the side effect related to each drug 5) The technician stills a report with the summarised information 6) The technician sends the report to the doctor by mail
ALTERNATIVE SCENARIO	<p>3.a. No consistency in drugs codes</p> <ol style="list-style-type: none"> 1) The technician chooses to eliminate or correct the referring line

TITLE	TECHNICIAN'S GENERAL CAPABILITIES
OBJECTIVE	The software functions accurately and reliably
MAIN ACTOR	TECHNICIAN
PRECONDITION	Some issues arise and the technician logs in
POSTCONDITION	The software works correctly
BASIC SCENARIO	<ol style="list-style-type: none"> 1) The technician configures access permissions, specifying the areas of the software the patient can access and any limitation 2) The technician solves technical issues encounter during the patient and doctor's use of the application 3) The technician manages the educational program, updating videos or guidelines designed by healthcare professionals 4) The technician performs software maintenance and updates

6. UML diagrams

In the following section, there are four use-case diagrams, five activity diagrams and one class diagram with their relative description.

6.1 Use Case Diagrams

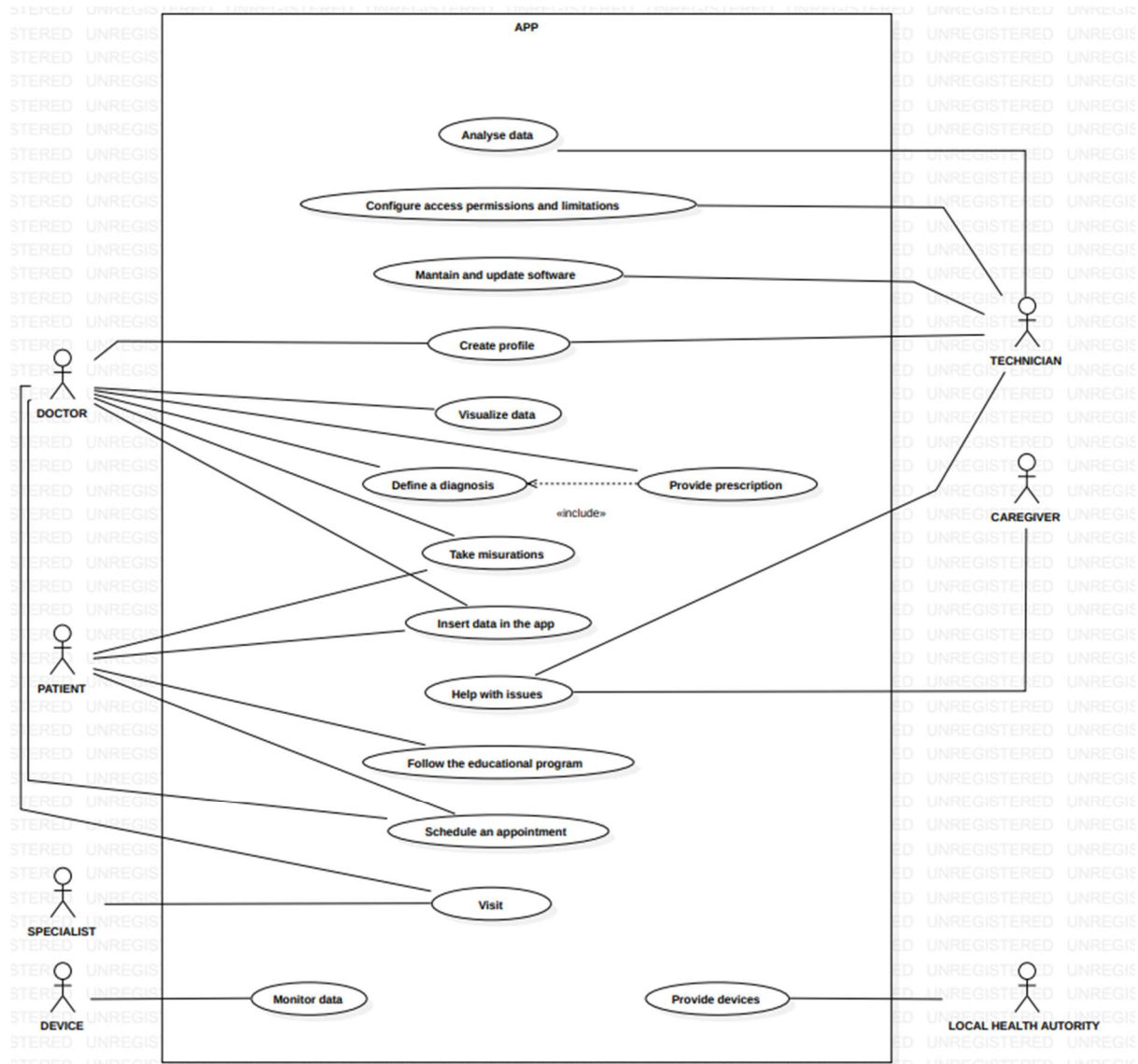


Figure 1: General's use case diagram. In this diagram the main interactions between the actors in the application are presented.

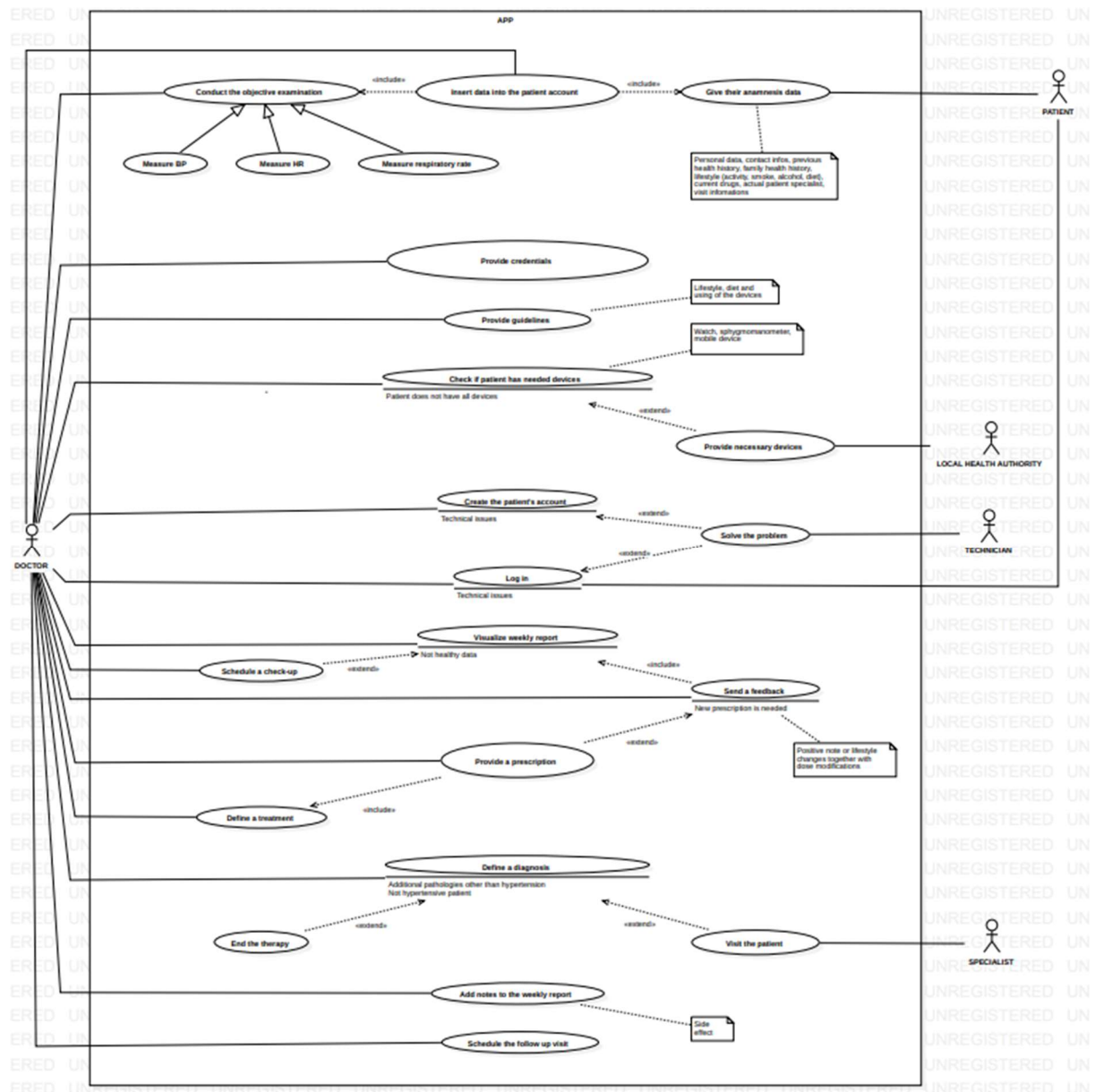


Figure 2: Doctor's use case diagram. In this diagram the main actions of the doctor are presented, which include: examination of the patient and managing the treatment, scheduling the follow-up visits, visualizing the weekly reports and sending a feedback.

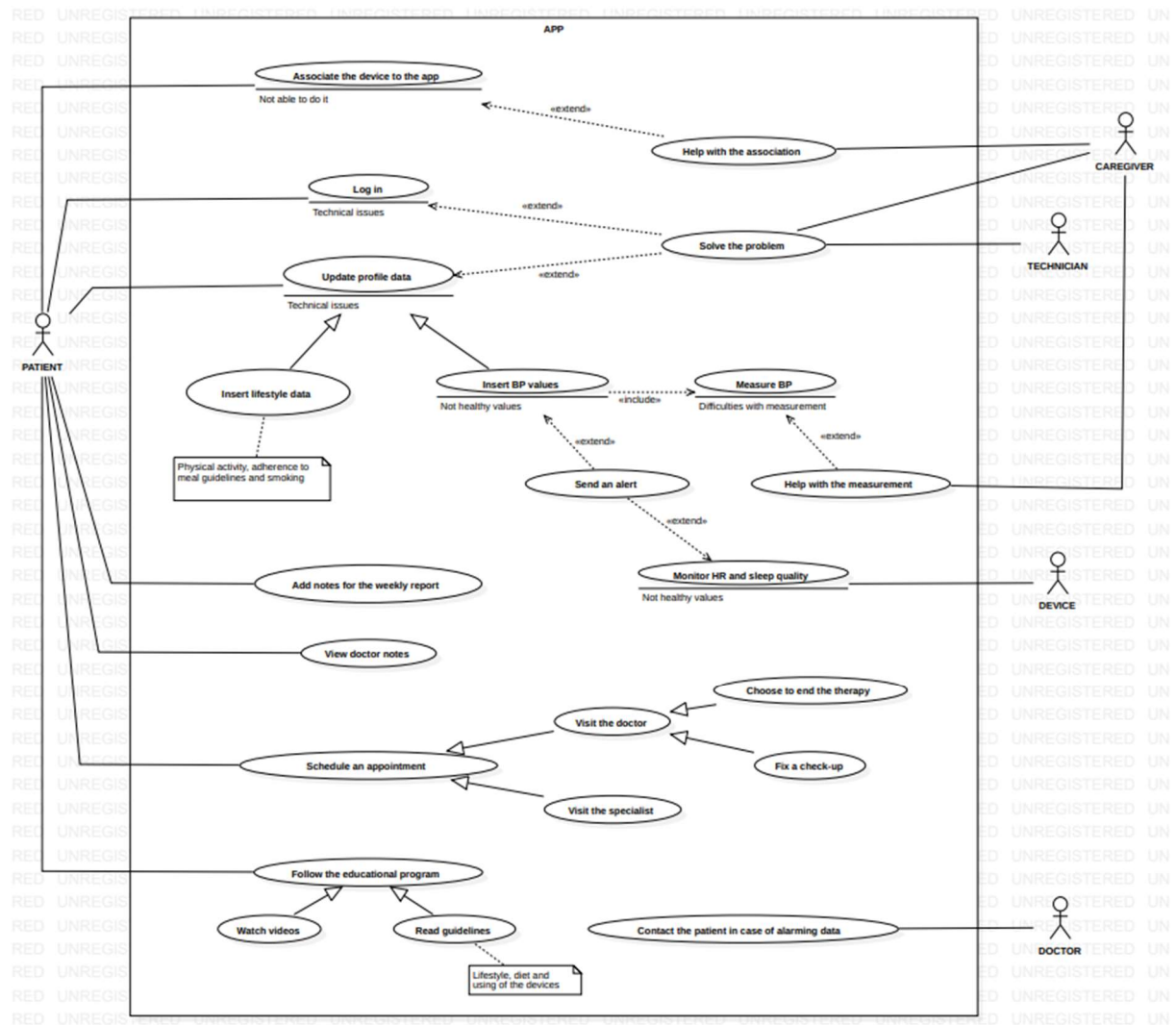


Figure 3: Patient's use case diagram. The main actions carried out by the patient are presented in this diagram. These actions include: data acquisition, scheduling an appointment, following the educational program.

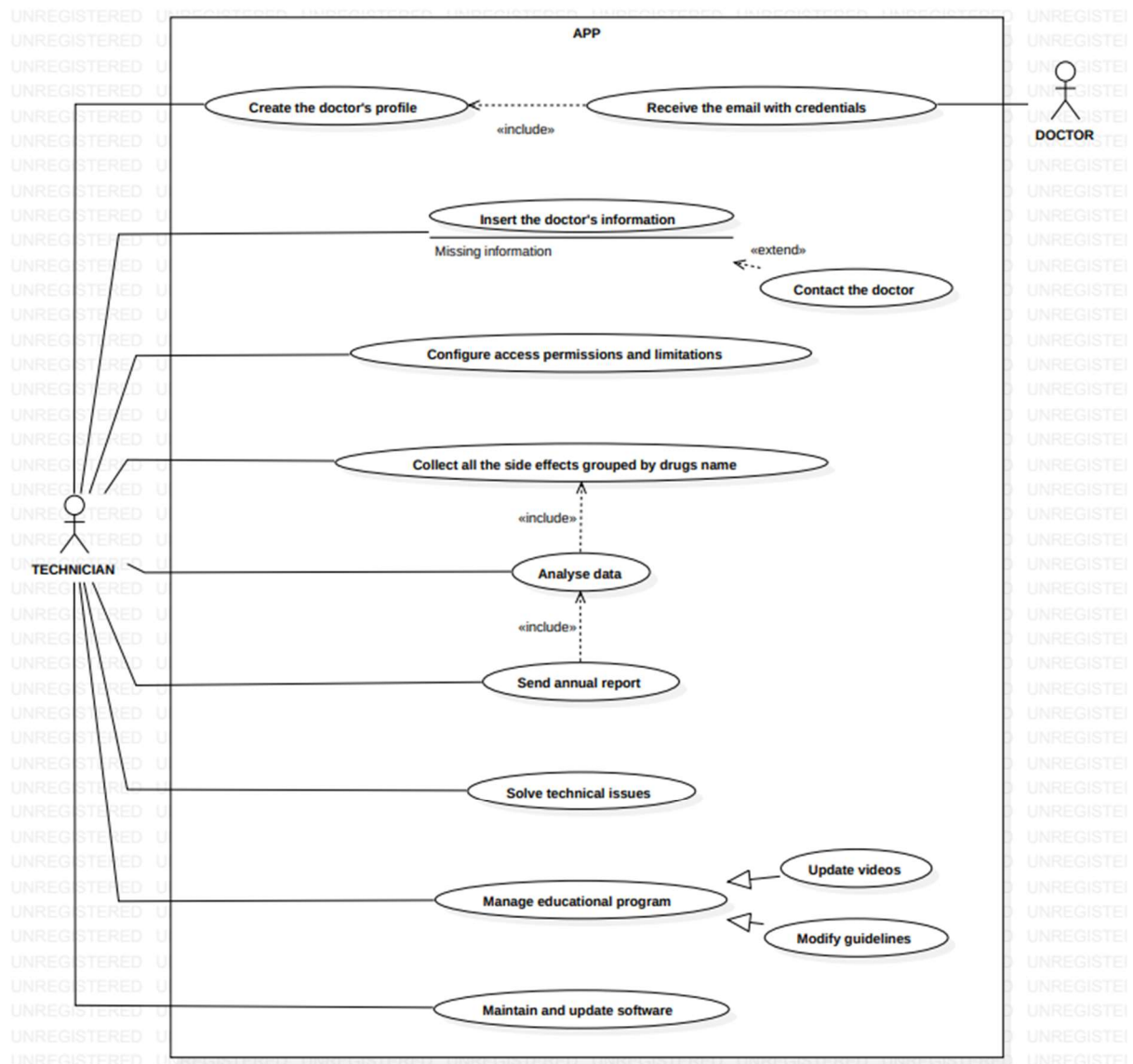


Figure 4: Technician's use case diagram. The actions carried out by technician mainly involve the creation of the profiles, solving technical issues, managing the software, analyzing the data.

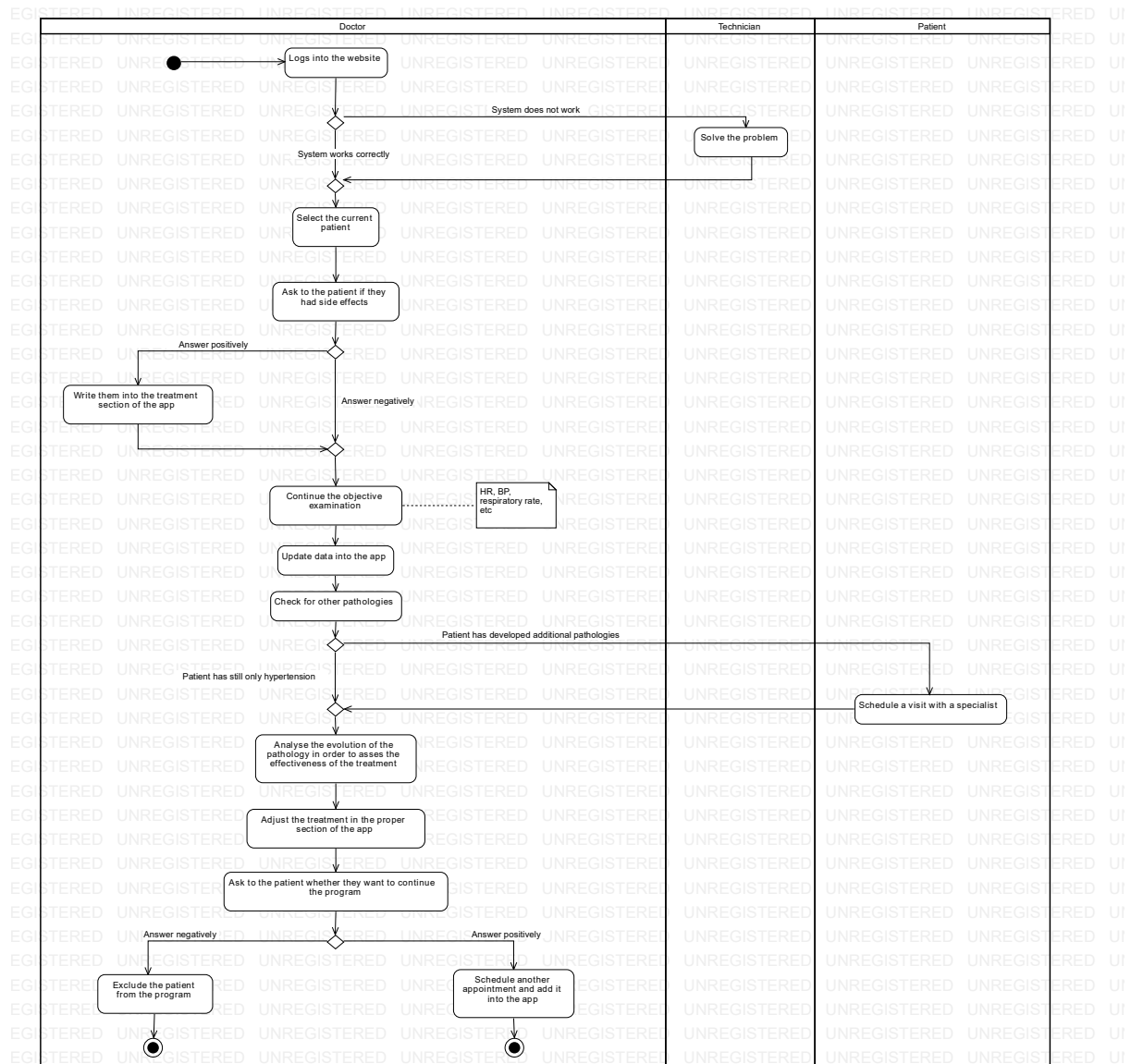


Figure 6: Follow-up visit. The follow-up visit begins with an objective examination of the patient, which includes analyzing the evolution of the pathology and assessing the effectiveness of the treatment.

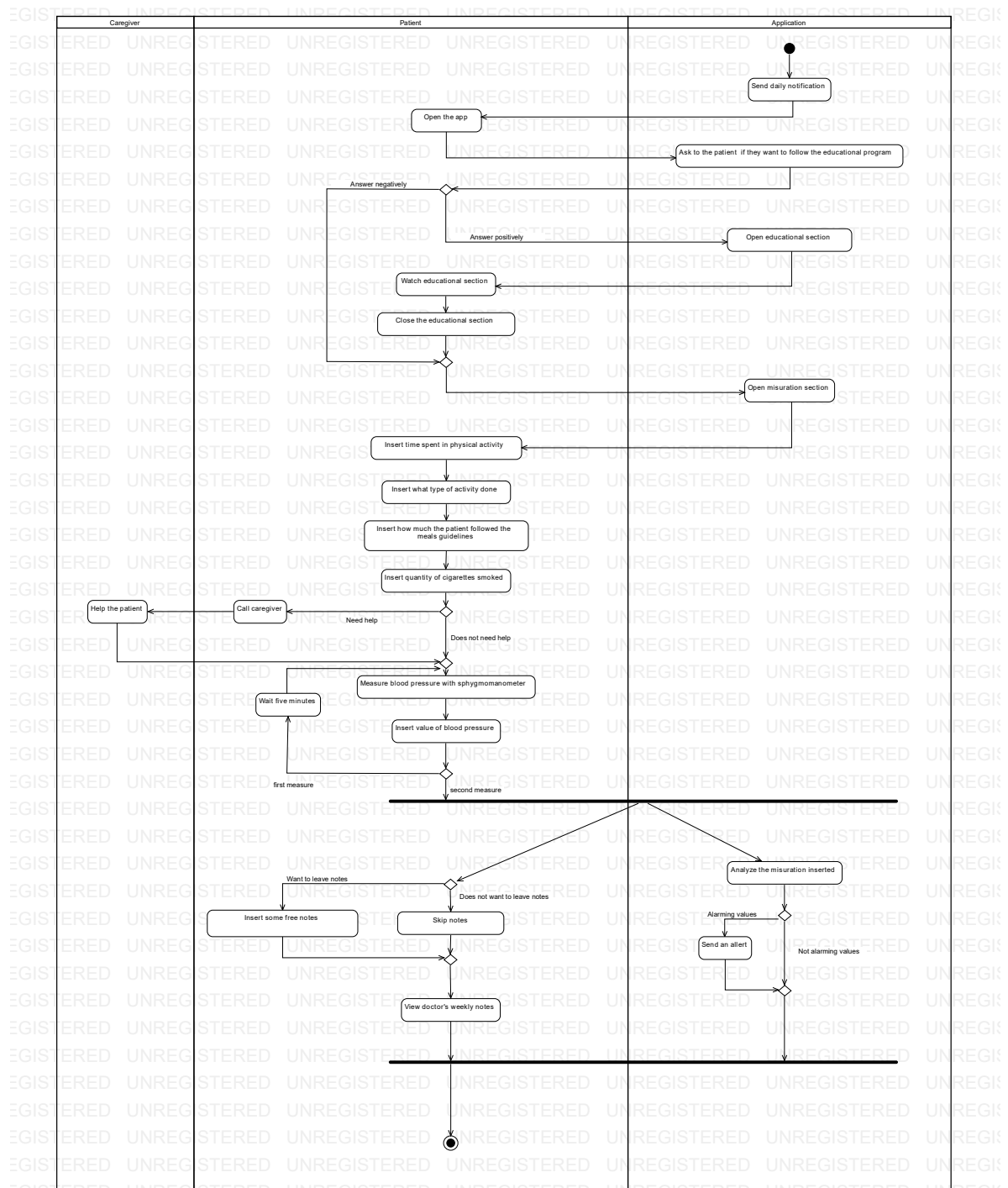


Figure 7: Data collection. The patient is reminded to add its measurements from a notification. The patient measures their parameters and inserts them in the app, together with additional information regarding eventual physical activity, diet and additional notes.

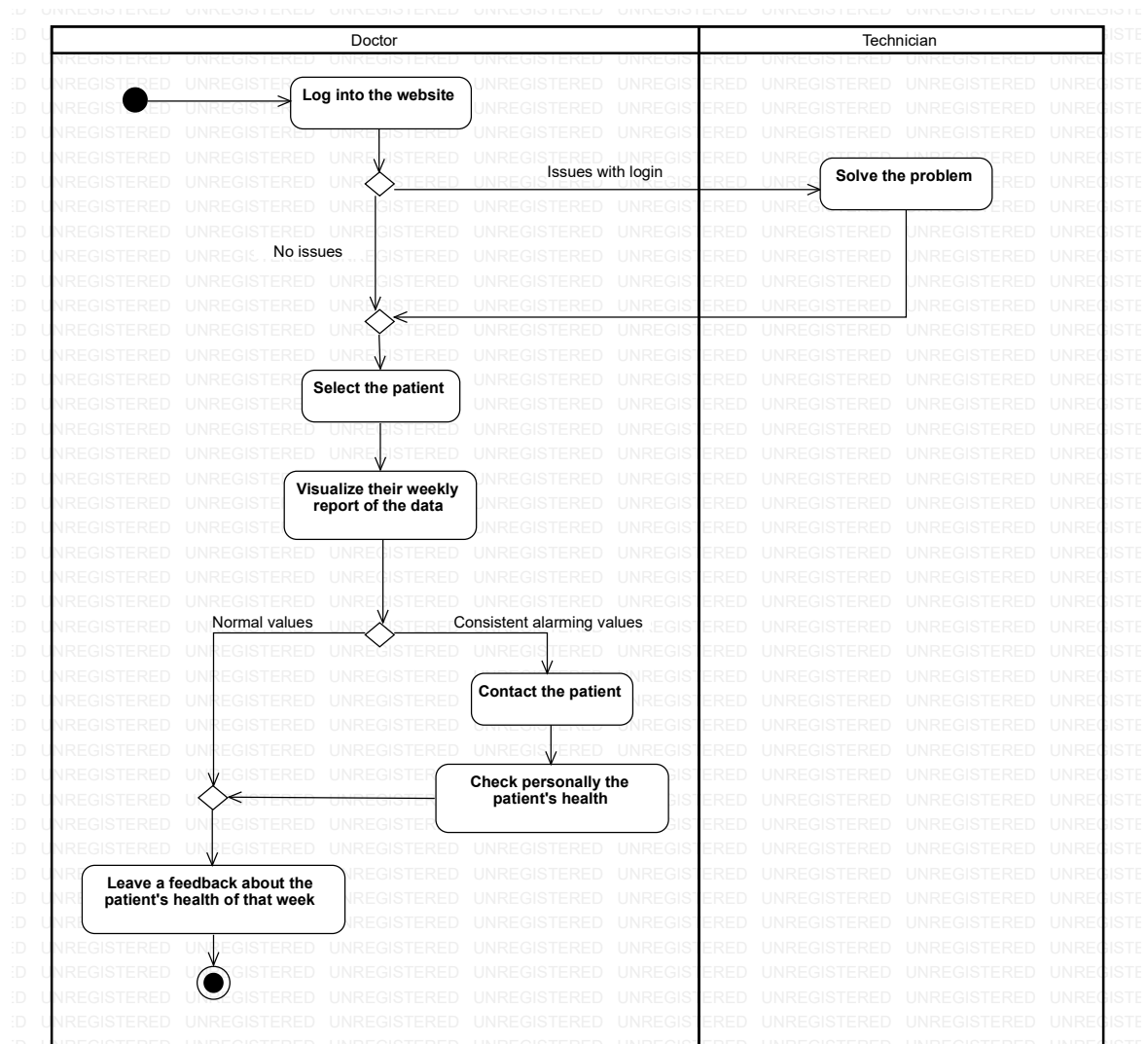


Figure 8: Data monitoring. This diagram illustrates how the doctor keeps track of the data collected during the week leading up, eventually, to a personal check in on the patient.

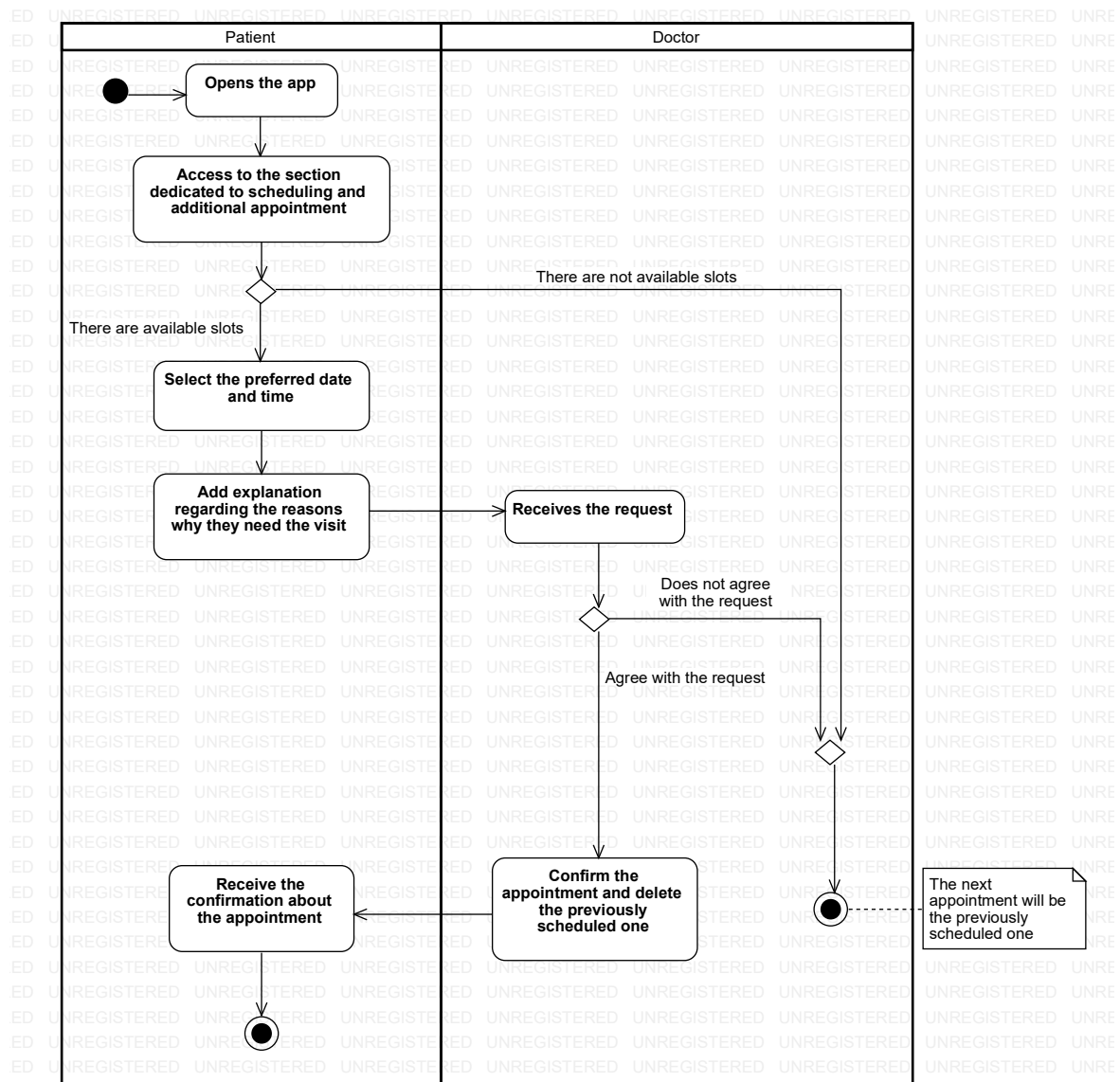


Figure 9: Request an appointment. This diagram presents the main actions that are necessary to request an appointment via the application.

6.3 Class diagram

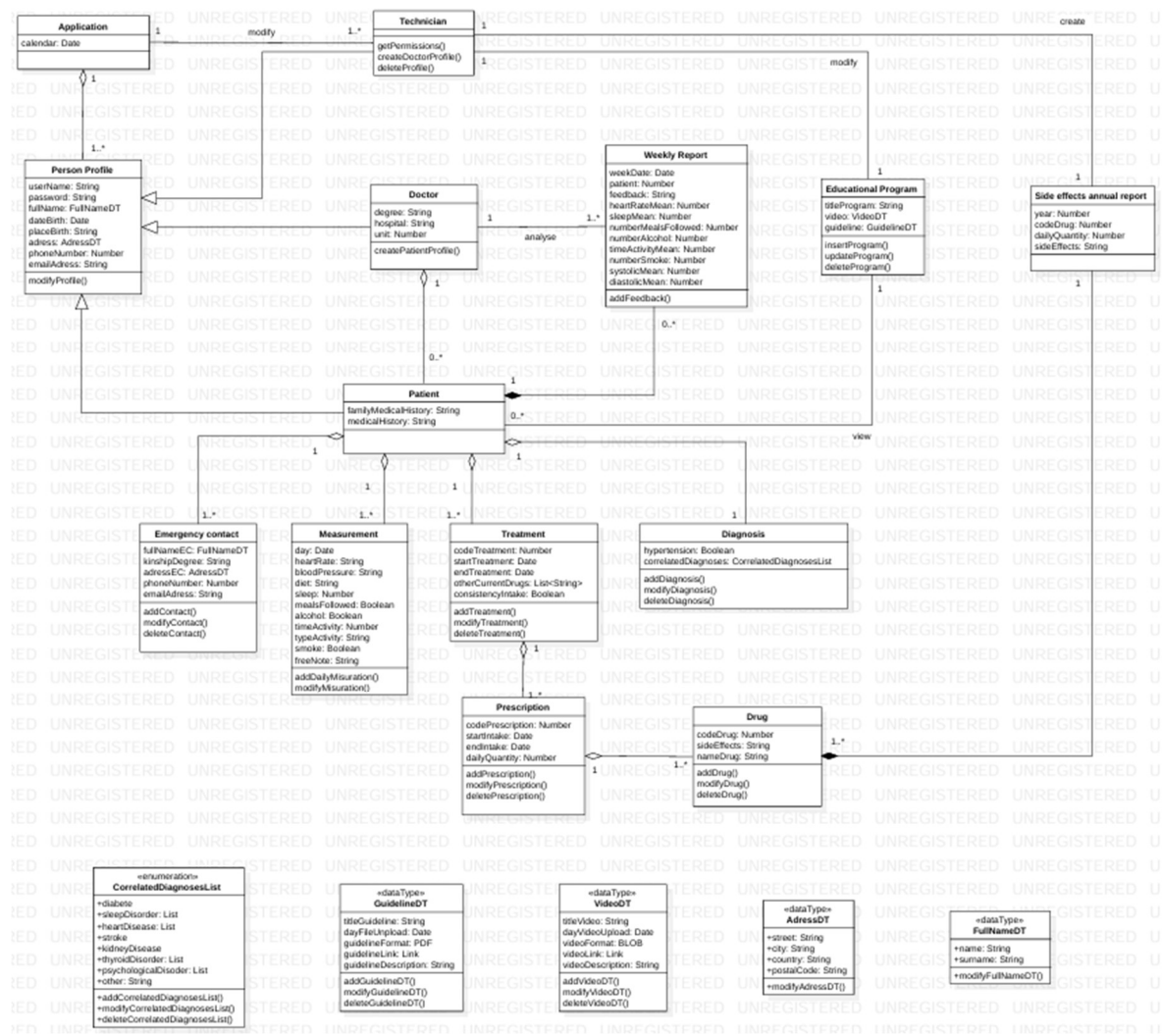


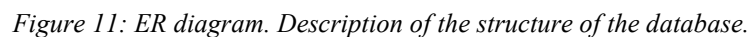
Figure 10: Class diagram. Description of the structure of the database.

6.4 Note

After integrating the ER diagram and the class diagram to ensure consistency between them, we made the following adjustments:

- In 'Weekly report' we added some attributes about the mean of the measurements taken during the week by the patient;
- We rename the entity from 'misuration' to 'measurement';
- In the 'drug' class we delete duration, dailyQuantity and consistencyIntake (these attributes will be added to other class) and add nameDrug, referred to the commercial name, to make 'drug' class a collection of all drugs used during the treatment;
- We add the class 'Diagnosis' to the class 'Patient' creating a more complete entity in the ER diagram;
- We remove the class 'Application' from the ER diagram because it is a collection of all the entities in the diagram;
- In 'Treatment' we incorporated the attributes: otherCurrentDrug and consistencyIntake for a better overview and visualization within the final app;
- In 'Prescription' we introduced 'startIntake', 'endIntake' and 'dailyQuantity'. This was done to enable users to accurately record the start and end dates of medication intake, along with the prescribed daily dosage which are crucial for effective treatment management;
- We added the entity "Appointments" related to the Doctor and to the Patient with all their attributes;
- When we create 'Patient', 'Doctor', 'Technician' entities we specify the full name of each entities.

In the following section, there is the ER-diagram and the relative data dictionary, regarding entity and relationship.



Entity	Description	Attributes	Description	Data type
Patient	The patient is the subject of the study, he is the one that will actively use the app	userNameP KEY	Unique identifier used to distinguish one person from another	Varchar
		password	The password must contain at least 1 lower case letter, 1 upper case letter, 1 numeric character and 1 special character	Varchar
		fullNameP	The full name is composed by name and surname in this order	FullnameDT
		dateBirth	The date of birth has to be expressed according to the	Date

			format day/month/year	
		placeBirth	The place of birth needs to specify city, country in which the patient was born	Varchar
		address	The address needs to express the specific road, city, country in which the patient currently lives	AddressDT
		phoneNumber	Needs to express the patient's phone number and the specific prefix related to its country	Char
		emailAddress	Needs to clearly express the patient's email	Varchar
		familyMedicalHistory	The medical history of the patient's family needs to be specified	Text
		medicaliHistory	The patient's medical history needs to be thoroughly reported	Text
		fullNameEC	Full name of the emergency contact. Equal to fullNameEC in Emergency Contact entity	FullnameDT
		hypertension	A flag which assumes the 1 value if the patient has the hypertension and the value 0 if not	Boolean

		correlatedDiagnoses	A list of possible condition associated with the hypertension	List
		userNameD	unique identifier to link the doctor and the patient. Equal to userNameD in Doctor entity	Varchar
Doctor	The doctor follows the treatment of his own patients, making prescription. He also checks the annual side effect report to update his knowledge	userNameD KEY	Key, unique identifier used to distinguish one person from another	Varchar
		password	The password must contain at least 1 lower case letter, 1 upper case letter, 1 numeric character and 1 special character	Varchar
		fullNameD	The full name is composed by name and surname in this order	FullnameDT
		dateBirth	The date of birth has to be expressed according to the format day/month/year	Date
		placeBirth	The place of birth needs to specify city, country in which the patient was born	Varchar
		address	The address needs to express the specific road, city, country in which the patient currently lives	AddressDT

		phoneNumber	Needs to express the patient's phone number and the specific prefix related to its country	Char
		emailAddress	Needs to clearly express the patient's email	Varchar
		degree	Last degree earned	Varchar
		hospital	Name of the hospital in which the doctor works	Varchar
		unit	Code of the unit in which the doctor works	Integer
Technician	The technician is a person that maintain and update the software	userNameT KEY	Key, unique identifier used to distinguish one person from another	Varchar
		password	The password must contain at least 1 lower case letter, 1 upper case letter, 1 numeric character and 1 special character	Varchar
		fullNameT	The full name is composed by name and surname in this order	FullnameDT
		dateBirth	The date of birth has to be expressed according to the format day/month/year	Date
		placeBirth	The place of birth needs to specify city, country in which the patient was born	Varchar

		address	The address needs to express the specific road, city, country in which the patient currently lives	AdressDT
		phoneNumber	Needs to express the patient's phone number and the specific prefix related to its country	Char
		emailAddress	Needs to clearly express the patient's email	Varchar
Educational program	Set of programs available to all the patient, whose objective is to teach them all the practical guidelines in an easy and effective way	titleProgram KEY	Title of the single program	Varchar
		video	A video that explains clearly the guidelines in question	VideoDT
		guideline	Written guidelines associated to the program	GuidelineDT
Drug	Drug that may be prescribed by de doctor to threat hypertensive cases but also other diseases	codeDrug KEY	Code drug identifier	Integer
		sideEffects	List of side effects associated to the specific drug	Text
		nameDrug	Commercial name of the drug	Varchar
Treatment	A treatment refers to a plan or course of action aimed at addressing	codeTreatment KEY	A unique code associated with the patient's treatment	Integer
		startTreatment	The date in which the treatment began	Date

	a medical condition		expressed according to the format day/month/year	
		endTreatment	The date in which the treatment is expected to terminate expressed according to the format day/month/year	Date
		otherCurrentDrugs	A list of the medicine the patient is currently taking	List
		codePrescription	Prescription code associated with the patient's prescription. Equal to codePrescription in Prescription entity	Integer
		consistencyIntake	Indicates if the patient followed the doctor prescription	Boolean
		userNameP	Identifier to link the treatment to the specific patient	Varchar
Prescription	Electronic order issued by a doctor for defining the information of drugs intake	codePrescription KEY	A unique code associated with the patient's prescription	Integer
		codeDrug	Code drug identifier. Equal to codeDrug in Drug entity	Integer
		dailyQuantity	Daily prescribed dose	Number
		startIntake	Starting date of the drug intake	Date
		endIntake	Ending date of the drug intake	Date

Measurement	This section includes all the measurement that the patient must provide to the doctor through the compilation of various sections of the app.	day KEY	Day of the measurement	Date
		heartRate	Heart rate monitors by the watch	Text
		bloodPressure	Twice a day the patient must acquire 2 times their blood pressure measurements, with a temporal distance of 5 minutes, and add all the values to the app	Text
		diet	The patient can add eventual notes to describe their diet	Text
		sleep	The approximate amount of hours of sleep needs to be specified	Number
		mealsFollowed	The patient needs to estimate whether they followed the meal guidelines or not	Boolean
		alcohol	The patient has to disclose whether they drank any alcohol or not	Boolean
		timeActivity	The patient must add the approximate amount of physical activity carried out throughout the day (in hours)	Number
		typeActivity	The patient needs to specify	Varchar

			the type of physical activity	
		smoke	A flag which assumes the 1 value if the patient is a smoker and the value 0 if not	Boolean
		freeNote	Annotations left by the doctor related to the value recorded by the patient (optionally)	Text
		userNameP KEY	Code regarding the patient which the measurement are link. Equal to userNameP in patient entity.	Varchar
Emergency contact	Information about the person designated to be contacted in case of an emergency involving the patient	fullNameEC KEY	The full name is composed by name and surname in this order	FullnameDT
		kinshipDegree	The level of relatedness between the patient and the emergency contact	Varchar
		address	Emergency contact's home address	AddressDT
		phoneNumber	Emergency contact's telephone number	Char
		emailAddress	Emergency contact's email address	Varchar
Side effects annual report	A report that annually informs the doctor about the most common and important side effects	Year KEY	Report year	Date
		codeDrug	Code drug identifier equal to code drug in Drug entity	Integer

	(associated to the drugs) reported by the patients	dailyQuantity	Daily prescribed dose	Number
		sideEffect	List of side effects correlated to the drug and the dose	Text
Weekly report	Report of the weekly information regarding the patient	weekDate KEY	Starting date of the week and the last date of the week according to the format day/month/year	Date
		fullNameP KEY	Unique identifier used to distinguish one person from another. Equal to userNameP of the Patient entity	FullNameDT
		feedback	Annotations left by the doctor related to the value recorded by the patient (optionally)	Text
		heartRateMean	Mean of the recorded HR in the week	Number
		sleepMean	Mean of the hours of sleep in the week	Number
		numberMealsFollowed	Amount of day on which the patient followed the suggested diet	Number
		numberAlcohol	Amount of alcohol intake during the week	Number
		timeActivityMean	Mean of the hour of activity in the week	Number
		numberSmoke	Amount of cigarettes smoked during the week	Number

		systolicMean	Mean of the SBP in the week	Number
		diastolicMean	Mean of the DBP in the week	Number
Appointments	Scheduled meetings or consultations between patients	appointmentID KEY	Unique identifier code for each appointment	Number
		daytime	Date in which the appointment is scheduled	Date
		reason	Description of the purpose of the appointment	Text
		status	Current state of the appointment	Boolean
		fullNameP	Username of the patient	FullNameDT
		fullNameD	Username of the doctor	FullNameDT

The following table provide a summary of the ER-diagram highlighting the relationships defined between the various entities to illustrate our design choices.

Relationship	Description	Components
Prescribe	The doctor can prescribe no drugs or more than one, vice versa a drug can be prescribed by more doctors or none (it could already be in the database even if not prescribed yet)	Drug Doctor
Definition	The doctor can define no treatment or more than one, vice versa a treatment can be defined by more doctors or none (it could already be in the database even if not defined yet)	Treatment Doctor
Provide	The prescription can be provided by one or more doctors (it must be prescribed for it to be in the database), whereas the doctor can provide zero or more prescriptions	Prescription Doctor
	The patient provides one specific emergency contact, but they can be the emergency contact to many patients	Patient Emergency contact
Include	A prescription must include one or more drugs, while the drug can be included in one or more prescriptions	Drug Prescription
Visualization	A weekly report is visualized by one or more doctors and the doctor visualizes one or more weekly reports (given for granted as otherwise we have a problem with	Weekly report Doctor

	the doctors). The weekly report is automatically generated by the system	
	The side effects annual report is visualized by zero to many doctors, respectively the doctor can visualize from zero to many reports	Side effects annual report Doctor
	The educational program is the same for many patients, while the patients can visualize a single educational program, however they might never actually visualize it	Educational program Patient
Assigned to	The doctor can be assigned to one to many patients, while the patient can be assigned to one doctor only. The link 'assigned to' between patient and doctor includes also the validation of the patient from the doctor, as it is the doctor to add the new patients to the platform	Doctor Patient
Validation	Link between doctor and technician as the technician validates the doctor. The doctor can be validated by one technician, while the technician can validate one or more doctors	Doctor Technician
Creation	The technician can create zero to more side effects annual reports, but the side effects annual reports can be created by one or more technicians, as they can work on it together	Technician Side effect annual report
Modification	The educational program can never be modified (in absence of errors) or modified by one or more technicians	Technician Educational program
Acquisition	The patient acquires one to many measurements (as if they forget to do so the application sends a notification to remind them), and vice versa	Patient Measurement
Manage	A doctor can manage one to many appointments and vice versa	Doctor Appointments
Request	A patient can request one to many appointments and vice versa	Patient Appointments

8. Relational schema

In the following section, there is the translation of the ER diagram into relational schema.

PATIENT(userNameP%, password, fullNameP, dateBirth, placeBirth, address, phoneNumber, emailAddress, familyMedicalHistory, medicalHistory, fullNameEC, codeTreatment, hypertension, correlatedDiagnosis, userNameD)

DOCTOR(userNameD%, password, fullNameD, dateBirth, placeBirth, address, phoneNumber, emailAddress, degree, hospital, unit)

TECHNICIAN(userNameT%, password, fullNameT, dateBirth, placeBirth, address, phoneNumber, emailAddress)

EMERGENCYCONTACT(fullNameEC%, kinshipDegree, address, phoneNumber, emailAddress)

DRUG(codeDrug%, sideEffects, nameDrug)

TREATMENT(codeTreatment%, otherCurrentDrugs, startTreatment, endTreatment, consistencyIntake)

PRESCRIPTION(codePrescription%, startIntake, endIntake, codeDrug, dailyQuantity, codeTreatment)

MEASUREMENT(day%, userNameP%, hearthRate, diet, sleep, mealsFollowed, alcohol, timeActivity, typeActivity, smoke, freeNote, bloodPressure)

WEEKLYREPORT(weekDay%, fullNameP, feedback, hearthRateMean, sleepMean, numberMealsFollowed, numberAlcohol, timeActivityMean, numberSmoke, systolicMean, diastolicMean)

SIDEEFFECTANNUALREPORT(year%, codeDrug, dailyQuantity, sideEffect)

EDUCATIONALPROGRAM(titleProgram%, video, guideline)

APPOINTMENT(appointmentID%, daytime, reason, status, fullNameP, fullNameD)

9. Implementation in MS Access and description of the Graphical User Interface (GUI)

In this section the main structure of the Graphical User Interface (GUI) will be presented, along with a more specific description of its implementation on Microsoft Access.

We implement ER diagram into MS Access, in particular the name of tables with multiple words has been attached for ease of use in MS Access, like 'Weekly Report' become 'WeeklyReport'.

We have implemented the general variables so that they can be visible from all the forms, the variables we have created are:

- Doctor_name: stores the doctor's name.
- Patient_name: stores the patient's name.
- Tec_name: stores the technician's name.
- Week_date: stores the considered week.
- Day_app: stores the specific day.
- code_treat: stores the code associated to the treatment.

The following two forms are similar for each user: the '**user_login**' form is the first page that everyone can see, instead the structure of the login page is equal for each user, but the code refers to the specific table of each user type (patient, technician and doctor).

User_login

In this form there are 3 buttons: Patient, Doctor, Technician. Each button leads to the relative individual page for the login. The buttons were created using the Command Button Wizard following the procedure to make them open another existing form.

Patient_login, Doctor_login, Technician_login

These forms all present the fields for username and password to allow the access to the specific home page. Moreover, there is the possibility to choose whether to hide or show the password. The user can either push the button 'Clear' in order to clear all the fields, or the button 'Login' which, once, clicked, checks if username and password are present in the relative table, otherwise it returns an error. This last section also saves the relative general variable (patient, technician or doctor).

Now we describe the patient section, consisting of a main page leading to subpages.

frmPatientMainPage

This form presents various buttons that lead to the indicated subsection, which are presented below.

Daily measurement whose form is called '**formMeasurement**' and presents various text boxes in which the patient can report the indicated information (day, blood pressure indicated as systolic-diastolic twice a day, what did you eat?, how long did you exercise for?, what type of activity?, free note). Moreover, there are also 3 Check Boxes to answer positively or negatively to the following questions: did you follow the meal guidelines? Did you drink alcohol? Did you smoke?

Some of the previously mentioned information are mandatory (day, blood pressure, did you follow the meal guidelines? Did you drink alcohol, did you smoke?, how long did you exercise for?) and marked by an asterisk.

In this section there are also 2 buttons, one is used to save the data and store it in the table Measurement, the other one, 'Go to home page', is used to go back to the patient's home page.

Educational program, whose form is called '**frmGuidelineSelection**' which presents the option to choose the title of the guidelines with the use of a Combo Box from which they can choose among all the programs, and then press a button called 'Show guidelines' which leads to the specific guideline.

The page in which the guideline details are showed (the form is called '**GuidelineDT**') presents the title of the guideline, its description, a button that leads to a YouTube video or a web page with additional information, a button that allows to go to the previous page and a button that allows to go back to the home page.

Request an appointment, opens a form called '**frmAppointment**', presents two Combo Box, one allows the patient to select a doctor, the other one updates based on the doctor selected and allows to also select a slot for an appointment. Moreover, it also presents a Text box in which the patient can specify the reason for the appointment. Finally, there is a button called 'Request an appointment' to confirm the selection, this action opens a notification which states 'Appointment booked.', sends a notification to the doctor and update the relative tables. Finally, there is a button that allows to go back to the home page.

See your treatment opens a form called '**frmSeeTreatment**' in which there is a Combo Box that allows the selection of the specific treatment, among all the treatments. Then the button 'check treatment' needs to be clicked, leading to the display of additional text boxes: Start treatment and End treatment; along with a Combo Box that allows to select the drug and a button called 'See drug' which opens the details about the specific drug with texts called 'Start intake', 'End intake', 'Daily quantity'. Finally, the usual 'Go to home page' button is also present.

View general info opens a form called '**sfrmPatientInfo**' which displays the various information of the patients through different Text boxes, including Username, Password, Full name, Date of birth, Place of birth, Address, Phone number, Email address, Family medical history, Medical history, Full name emergency contact, Correlated diagnoses; and a Check Box for Hypertension. Finally, the usual button 'Go to home page'.

Any problems? opens a form called '**frmEmergencyContact**' which presents 3 buttons: 'Call Doctor', 'Call Technician', 'Call Caregiver'. These buttons allow the patient to call one of the previously mentioned actors in case of any problems.

Now we describe the doctor section, consisting of a main page leading to subpages.

frmDoctorMainPage

This form presents various buttons that lead to the indicated subsection, which are presented below.

View patient weekly report opens a form called '**sfrmWeeklyReport**' that reviews the detailed weekly health data of their patients. This information is automatically collected and averaged by an algorithm, providing a comprehensive overview of the patient's condition.

This form includes Start day of the week examined, Write feedback which is a text box where the doctor can input and save feedback for the patient, Heart Rate mean, Hours mean of sleep, Number of meals followed, Rate of alcohol intake, Mean of time spend in activity, Rate of smoke, Diastolic blood pressure mean, Systolic blood pressure mean. Fields marked with an asterisk (*) are rated from 1 to 5, indicating a scale from 'bad' to 'very good'.

Some of these fields are marked with the * that are represented from 1 to 5 with a score of bad and very good. Finally, there is the usual button 'Go to home page'.

View general info opens a form called '**sfrmDoctorInfo**' that represents the various information of the doctor through several Text boxes, including Username, Password, Full name, Date of birth, Place of birth, Address, Phone number, Email address, Degree, Hospital, Unit. Lastly, there is the usual button 'Go to home page'.

See your appointments opens a form called '**frmAppointmentDoctor**'. Firstly, there is a combo box labelled 'Select patient' (drop-down list) that allows the doctor to select a patient from the "Patient" table containing all patient data. Next, there is a text box labelled 'Day' to display the date of the

appointment selected by the patient, and a text box labelled 'Reason' to show the reason for the appointment request written by the patient. Finally, a checkbox labelled 'Status' indicates the status of the appointment.

Afterward, the 'Save appointment' button saves the appointment details into the database, and the 'Delete appointment' button removes the selected appointment, both send a message to the patient with the new status of their appointment. Finally, the 'Go to home page' button redirects the user to the main page of the system.

Report inconsistency in a treatment opens a form called '**frmCheckTreatment**' which present two sections: one for feedback on a current treatment and the other to report the side effect of the drugs. The first is structured with a combo box for the selection of the treatment, a check box to click if the patient has been consistent during the treatment and a button 'Save consistency' to save the status. This section is implemented to have a global view of the values: if the values during therapy did not improve, one cause could be that the patient did not follow the prescribed therapy. The other section is composed with a combo box for the selection of the drug and a button 'View side effects' to show the list of the side effects of the choose drug. After clicking on the button appears a text box, in which are present the side effects already reported and in which you can add new ones, and a button 'Save side effect' to update the list of them. Finally, the usual button 'Go to home page'. All save buttons update the relative tables.

Define a treatment opens a form called '**frmDefineTreatment**' composed by a combo box for the selection of the patient, a text box to define the unique name of the treatment (for better research, it is recommended that the doctor report in the patient's name in the treatment definition e.g. Initial treatment IRENE CARIDI), two text boxes for the selection of the start and end day of the treatment and a button 'Save' for save the data. After clicking of the button, a list box containing all the drugs appear and another button 'Save'. Thanks to this list the doctor can add all the drugs that the patient is taken outside the prescribed treatment and save them. At the end there is a button 'Write a prescription' that opens a form '**frmDefinePrescription**' to add all the needed prescription for the treatment. Finally, the usual button 'Go to home page'.

In the '**frmDefinePrescription**' form there is six text boxes and a button 'Save the prescription' to save the written prescription. The first text box contain the number of the prescription and it is automatic compiled and, also the last is automatic compiled with the referring treatment, thanks to the general variable code_treat; in the others the doctor can add all the needed information for make the prescription such as the initial and final day on which the drug is to be taken, the name of the drug and the daily quantity. After clicking on the button save, it opens a form called '**sfrmAddPrescription**'. Finally, the usual button 'Go to home page'.

In the '**sfrmAddPrescription**' form there is a button 'Add another prescription' that allows you to add a new prescription by opening the '**frmDefinePrescription**' form with the update code prescription. Finally, the usual button 'Go to home page'. All save buttons update the relative tables.

Add a patient opens the form called '**frmAddPatient**' composed by 13 text boxes and a check box in which the doctor can add the information relating to the patient that want to start the program. The doctor with the patent during their first visit set up the profile with credentials, anagraphic data, their medical history and the one related to their family. They also check the hypertension check box if the patient as already a diagnosis of hypertension, add correlated diagnoses and the username of the doctor to link these profiles together. At the add save the information by clicking of the button 'Add'. Finally, the usual button 'Go to home page'. All save buttons update the relative tables.

Any problems? opens a form called '**frmECDoctor**' which presents the button 'Call Technician'. This button allows the doctor to call the technician in case of any problems.

Now we describe the technician section, consisting of a main page leading to subpages.

frmTechnicianMainPage

This form presents two buttons that lead to the indicated subsection, which are presented below.

Add doctor opens the form called '**frmAddDoctor**' composed by 11 text boxes containing the information needed to add the doctor in the program. To add a doctor the technician needs to fill the text boxes with the corresponding information, including the degree, the hospital and the work unit, then to save the information by clicking the 'add' button; finally, can return to home page by clicking the button 'go to the home page'. All save buttons update the relative tables.

View general info opens a form called '**sfrmTechnicianInfo**' that represents the various information of the technician through several Text boxes, including Username, Password, Full name, Date of birth, Place of birth, Address, Phone number, Email address. Lastly, there is the usual button 'Go to home page'.