

**POLITECNICO DI MILANO**



# **TELEMEDICINE MONITORING SYSTEM FOR HYPERTENSIVE PATIENTS**

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Medical Informatics

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## PURPOSE

The purpose of the project is the design and implementation of a comprehensive monitoring system for people suffering from hypertension, with the aim of improving the management and treatment of this prevalent cardiovascular condition. Indeed, it is widely spread worldwide and it is really important to use digital tools like this to measure and monitor some useful parameters that could help to maintain the situation under control and, in the best case, to also avoid, prevent and reduce the onset of other pathologies, such as diabetes, other cardiovascular diseases, nephropathies, retinopathy, and so on. Indeed, in our system we have tried to consider many factors that could give the physician all the tools to evaluate in toto the patient status, therefore not only parameters strictly connected to a situation of high blood pressure, but also questionnaires, measurements that are indexes of other common comorbidities and lifestyle behaviors. Everything is done keeping in mind as final goal the health of the patient to whom we want to assure the best possible therapy and care. By developing an innovative solution, this project seeks to address the challenges associated with hypertension monitoring, empower patients and facilitate health care professionals in delivering personalized care. During modeling, we adopt the perspective of each individual user, defining their tasks and developing methodologies to execute them in the simplest and most intuitive way possible, thereby making the system as user-friendly as possible.

Designing the system, we assumed that each patient could interact with several specialized physicians according to the patient's clinical needs. The system is thought both for specialized practitioners and clinics that includes other health care providers. In the latter perspective, it can be useful to introduce another user belonging to the clinic environment that could manage the patient from another point of view with respect to the physician (e.g. a nurse that has to deliver a drug to one patient).

Furthermore, to fully manage the patient's condition it can be useful to assess their risk. To better evaluate the overall status, considering as many useful information as possible, we assume the usage by the system of an already trained machine-learning classification algorithm able to establish whether the patient is in a risky situation. In fact, it has been demonstrated a strong evidence of the relationship between cardiovascular diseases related to hypertension and several parameters like: sex, age, systolic blood pressure, diastolic blood pressure, smoking, BMI, comorbidities, etc. From the literature, it emerges that many solutions currently implemented can be tailored to our needs. [1][2][3][4][5]

This monitoring system assures a daily registration of data that are central to hypertensive patient's status assessment, that are uploaded both manually and through wearable devices synchronized with the system.

To promote a sense of collectivity achievable via communication among patients, we designed in the system a forum section. Through the latter, it is also possible to inform the patient with lifestyle suggestions referred to hypertension, increasing a sense of awareness in living with the pathology. This brings effective self-management, together with decreasing patients' reliance on health care system.

## CONTEXT ANALYSIS

### HYPERTENSION AND MONITORING SYSTEM

Hypertension is a chronic medical condition characterized by elevated blood pressure levels in the arteries. The World Health Organization (WHO) estimated that 1.28 billion adults aged 30–79 years worldwide have hypertension, most (two-thirds) living in low- and middle-income countries. About 46% of adults with hypertension are unaware that they have the condition, and approximately 1 in 5 adults (21%) with hypertension have it under control [6]. In this panorama our system has as main aim to increase the percentage (21%) of people having hypertension under control.

Unhealthy lifestyle habits such as a sedentary lifestyle, poor dietary choices (excessive salt intake, low potassium intake), obesity, excessive alcohol consumption, and smoking can contribute to the development of hypertension. In this view thanks to the forum section, it is possible to give health lifestyle advice.

Family history, genetic predisposition and patient's anamnesis play an important role in hypertension. Certain genetic variations can influence blood pressure regulation and increase the likelihood of developing the condition. To consider this important influence on the pathology, from the start of the monitoring, the patient is able to upload on the system, in the personal section, not only optional personal data, but also family and clinical history, useful for the monitoring.

Hypertension is defined as a complex condition, and the treatment approach may vary based on individual circumstances. The management typically involves a combination of lifestyle modifications and medication prescribed by physicians. The possibility to upload and consult medical prescriptions by physician and patient side, respectively, results fundamental.

As regards medications, various antihypertensive medications are available to control blood pressure. These include diuretics, beta-blockers, ACE inhibitors, angiotensin II receptor blockers (ARBs), calcium channel blockers, and others.

It is well-known that hypertension is associated with several comorbidities, which are additional medical conditions that often coexist with hypertension. For this reason, while designing this system, we have to be aware of which are the main comorbidities, because in this way we can add other more specific analysis and measurements we want the patient to insert if necessary. To allow the adding of these measurements is important to give the physician, who recognizes the comorbidity, the possibility to ask the technical administrator the new parameter or new questionnaire system upload (if that parameter/questionnaire does not exist on the system yet) and so to select the new measurement useful for that patient monitoring. Below we recall some of the major hypertension-related comorbidities. Among these we have: Cardiovascular diseases (coronary artery disease, heart failure, and stroke); Kidney disease; Diabetes (often coexist and increase the risk of developing complications); Metabolic syndrome (abdominal obesity, high blood sugar levels, high triglycerides, and low levels of HDL cholesterol); Mood and sleep disorders.

## MEASUREMENT TOOLS

Regular monitoring, timely intervention, and adherence to treatment plans are crucial in effectively managing hypertension and reducing the risk of associated complications. The monitoring system relies on the systematic use of measurement tools such as validated questionnaires, wearable devices and other measuring instruments that the patient can have at home, such as sphygmomanometers, to observe outcomes and support clinical decision-making. For deciding which wearable device we want to include in our system, a research on the available and certified wearable devices has been done, in order to assess if some parameters could effectively be measured at home in an effortless way.

The research conducted involves finding devices through which acquire parameters of interest, allowing the evaluation of their advantages and disadvantages. The analysis covers various wearable devices, including: BPM Core (a certified sphygmomanometer, capable of monitoring blood pressure but bulky to wear frequently); Whoop Strap (a soft bracelet capable of monitoring heart, sleep, strain and recovery, but not FDA-approved); Oura Ring (a titanium ring capable of monitoring PPG and heart rate, but not ABP); Textiles and patches (such as smart shirts or smart wrist covers, impractical for daily monitoring); Smartwatches.

HUAWEI WATCH D is what we recommend considering pros and cons. It is a smartwatch introduced to the Chinese market in 2021 and to the European market in 2022, priced at €350. It can measure blood pressure, heart rate, monitor sleep, stress, and body temperature and its battery can last up to 7 days. With compatibility for both iOS and Android, users can effortlessly share all these parameters afterward. Thanks

to the blood pressure measurement technique using an inflatable cuff within the watch band, whether you follow the protocol [7], the watch results CE certificated in blood pressure measurement.

The following table groups the measurements we are interested in acquiring to monitor the patient. The frequencies listed are subject to change depending on the patients' needs.

Not all the questionnaires are compulsory for all the patients, but we assume that at least two of them (MMAS-8 and EuroQol-5D) are mandatory. The other can be prescribed to the patient according to the physician's evaluation, hence their frequency is decided by the doctor.

As far as the examinations are concerned, some of them are generally recommended also for healthy subject and, according to the patient's requirements, the physician can vary the frequency to provide them. For the remaining examination they can be occasionally scheduled for a certain patient's condition to be monitored.

NAME	METHOD	FREQUENCY	EVIDENCE
<b>PARAMETERS</b>			
<b>Systolic blood pressure</b>	From wearable device or manually inserted	Everyday	Monitoring blood pressure is the most straightforward method for assessing hypertension, a condition characterized by consistently elevated blood pressure. [8]
<b>Diastolic blood pressure</b>			
<b>Heart rate</b>	From wearable device or manually inserted	Everyday	Hypertension can lead to an increased resting heart rate as the heart works harder to pump blood against elevated pressure in the arteries. [8], [9]
<b>Weight</b>	Manually inserted	At least once a trimester	The relationship between weight and hypertension is characterized by excess weight, being a significant risk factor for developing high blood pressure. [10], [11]
<b>Circadian rhythms</b>	From wearable device	Everyday	Disruption to circadian rhythms, such as poor sleep, can contribute to high blood pressure. [12]
<b>Sleep hours</b>			
<b>Steps number</b>	From wearable device or manually inserted	Everyday	Exercise improves cardiovascular health and reduces stress, leading to lower blood pressure levels and better overall hypertension management. [13]
<b>Physical activity hours</b>			
<b>Burnt Calories</b>			
<b>Glycemia</b>	Manually inserted	Everyday in case of diabetic patient	Monitoring glycemia in hypertensive patients with diabetes is essential for reducing the risk of cardiovascular complications, optimizing treatment outcomes. [14]
<b>QUESTIONNAIRES</b>			
<b>MMAS-8- Morisky Medication Adherence Scale</b>	Manually filled out	At least every semester	Monitoring adherence to hypertensive therapy is essential for ensuring the effectiveness of treatment, optimizing treatment plans. [8]
<b>Block FFQ-Block Food Frequency Questionnaire</b>	Manually filled out	Chosen by the physician	Assessing dietary intake and food habits over time in relation to hypertension is crucial for identifying dietary patterns, adherence to recommendations and preventing complications. [15]

<b>AUDIT-Alcohol Use Disease Identification Test</b>	Manually filled out	Chosen by the physician	Monitoring alcohol consumption in relation to hypertension is crucial because excessive drinking can raise blood pressure, interact with medications and contribute to cardiovascular complications.[16]
<b>CPSS-Cohen's Perceived Stress Scale</b>	Manually filled out	Chosen by the physician	Monitoring stress levels is important for hypertension since it can raise blood pressure, affect lifestyle changes, and contribute to cardiovascular issues. [17]
<b>PSQI-Pittsburgh Sleep Quality Index</b>	Manually filled out	Chosen by the physician	Poor sleep quality can worsen hypertension in patients by disrupting blood pressure regulation and contribute to elevated blood pressure levels. [18]
<b>EuroQol-5D (Quality of life)</b>	Manually filled out	At least every semester	The quality of life impacts hypertension by influencing psychological well-being, lifestyle habits, treatment adherence, social support, and overall health outcomes. [19]
<b>PHQ-9-Patient Health Questionnaire (Depression)</b>	Manually filled out	Chosen by the physician	Depression can impact hypertension by increasing sympathetic nervous system activity, promoting unhealthy lifestyle habits, reducing treatment adherence, all of which can worsen blood pressure control and increase cardiovascular risk. [20]
<b>EXAMINATIONS</b>			
<b>Blood analysis</b>	Inserted as medical report	At least every semester	Blood analysis is a critical component of hypertension management, providing valuable information for risk assessment, detection of organ damage, evaluation of treatment response, identification of secondary causes, and monitoring for complications [8],[21],[22]
<b>Urinalysis</b>	Inserted as medical report	At least every semester	Urinalysis is a valuable tool for monitoring hypertension as it provides information about kidney functionality, detects secondary causes of hypertension, monitors medication side effects and assesses cardiovascular risk. [23]
<b>ECG</b>	Inserted as medical report	At least every semester	ECG is essential for assessing heart functionality, detecting arrhythmias and ischemic changes, evaluating treatment effects, establishing a baseline, and monitoring changes due to hypertension over time. [8], [24]
<b>Fundus oculi</b>	Inserted as medical report	Chosen by the physician	Fundus oculi examination is essential for monitoring hypertensive patients as it allows for the assessment of hypertensive retinopathy. [25]
<b>Endocrine analysis</b>	Inserted as medical report	Chosen by the physician	Endocrine analysis for hypertensive patients helps detect hormonal imbalances and monitors treatment effectiveness. [26]

## TEXTUAL DESCRIPTIONS

The textual descriptions below aim to explain the main actions that the principal users involved in the monitoring system can perform through the platform. The users allowed to use the software are:

- Physician
- Patient
- Technical Administrator
- Other health care provider (nurse, physiotherapist, psychologist, nutritionist and others).

The same scheme is always followed in order to represent them in the most comprehensible and clear way: the title of the activity described is specified in the first row, followed by the objective in which the main aim of the activity is presented, then the main actors involved are specified and the precondition and the postcondition defined refer to the starting and ending points of the activity, respectively; after that the basic scenario is reported, which is the one following the ideal course of events, while the alternative scenario explores the path of actions that could be followed if something does not go as planned.

These textual descriptions are representative of everything that is going to be modelized through all the diagrams in this report.

After the step 1 where the patient has been prescribed to use the telemedicine system:

Title	LOG-IN
<b>Objective</b>	User logs in the software.
<b>Main actor</b>	User (Specialized practitioner, Patient, Other health care provider, Technical administrator).
<b>Precondition</b>	User has already opened the software.
<b>Postcondition</b>	User has logged in.
<b>Basic scenario</b>	<ol style="list-style-type: none"><li>1. The software verifies if the system is available for the usage</li><li>2. The software displays the boxes for inserting username and password, and the option "Forgotten username or password"</li><li>3. User inserts log-in credentials</li><li>4. The software checks the validity of the data</li><li>5. The software shows the homepage</li></ol>
<b>Alternate scenario</b>	<ol style="list-style-type: none"><li>1.a The software is under maintenance<ol style="list-style-type: none"><li>1. The software shows the error message "System under maintenance"</li></ol></li><li>3.a. The user clicks on "Forgotten username or password"<ol style="list-style-type: none"><li>1. The software asks username or contact email</li><li>2. The user inserts the information requested</li><li>3. The software verifies the profile's existence</li><li>4. The software sends the new log-in credentials to the contact email, otherwise shows the error message "User not found"</li></ol></li><li>5.a. Wrong username or password<ol style="list-style-type: none"><li>1. The software shows the error message "Wrong username or password"</li><li>2. Return to 1</li></ol></li></ol>

<b>Title</b>	<b>PHYSICIAN OR OTHER HEALTH CARE PROVIDER'S PROFILE ACTIVATION</b>
<b>Objective</b>	Creation and activation of Physician or Other health care provider's profile.
<b>Main actor</b>	Technical administrator, Physician, Other health care provider.
<b>Precondition</b>	A new Physician or Other health care provider decides to join the monitoring system.
<b>Postcondition</b>	A new Physician or Other health care provider's profile is added to the database.
<b>Basic scenario</b>	<ol style="list-style-type: none"> <li>1. By PEC the user sends the request of profile creation and activation to the Technical administrator</li> <li>2. The Technical administrator asks their personal information (Surname, Name, fiscal code (CF), Telephone number, Work address, Specialization/Role)</li> <li>3. The user sends the requested information</li> <li>4. The Technical administrator logs in the system and selects the option "Add new user"</li> <li>5. The software shows the options: "Physician", "Other health care provider", "Technical administrator"</li> <li>6. The Technical administrator selects "Physician" or "Other health care provider"</li> <li>7. The Technical administrator manually inserts the personal user's data in the database</li> <li>8. The software checks the validity of the data</li> <li>9. The software sequentially generates a unique username</li> <li>10. The software associates the username with the user profile</li> <li>11. The software sends the user the username and a link for the password creation</li> <li>12. The user creates the password within 48h (respecting the security policies)</li> <li>13. The software associates the password with the user profile</li> <li>14. The software adds the profile in the database</li> </ol>
<b>Alternate scenario</b>	<p>9.a Invalid data</p> <ol style="list-style-type: none"> <li>1. The software shows the error message "Invalid data"</li> <li>2. The Technical administrator verifies to have correctly inserted the user's information (if not, return to 7)</li> <li>3. The Technical administrator asks again the information to the user</li> <li>4. Return to 7</li> </ol> <p>9.b The data are already associated with an existing profile</p> <ol style="list-style-type: none"> <li>1. The software shows the error message "User already present in the database"</li> <li>2. The Technical administrator communicates the user that the profile is already active</li> </ol> <p>12.a The password is not created within the 48h</p> <ol style="list-style-type: none"> <li>1. The software unlinks the username from the profile</li> <li>2. The software deactivates the link for the password creation</li> <li>3. The software sends the user, via PEC, the information of closure of the activation procedure</li> </ol> <p>12.b The inserted password does not respect security policy</p> <ol style="list-style-type: none"> <li>1. The software shows the error message "Invalid password"</li> <li>2. Return to 12</li> </ol>

<b>Title</b>	<b>NEW TECHNICAL ADMINISTRATOR'S PROFILE ACTIVATION</b>
<b>Objective</b>	Add a new Technical administrator to the system.
<b>Main actor</b>	Technical administrator (the already registered one).
<b>Precondition</b>	A new Technical administrator has been hired and needs to be inserted in the database from an already registered Technical administrator, which is logged in.
<b>Postcondition</b>	The new Technical administrator can access their personal profile and manage the system.
<b>Basic scenario</b>	<ol style="list-style-type: none"> <li>1. The Technical administrator selects from the homepage the option “Add new user”</li> <li>2. The software shows the options: “Physician”, “Other health care provider”, “Technical administrator”</li> <li>3. The Technical administrator selects “Technical administrator”</li> <li>4. The Technical administrator inserts the new Technical administrator’s personal information, previously communicated, (Surname, Name, CF, Phone number, Company email) in the database</li> <li>5. The software checks the validity of the data</li> <li>6. The software sequentially generates a unique username</li> <li>7. The software associates the username with the Technical administrator’s profile in the database</li> <li>8. The software sends the username to the new Technical administrator (the password is the same of the Company email)</li> <li>9. The software adds the profile in the database</li> </ol>
<b>Alternate scenario</b>	<p>6.a Invalid data</p> <ol style="list-style-type: none"> <li>1. The software shows the error message “Invalid data”</li> <li>2. The Technical administrator verifies to have correctly inserted the new Technical administrator’s information (if not, return to 4)</li> <li>3. The Technical administrator asks the new Technical administrator the correct personal information</li> </ol>

While the profile of a new technical administrator, a physician or other health care provider is activated by the technical administrator, the patient profile is created by the physician during the visit, when the physician deems it is necessary for the patient to use this platform.

<b>Title</b>	<b>NEW PATIENT'S PROFILE ACTIVATION</b>
<b>Objective</b>	Creation and activation of a Patient's profile.
<b>Main actor</b>	Physician.
<b>Precondition</b>	During the visit with the Physician (already logged in), a Patient suffering from hypertension has been prescribed to register to a monitoring system in order to improve the follow up.
<b>Postcondition</b>	The new Patient's profile is active and added into the database. Now the Patient can log in and complete their profile with additional information.
<b>Basic scenario</b>	<ol style="list-style-type: none"> <li>1. The Physician selects from the homepage "Create new patient profile"</li> <li>2. The Physician inserts the Patients' personal information (Surname, Name, CF, Address, Telephone number, Email) in the database</li> <li>3. The software checks the validity of the data</li> <li>4. The software sequentially generates a unique username and password</li> <li>5. The software associates the username and password with the user profile</li> <li>6. The software adds the profile in the database</li> </ol>
<b>Alternate scenario</b>	4.a Invalid data <ol style="list-style-type: none"> <li>1. The software shows the error message "Invalid data"</li> <li>2. The Physician verifies to have correctly inserted the user's information (if not, return to 2)</li> <li>3. The Physician asks again the information to the Patient</li> <li>4. Return to 2</li> </ol> 4.b The data are already associated with an existing profile <ol style="list-style-type: none"> <li>1. The software shows the error message "Already existing profile"</li> <li>2. The Physician communicates the Patient that the profile is already active</li> </ol>

<b>Title</b>	<b>ADD/REMOVE PATIENT FROM THE PHYSICIAN'S LIST</b>
<b>Objective</b>	Add or remove a Patient from the Physician's personal list.
<b>Main actor</b>	Physician.
<b>Precondition</b>	The Physician needs to add or remove one Patient from their personal list of patients. The Physician is already logged in.
<b>Postcondition</b>	The Patient is added or removed from the Physician's list.
<b>Basic scenario</b>	<ol style="list-style-type: none"> <li>1. The Physician selects from the homepage "My list"</li> <li>2. The software shows the list and the options "Add to the list" and "Remove from the list"</li> <li>3. The Physician selects "Add to the list"</li> <li>4. The Physician searches the Patient in the database</li> <li>5. The Physician selects the Patient</li> <li>6. The Physician adds that Patient to their list</li> <li>7. The software updates the database</li> </ol>
<b>Alternate scenario</b>	<ol style="list-style-type: none"> <li>3.a The Physician selects "Remove from the list" <ol style="list-style-type: none"> <li>1. The Physician searches the Patient in the list</li> <li>2. The Physician selects the Patient</li> <li>3. The Physician removes that Patient to their list</li> </ol> </li> <li>5.a The Patient does not exist in the database <ol style="list-style-type: none"> <li>1. The Physician verifies to have correctly inserted the Patient's information (if not, return to 4)</li> <li>2. The Physician registers the new Patient</li> </ol> </li> <li>5.b The Patient is already in the Physician's list <ol style="list-style-type: none"> <li>1. The software shows the message "Patient already in My list"</li> </ol> </li> </ol>

<b>Title</b>	<b>INSERT/UPLOAD SELF-OBTAINED DATA</b>
<b>Objective</b>	Uploading of patient's parameters obtained from wearable devices (by synchronizing the device) or medical instrumentation (manually inserting them) or uploading medical reports (ex. blood analysis, obtained from some analysis laboratory).
<b>Main actor</b>	Patient.
<b>Precondition</b>	Patient collects data about their health state and wants to add them to the system. The Patient has already logged in.
<b>Postcondition</b>	The new inserted data are added in the database and can be visualized and managed by the Physician.

<b>Basic scenario</b>	<ol style="list-style-type: none"> <li>1. The Patient selects from the homepage “Insert parameters”</li> <li>2. The software shows the options “Synchronize with wearable device”, “Insert parameters manually”, “Insert medical reports”</li> <li>3. The Patient selects “Insert parameters manually”</li> <li>4. The software shows the parameters that can be inserted</li> <li>5. The Patient selects the parameter</li> <li>6. The software sets current time and day</li> <li>7. The Patient verifies that the parameter is referred to the right time and day selected by the software</li> <li>8. The Patient inserts the value of the parameter</li> <li>9. The Patient clicks on “Save”</li> <li>10. The software checks the data validity</li> <li>11. The software adds the Patient’s data to the database</li> <li>12. The software shows a recap of the inserted data</li> <li>13. The software shows the options: “Modify”, “Delete”, “Back to the homepage”</li> <li>14. The Patient selects “Back to the homepage”</li> </ol>
<b>Alternate scenario</b>	<p>3.a The Patient selects “Synchronize with wearable device”</p> <ol style="list-style-type: none"> <li>1. The software automatically records the data collected since the last synchronization from the wearable device previously paired</li> <li>2. The software shows the message “Synchronized successfully”</li> <li>3. The Patient selects “Back to the homepage”</li> </ol> <p>3.b The Patient selects “Insert medical reports”</p> <ol style="list-style-type: none"> <li>1. The Patient uploads the medical report in pdf or jpeg format</li> <li>2. The software checks the validity</li> <li>3. The Patient selects from the options the type of report they have inserted</li> <li>4. Return to 9</li> </ol> <p>7.a The parameter does not refer to the current time and day</p> <ol style="list-style-type: none"> <li>1. The Patient modifies time and day</li> <li>2. Return to 8</li> </ol> <p>11.a The parameters are not valid</p> <ol style="list-style-type: none"> <li>1. The software shows the error message “Invalid data”</li> <li>2. Return to 6</li> </ol> <p>13.a The Patient has not correctly inserted the value of the parameter</p> <ol style="list-style-type: none"> <li>1. The Patient clicks on “Modify”</li> <li>2. Return to 6</li> </ol> <p>13.b The Patient has inserted the data in the wrong parameter’s section</p> <ol style="list-style-type: none"> <li>1. The Patient clicks on “Delete” and removes the incorrect data</li> <li>2. Return to 5</li> </ol>

<b>Title</b>	<b>ANSWER QUESTIONNAIRES</b>
<b>Objective</b>	Collecting semi-quantitative questionnaires scores assessing the habits and the status of the Patient .
<b>Main actor</b>	Patient.
<b>Precondition</b>	After the log-in, the Patient wants to answer questionnaires.
<b>Postcondition</b>	The answered questionnaires are addend in the database and can be visualized and managed by the Physician.
<b>Basic scenario</b>	<ol style="list-style-type: none"> <li>1. The Patient selects from the homepage “Answer questionnaires”</li> <li>2. The software shows the available questionnaires</li> <li>3. The Patient selects a questionnaire</li> <li>4. The Patient fills out the questionnaire</li> <li>5. The software shows the options “Save” and “Delete”</li> <li>6. The Patient clicks on “Save”</li> <li>7. The software verifies the fulfillment of the questionnaire</li> <li>8. The software shows a recap of the questionnaire</li> <li>9. The software shows the options “Modify” and “Exit”</li> <li>10. The Patient clicks on “Exit”</li> <li>11. The software adds the questionnaire to the database</li> </ol>
<b>Alternate scenario</b>	<p>6.a The Patient interrupts the questionnaire compilation</p> <ol style="list-style-type: none"> <li>1. The Patient clicks on “Delete”</li> <li>2. The software shows the homepage</li> </ol> <p>8.a The Patient forgets to answer al least one question</p> <ol style="list-style-type: none"> <li>1. The software shows the error message “Incomplete data”</li> <li>2. Return to 4</li> </ol> <p>10.a The Patient has not inserted the correct answer</p> <ol style="list-style-type: none"> <li>1. The Patient clicks on “Modify” and modifies the answers</li> <li>2. Return to 4</li> </ol>

<b>Title</b>	<b>MANAGEMENT OF THE PATIENT BY THE PHYSICIAN</b>
<b>Objective</b>	Patient monitoring, addition and modification of patient's monitoring tools, medical reports and/or prescriptions.
<b>Main actor</b>	Physician.
<b>Precondition</b>	During a visit, the Physician needs to visualize Patient's data gathered in the software, to manage the monitoring tools required to be inserted by the Patient or to manage prescriptions and medical reports. The Patient is already in the Physician's list.
<b>Postcondition</b>	The Patient's data has been updated in the database. At the end of the visit, at least one medical report is produced.
<b>Basic scenario</b>	<ol style="list-style-type: none"> <li>1. The Physician selects "My list"</li> <li>2. The Physician searches the Patient in the list</li> <li>3. The Physician selects the Patient</li> <li>4. The software shows the Patient's information and the options "Parameters", "Questionnaires", "Medical reports", "Prescriptions/Tasks" and "Save and exit". If the Patient is in a risk condition, according to the software assessment, the software also shows a warning message</li> <li>5. The Physician selects "Parameters"</li> <li>6. The software shows the list of parameters available for the Patient with the possibility of changing the list</li> <li>7. The Physician selects the parameter of which they want to know the trend</li> <li>8. The software shows the statistics of the selected parameter through a line plot of the values of the last week and the option "View more statistics"</li> <li>9. The Physician selects "Back to the patient"</li> <li>10. The Physician selects "Questionnaires"</li> <li>11. The software shows the list of questionnaires that the Patient can answer with the possibility of changing the list</li> <li>12. The Physician selects the questionnaire of which they want to visualize the score trend</li> <li>13. The software shows the statistics of the selected questionnaire</li> <li>14. The Physician selects "Back to the patient"</li> <li>15. The Physician selects "Medical reports"</li> <li>16. The software shows the medical reports already uploaded and the option "Add medical report"</li> <li>17. The Physician selects "Add medical report"</li> <li>18. The Physician uploads the medical report in the pdf or jpeg format</li> <li>19. The software checks the validity of the format</li> <li>20. The Physician selects among the options the type of report they have inserted</li> <li>21. The Physician clicks on "Save"</li> <li>22. The Physician clicks on "Back to the patient"</li> <li>23. The Physician clicks on "Prescriptions/Tasks"</li> <li>24. The software shows the prescriptions and the associated tasks and the options "Add task (for Other health care provider)" and "Upload prescription"</li> <li>25. The Physician clicks on "Add task" referred to the prescription of interest</li> </ol>

	<p>26. The Physician inserts the task (which can be modified in terms of frequency and dosage by the Physician and can be marked as completed from Other health care provider when delivered)</p> <p>27. The Physician clicks on “Back to the patient”</p> <p>28. The Physician clicks on “Save and exit”</p> <p>29. The software updates the database</p>
<b>Alternate scenario</b>	<p>3.a The Patient is not found in the list</p> <ol style="list-style-type: none"> <li>1. The software shows the error message “Patient not found”</li> <li>2. Return to 2</li> </ol> <p>7.a The Physician wants to modify the parameters the Patient has to monitor</p> <ol style="list-style-type: none"> <li>1. The Physician modifies the parameters list, the entry’s frequency, the normality range and the thresholds for a specific parameter</li> <li>2. The Physician selects “Back to the patient”</li> <li>3. Return to 4</li> </ol> <p>9.a The Physician wants to visualize the values in a different plot</p> <ol style="list-style-type: none"> <li>1. The Physician selects “View more statistics”</li> <li>2. The Physician selects the time slot</li> <li>3. The Physician selects the type of plot among the available ones</li> <li>4. The Physician selects “Back to the patient”</li> <li>5. Return to 4</li> </ol> <p>12.a The Physician wants to change the questionnaires the patient has to answer</p> <ol style="list-style-type: none"> <li>1. The Physician modifies the questionnaires list and the entry’s frequency</li> <li>2. The Physician selects “Back to the patient”</li> <li>3. Return to 4</li> </ol> <p>25.a The Physician selects “Upload prescription”</p> <ol style="list-style-type: none"> <li>1. The Physician uploads the prescription in pdf format</li> <li>2. Return to 4</li> </ol>

<b>Title</b>	<b>VISUALIZATION OF BOOKED VISITS</b>
<b>Objective</b>	Visualize the booked visits both from Patient and Physician side.
<b>Main actor</b>	Physician, Patient.
<b>Precondition</b>	The user is logged in and wants to visualize the scheduled visits.
<b>Postcondition</b>	The user has visualized the scheduled visits.
<b>Basic scenario</b>	<ol style="list-style-type: none"> <li>1. The user selects from the homepage “My visits”</li> <li>2. The software shows the scheduled visits</li> <li>3. The user clicks on “Back to the homepage”</li> </ol>
<b>Alternate scenario</b>	<p>2.a The user has no visits scheduled</p> <ol style="list-style-type: none"> <li>1. The software shows the message “No visits in your calendar”</li> <li>2. Return to 4</li> </ol>

<b>Title</b>	<b>BOOK AND MANAGE PATIENT'S VISITS</b>
<b>Objective</b>	Booking and management of a visit for a specific Patient.
<b>Main actor</b>	Physician.
<b>Precondition</b>	The Physician, once selected the Patient's profile, wants to book or modify a medical appointment, in agreement with the Patient.
<b>Postcondition</b>	The Physician has booked or modified successfully the visit with the Patient.
<b>Basic scenario</b>	<ol style="list-style-type: none"> <li>1. The software shows the options: "Visualize or Modify booked visit" and "Book new visit"</li> <li>2. The Physician selects "Visualize or Modify booked visit"</li> <li>3. The software shows all the visits associated with the current Patient</li> <li>4. The Physician clicks on "Modify" once selected the visit of their interest</li> <li>5. The software shows the days in which the Physician is available after checking the Physician calendar</li> <li>6. The Physician selects the new day for the visit</li> <li>7. The software shows, if present, the old note associated with the visit with the possibility to edit it and the option "Save"</li> <li>8. The Physician clicks on "Save"</li> <li>9. The software updates the database</li> <li>10. The software brings the Physician back to the visualization of the visits</li> <li>11. The Physician selects "Back to the homepage"</li> </ol>
<b>Alternate scenario</b>	<ol style="list-style-type: none"> <li>2.a The Physician clicks on "Book new visit" <ol style="list-style-type: none"> <li>1. The software shows the days in which they are available after checking the Physician calendar</li> <li>2. The Physician chooses a day for the visit</li> <li>3. The software allows the Physician to add a note to the visit</li> <li>4. The Physician inserts, if necessary, a note</li> <li>5. Return to 8</li> </ol> </li> <li>4.a The Physician does not want to modify the visit <ol style="list-style-type: none"> <li>1. Return to 11</li> </ol> </li> <li>4.b The Physician wants to delete the medical appointment <ol style="list-style-type: none"> <li>1. The Physician selects the visit and clicks on "Delete"</li> <li>2. The software asks confirmation for the elimination of the visit</li> <li>3. The Physician confirms the elimination (otherwise, return to 11)</li> <li>4. Return to 8</li> </ol> </li> <li>6.a The Physician wants to modify only the note of a visit <ol style="list-style-type: none"> <li>1. The physician clicks on "Keep the date"</li> <li>2. Return to 7</li> </ol> </li> </ol>

Recalling the assumptions at the beginning, the Other health care provider is thought as a marginal actor that can be anyway included in the system whenever is needed. Their main function is to cooperate in the Patient management executing some tasks established by the Physician. Anytime the Other health care provider executes the task, they have to tick it to record it as done in the database. Thanks to the integration of this figure, it is possible to gather and control as many information as possible, in order to have the most complete possible view of the Patient condition and their therapy adherence.

<b>Title</b>	<b>MANAGEMENT OF THE PATIENT BY OTHER HEALTH CARE PROVIDER</b>
<b>Objective</b>	Allowing the Other health care provider to visualize Patient's data and the tasks associated with them.
<b>Main actor</b>	Other health care provider.
<b>Precondition</b>	The Other health care provider, after the log-in, wants to visualize the Patient's profile and eventually execute the associated tasks.
<b>Postcondition</b>	The Other health care provider has visualized the Patient's profile and has ticked the executed tasks that now are recorded as done in the database.
<b>Basic scenario</b>	<ol style="list-style-type: none"> <li>1. The Other health care provider searches the Patient in the database</li> <li>2. The Other health care provider selects the Patient</li> <li>3. The software shows the Patient's data, if the Patient is in a risk condition and the options "Parameters" and "Tasks"</li> <li>4. The Other health care provider selects "Parameters"</li> <li>5. The software shows the list of parameters available for the Patient</li> <li>6. The Other health care provider selects the parameter of which they want to know the trend</li> <li>7. The software shows the statistics of the selected parameter through a line plot of the values of the last week and the option "View more statistics"</li> <li>8. The Other health care provider selects "Back to the patient"</li> <li>9. The software updates the database</li> </ol>
<b>Alternate scenario</b>	<p>2.a The Patient is not found</p> <ol style="list-style-type: none"> <li>1. The software shows the error message "Patient not found"</li> <li>2. Return to 2</li> </ol> <p>4.a The Other health care provider wants to execute a task</p> <ol style="list-style-type: none"> <li>1. The Other health care provider selects "Tasks"</li> <li>2. The software shows the list of tasks associated with the Patient</li> <li>3. The Other health care provider ticks the executed task</li> <li>4. Return to 8</li> </ol> <p>8.a The Other health care provider wants to visualize the values in a different plot</p> <ol style="list-style-type: none"> <li>1. The Other health care provider selects "View more statistics"</li> <li>2. The Other health care provider selects the time slot</li> <li>3. The Other health care provider selects the type of plot among the available ones</li> <li>4. Return to 8</li> </ol>

<b>Title</b>	<b>MANAGEMENT OF PERSONAL DATA</b>
<b>Objective</b>	Visualize, modify and add new personal data in the database.
<b>Main actor</b>	User (Physician, Patient, Other health care provider, Technical administrator).
<b>Precondition</b>	The user wants to visualize, modify or add new personal information (personal data, family history, other information relevant for the Patient's monitoring). The user is already logged in.
<b>Postcondition</b>	The user's profile is updated in the database and the new information are visible.
<b>Basic scenario</b>	<ol style="list-style-type: none"> <li>1. The user selects in the homepage the option "My profile"</li> <li>2. The software shows the personal data inserted in the database and the option "Modify"</li> <li>3. The user clicks on "Modify"</li> <li>4. The user modifies or adds new personal information</li> <li>5. The user clicks on "Save and exit"</li> <li>6. The software checks the validity of the data</li> <li>7. The software updates the database</li> <li>8. The software brings the user back to the user's personal information recap page</li> <li>9. The user returns to the homepage</li> </ol>
<b>Alternate scenario</b>	<p>3.a The user wants to visualize only the personal data</p> <ol style="list-style-type: none"> <li>1. Return to 9</li> </ol> <p>7.a The inserted data are not valid</p> <ol style="list-style-type: none"> <li>1. The software shows the error message "Invalid data"</li> <li>2. Return to 4</li> </ol>

<b>Title</b>	<b>NOTIFICATION TO THE PATIENT</b>
<b>Objective</b>	Inform the Patient of the urgency of inserting a measurement, filling out a questionnaire or remind them of an upcoming visit.
<b>Main actor</b>	Software.
<b>Precondition</b>	The software, based on the information inserted by the Physician, must ask the Patient to enter the missing data (parameters or questionnaires), and based on the calendar, remember upcoming appointments (1 day before).
<b>Postcondition</b>	The Patient receives a notification to remind them what to insert and the upcoming visits.
<b>Basic scenario</b>	<ol style="list-style-type: none"> <li>1. The software analyses a Patient's profile</li> <li>2. The software checks the parameters that the Patient must insert</li> <li>3. The software identifies which parameter needs to be inserted based on the time elapsed since the last insertion, based on the frequency of compilation requested by the Physician</li> <li>4. The software sends a notification to the Patient requesting to insert the parameter measurement</li> <li>5. The software checks the questionnaires that the Patient must fill out</li> <li>6. The software identifies which questionnaires need to be compiled based on the time elapsed since the last compilation, based on the frequency of compilation requested by the Physician</li> <li>7. The software enables access to the questionnaires to be filled out</li> <li>8. The software sends a notification to the Patient requesting the compilation of the questionnaire</li> <li>9. The software checks if there are scheduled events for the next day</li> <li>10. The software sends a notification to the Patient with the appointment details</li> <li>11. The software starts analysing another Patient's profile</li> </ol>
<b>Alternate scenario</b>	<p>3.a There are no parameters to be inserted</p> <ol style="list-style-type: none"> <li>1. Return to 5</li> </ol> <p>6.a There are no questionnaires to complete</p> <ol style="list-style-type: none"> <li>1. Return to 9</li> </ol> <p>9.a The software does not find any upcoming appointments</p> <ol style="list-style-type: none"> <li>1. Return to 11</li> </ol>

<b>Title</b>	<b>DEACTIVATION OF USER'S PROFILE</b>
<b>Objective</b>	Deactivate a user's profile from the database.
<b>Main actor</b>	User (Physician, Patient, Other health care provider), Technical administrator.
<b>Precondition</b>	The user wants to deactivate the profile.
<b>Postcondition</b>	The user's profile is deactivated.
<b>Basic scenario</b>	<ol style="list-style-type: none"> <li>1. The user logs in</li> <li>2. The user selects from the homepage "Delete profile"</li> <li>3. The software shows the message "Do you want to open a request to delete your profile?" and the answer options "Yes" and "No"</li> <li>4. The user clicks on "Yes"</li> <li>5. The software sends an email to the Technical administrator with the data of the user who wants to delete the profile</li> <li>6. The Technical administrator deactivates the profile associated with the user</li> <li>7. The software sends an email to the user confirming that the profile has been correctly deactivated and a link to the system satisfaction survey</li> <li>8. The software updates the database, changing the profile status from active to inactive</li> </ol>
<b>Alternate scenario</b>	<p>1.a The user has not accessed the system for at least one year</p> <ol style="list-style-type: none"> <li>1. The software sends an SMS or an email to the user asking to access the profile within a week</li> <li>2. The user does not log in within a week</li> <li>3. Return to 5</li> </ol> <p>4.a The user clicks on "No"</p> <ol style="list-style-type: none"> <li>1. The software returns to the homepage</li> </ol>

<b>Title</b>	<b>REQUEST OF TECHNICAL ASSISTANCE</b>
<b>Objective</b>	Physician, Patient and Other health care provider need technical assistance and send a request to the Technical administrator.
<b>Main actor</b>	User (Physician, Patient, Other health care provider), Technical administrator.
<b>Precondition</b>	Physician, Patient or Other health care provider, already logged in, need technical assistance for solving a problem in the software and send a request to the Technical administrator.
<b>Postcondition</b>	Physician, Patient or Other health care provider have received assistance and can correctly use the software.
<b>Basic scenario</b>	<ol style="list-style-type: none"> <li>1. The user selects from the homepage "Ask for technical assistance"</li> <li>2. The user writes the request with the possibility of linking an attachment</li> <li>3. The user clicks on "Send"</li> <li>4. The software sends a notification to the Technical administrator</li> <li>5. The Technical administrator opens the request and gives assistance to the user</li> <li>6. The Technical administrator, once ended the operation, closes the request of assistance</li> <li>7. The software sends to the user the link to the satisfaction survey for the assistance received</li> <li>8. The user fills out and send the survey</li> <li>9. The software updates the statistics of the survey's answer on the database</li> </ol>
<b>Alternate scenario</b>	<p>8.a The user does not answer the survey within a week</p> <ol style="list-style-type: none"> <li>1. The software deactivates the link of the survey</li> </ol>

<b>Title</b>	<b>VISUALIZATION OF STATISTICS</b>
<b>Objective</b>	Visualize different kinds of statistics depending on the user. Technical administrator is going to visualize mostly statistics regarding the usage of the system, while the Patient can see the trends of their own parameters.
<b>Main actor</b>	User (Patient, Technical administrator).
<b>Precondition</b>	The user has already logged in in their profile.
<b>Postcondition</b>	User has visualized the statistics they are interested in.
<b>Basic scenario</b>	<ol style="list-style-type: none"> <li>1. The user selects from the homepage "Visualize statistics"</li> <li>2. The software shows the variables that the user can visualize</li> <li>3. The user selects the variable they want to visualize</li> <li>4. The software shows the statistics of the selected variable through a line plot of the values of the last week and the option "View more statistics"</li> <li>5. The user returns to the homepage</li> </ol>
<b>Alternate scenario</b>	<p>5.a The user wants to visualize other statistics</p> <ol style="list-style-type: none"> <li>1. The user selects "View more statistics"</li> <li>2. The user selects the time slot</li> <li>3. The user selects the type of plot among the available ones</li> <li>4. Return to 5</li> </ol>

In the following table, we describe how risk assessment is conducted and how the risk conditions are managed. In particular, we decided that the system will provide a notification only to the Patient to avoid a condition of overload of information or false alarms provided to the Physician. This notification is sent whether the risk condition is recognized or if the value of the parameter overcame the upper threshold. We assume that for each parameter two thresholds are defined, identifying three ranges of measurement. Below the lower threshold, we are in normality range. Between lower and upper thresholds, the measurement is slightly higher with respect to the normal condition. Above the upper threshold, the measurement is in a range that represents a dangerous condition.

<b>Title</b>	<b>RISK ASSESSMENT AND MANAGEMENT</b>
<b>Objective</b>	Verify if the Patient is in a risk condition and send a notification in that case.
<b>Main actor</b>	Software.
<b>Precondition</b>	After the Patient has inserted a new parameter or has uploaded his personal data, the software has to verify if the parameter has overcome the upper threshold and, through an already trained classification algorithm, if the Patient is in a risky condition.
<b>Postcondition</b>	The software has checked the new inserted measurement and evaluated the new risk associated to the Patient.
<b>Basic scenario</b>	<ol style="list-style-type: none"> <li>1. The software checks for the uploaded parameter if it is below the upper threshold</li> <li>2. The software calculates with the new parameters if the Patient is in a risk condition</li> <li>3. The software identifies a risk condition</li> <li>4. The software updates the new condition in the database</li> <li>5. The software sends a notification to the Patient and informs them that they may be in a risk condition and invites them to contact a Physician as soon as possible</li> </ol>
<b>Alternate scenario</b>	<ol style="list-style-type: none"> <li>2.a The parameter is above the upper threshold             <ol style="list-style-type: none"> <li>1. The software notifies the Patient asking if he has correctly taken the measurement following the guidelines</li> <li>2. Return to 2</li> </ol> </li> <li>3.a The Patient is not in a risk condition             <ol style="list-style-type: none"> <li>1. The software updates the new condition in the database</li> </ol> </li> </ol>

<b>Title</b>	<b>UPLOAD QUESTIONNAIRES AND PARAMETERS DOMAIN AND FORMAT</b>
<b>Objective</b>	Upload in the database the semi-quantitative questionnaires for the Patient and set the parameters that the Patient has to monitor.
<b>Main actor</b>	Technical administrator, Physician.
<b>Precondition</b>	The Physician wants to add in the system new parameters or new questionnaires.
<b>Postcondition</b>	The database is uploaded with new questionnaires and parameters.
<b>Basic scenario</b>	<ol style="list-style-type: none"> <li>1. The Physician selects from the homepage “Request of add new parameter or questionnaire”</li> <li>2. The Physician inserts the documentation of the questionnaire (Name, Description, Questions, Score and Score assessment) or the parameter (Name, Unit of measurement, Type, Range values)</li> <li>3. The Physician clicks on “Send”</li> <li>4. The software sends a notification to the Technical administrator</li> <li>5. The Technical administrator reads the request</li> <li>6. The Technical administrator manually verifies if the parameter or questionnaire already exists</li> <li>7. The software shows in the Technical administrator’s homepage the options “New questionnaire” and “New parameter”</li> <li>8. The Technical administrator clicks on “New questionnaire”</li> <li>9. The Technical administrator manually uploads in the database the questionnaire question and the scores associated to the answers sent by the Physician</li> <li>10. The Technical administrator clicks on “Save and exit”</li> <li>11. The software updates the database</li> </ol>
<b>Alternate scenario</b>	<p>7.a The questionnaire or the parameter already exists in the database</p> <ol style="list-style-type: none"> <li>1. The Technical administrator informs the Physician of their presence in the database</li> </ol> <p>8.a The Technical administrator clicks on “New parameter”</p> <ol style="list-style-type: none"> <li>1. The Technical administrator sets the information (also regarding risk assessment) and the values of the new parameter sent by the Physician</li> <li>2. Return to 10</li> </ol>

In our system a forum section is present in order to raise awareness in the Patient thanks to the lifestyle suggestions uploaded by Physicians, allow the exchange of information and personal experiences among people suffering from the same condition and build a community.

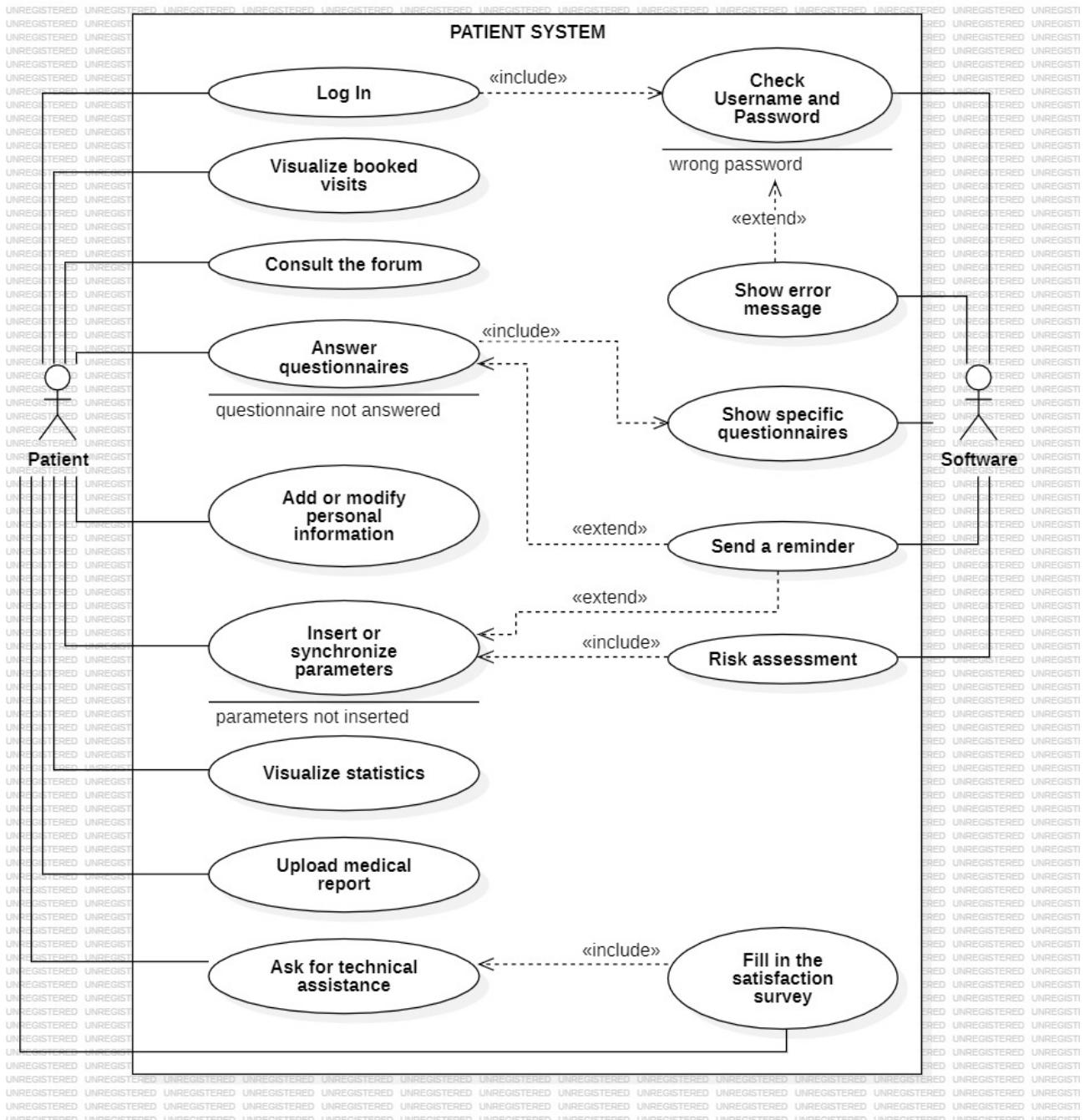
<b>Title</b>	<b>FORUM CONSULTATION</b>
<b>Objective</b>	Read lifestyle suggestions, ask new questions in the forum or answer other users' questions.
<b>Main actor</b>	Patient.
<b>Precondition</b>	The Patient, already logged in, wants to get informed about lifestyle suggestions, asks or answers a question.
<b>Postcondition</b>	The Patient has obtained the information needed, has uploaded a question or has answered some questions.
<b>Basic scenario</b>	<ol style="list-style-type: none"> <li>1. The Patient selects from the homepage "Lifestyle suggestions"</li> <li>2. The software shows a list of suggestions evidence based (for example textual suggestions, links to papers, FAQ) and the section "Ask the community"</li> <li>3. The Patient verifies if the information is already in the page</li> <li>4. The Patient does not find the information they want and clicks on "Ask the community"</li> <li>5. The software shows a disclaimer which informs the Patient that the answers they will receive are not certified by a clinician and to contact a specialist before taking any action</li> <li>6. The software shows the questions without an answer and then the already answered questions</li> <li>7. The Patient does not answer any question</li> <li>8. The Patient does not find the information among the questions</li> <li>9. The Patient clicks on "Write a question"</li> <li>10. The Patient writes the question</li> <li>11. The Patient clicks on "Save"</li> <li>12. The software updates the database</li> </ol>
<b>Alternate scenario</b>	<p>4.a The information already exists in the suggestions</p> <ol style="list-style-type: none"> <li>1. The Patient clicks on "Back to the homepage"</li> </ol> <p>7.a The Patient wants to answer a question</p> <ol style="list-style-type: none"> <li>1. The Patient clicks on "Answer"</li> <li>2. The Patient writes the answer</li> <li>3. The Patient clicks on "Save"</li> <li>4. The software updates the database</li> <li>5. Return to 6</li> </ol> <p>8.a The Patient finds the answer they were looking for</p> <ol style="list-style-type: none"> <li>1. The Patient reads the answers</li> <li>2. The Patient clicks on "Back to the homepage"</li> </ol>

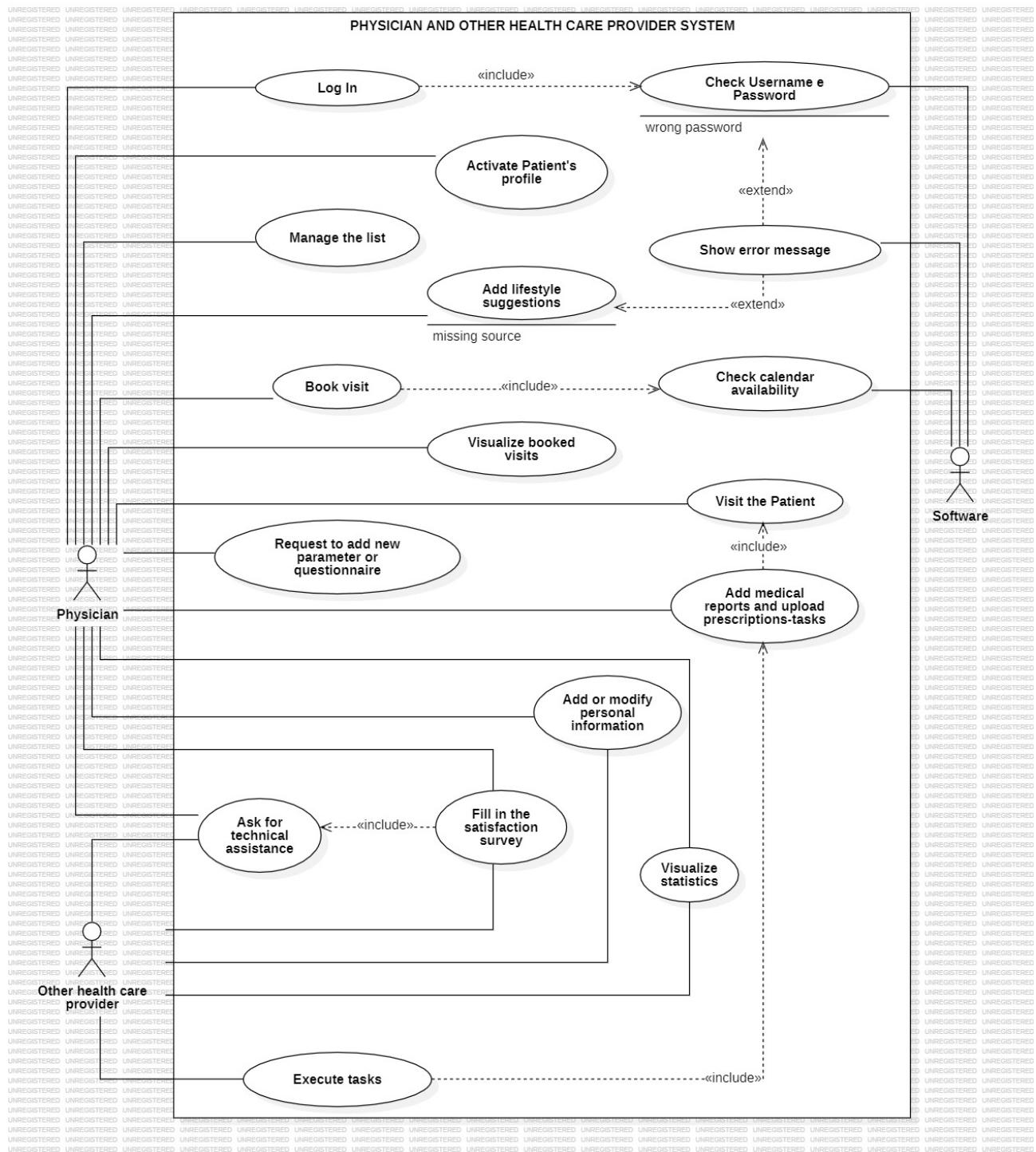
<b>Title</b>	<b>UPDATE OF LIFESTYLE SUGGESTIONS</b>
<b>Objective</b>	Add lifestyle suggestions in the forum section according to the state of the art.
<b>Main actor</b>	Physician.
<b>Precondition</b>	The Physician, already logged in, wants to add new information in the lifestyle suggestion section of the forum in order to improve the awareness of the Patients.
<b>Postcondition</b>	The lifestyle suggestion section is aligned with the state of the art.
<b>Basic scenario</b>	<ol style="list-style-type: none"> <li>1. The Physician selects from the homepage “Add lifestyle suggestion”</li> <li>2. The software shows the advice box and the source box</li> <li>3. The Physician inserts the advice and its source</li> <li>4. The Physician clicks on “Confirm”</li> <li>5. The software checks data completeness</li> <li>6. The software updates the database</li> </ol>
<b>Alternate scenario</b>	<p>6.a The source is missing</p> <ol style="list-style-type: none"> <li>1. The software shows the error message “Missing source”</li> <li>2. Return to 2</li> </ol>

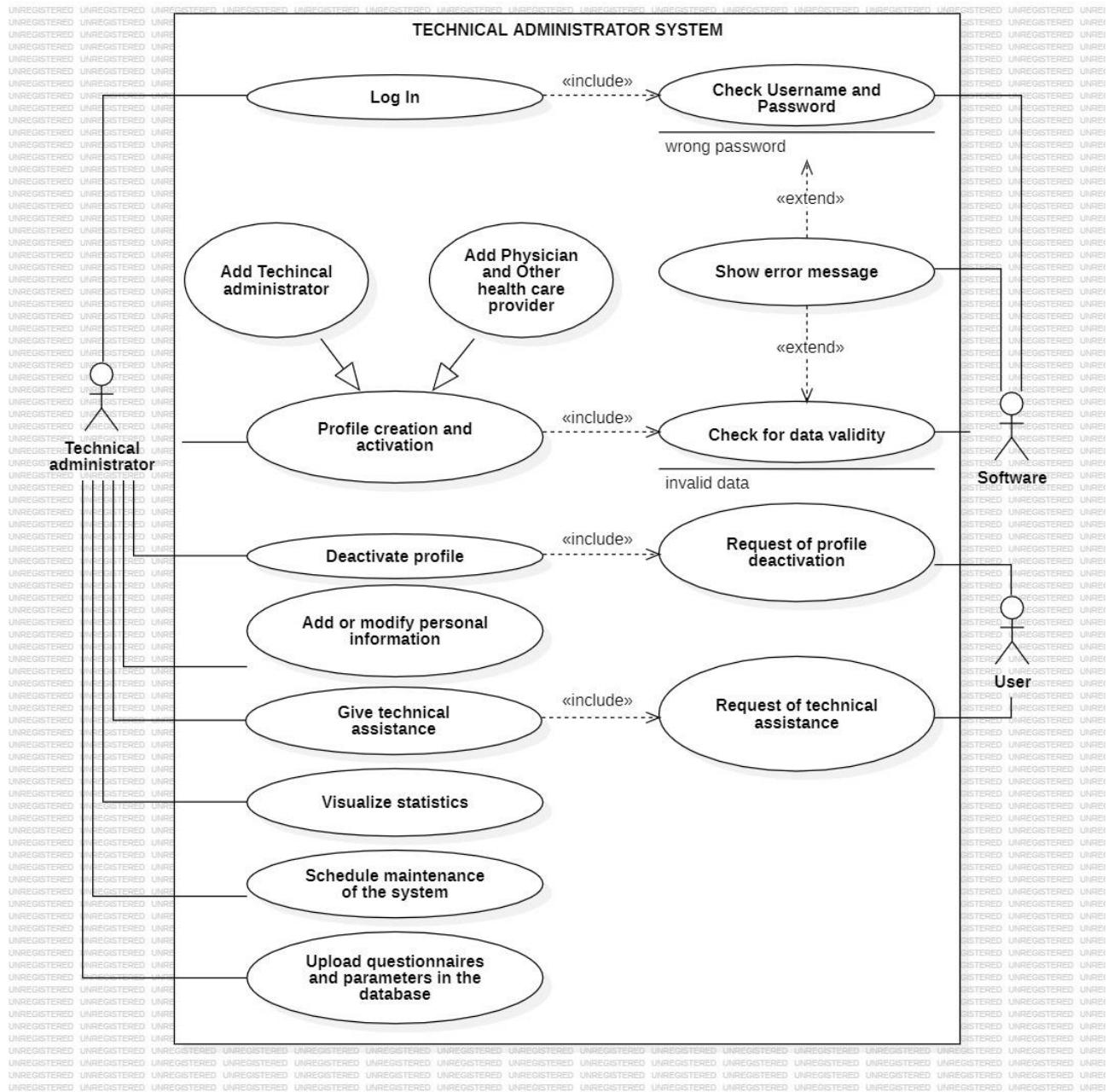
<b>Title</b>	<b>SCHEDULE MAINTENANCE OF THE SYSTEM</b>
<b>Objective</b>	Update the system functionalities or correct bugs.
<b>Main actor</b>	Technical administrator.
<b>Precondition</b>	The Technical administrator, already logged in, wants to plan a maintenance intervention to update the functions of the system or correct a bug that may have occurred.
<b>Postcondition</b>	The system maintenance is scheduled and users are informed.
<b>Basic scenario</b>	<ol style="list-style-type: none"> <li>1. The Technical administrator selects from the homepage “Program maintenance of the system”</li> <li>2. The software shows the calendar</li> <li>3. The Technical administrator selects day and time slot for maintenance</li> <li>4. The software shows the options “Confirm” and “Delete”</li> <li>5. The Technical administrator clicks on “Confirm”</li> <li>6. The software sends a notification to all the users informing them about the maintenance intervention with day and time details</li> </ol>
<b>Alternate scenario</b>	<p>5.a The Technical administrator clicks on “Delete”</p> <ol style="list-style-type: none"> <li>1. Return to the homepage</li> </ol>

## USE CASE DIAGRAMS

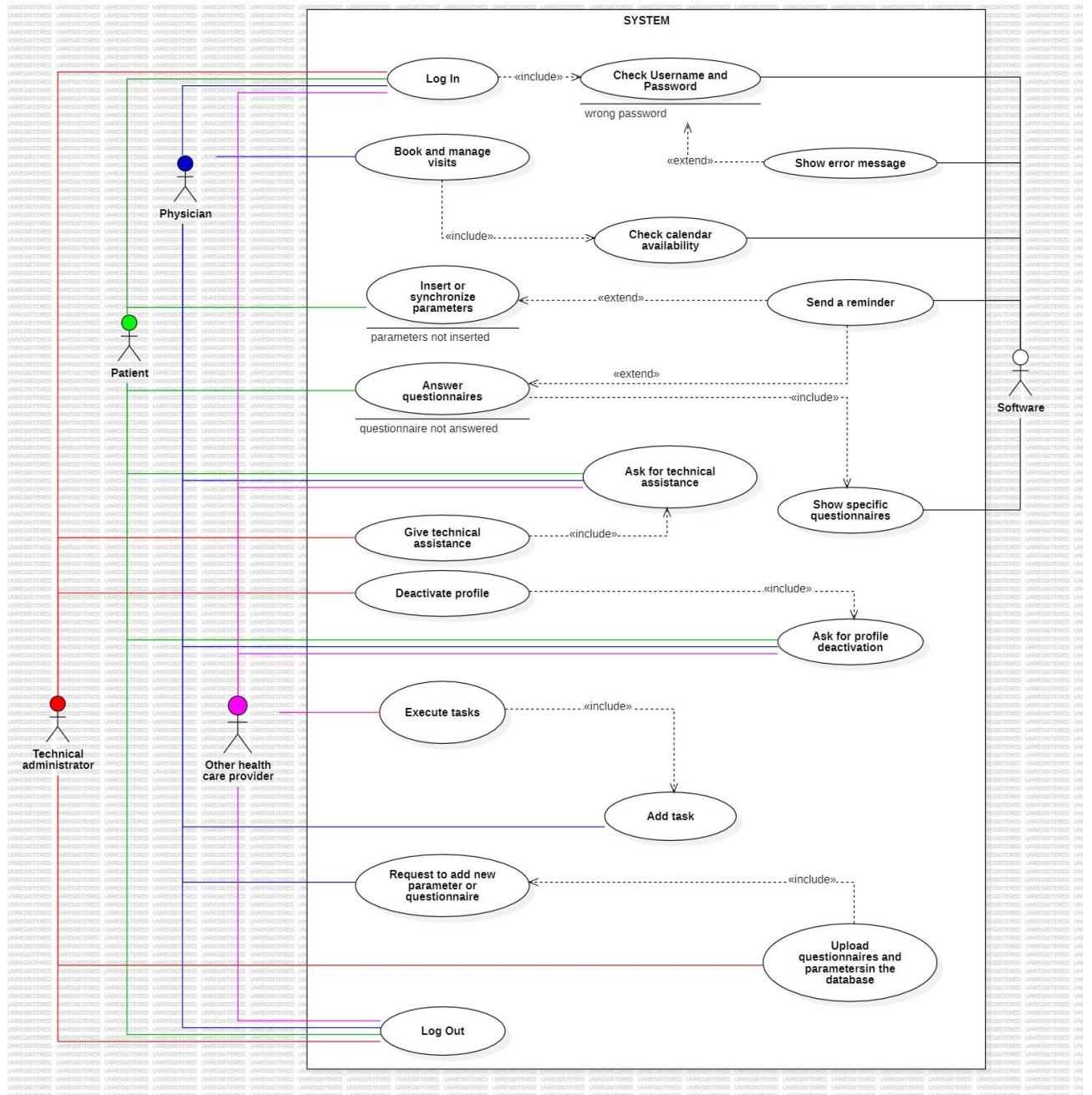
The diagrams below will depict the primary actions undertaken by key participants: the Patient, the Physician, the Other health care provider and the Technical administrator. These diagrams cross the majority of the textual description, merging various actions performed by users, rather than delineating each action sequentially.





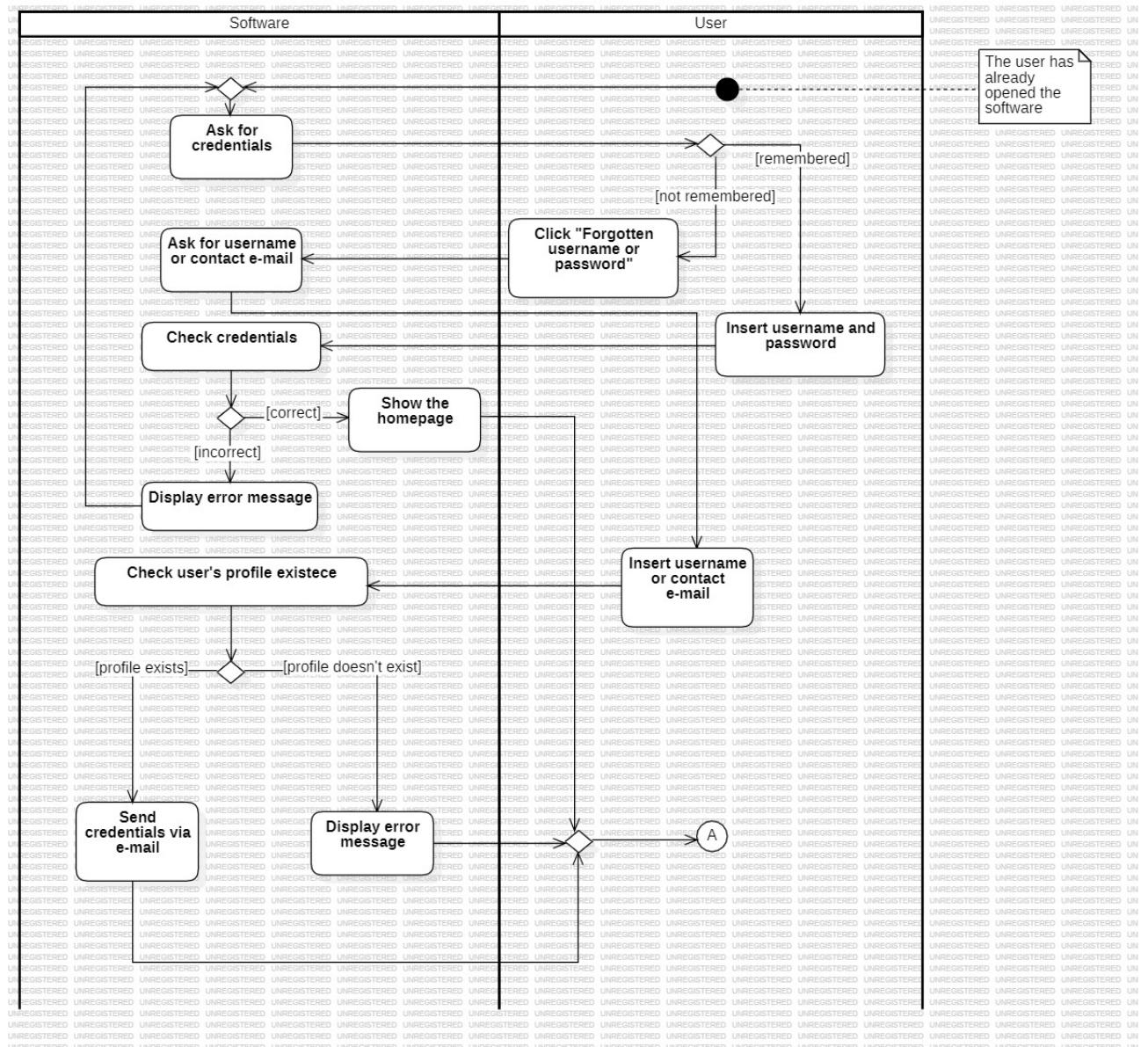


In the last use case diagram, we depict the main actions performed by various users and how they interact with each other. To enhance readability, we employed a color-coded method, assigning a specific color to each main actor, specifically: green for the Patient, blue for the Physician, red for the Technical administrator, and magenta for the Other health care provider.

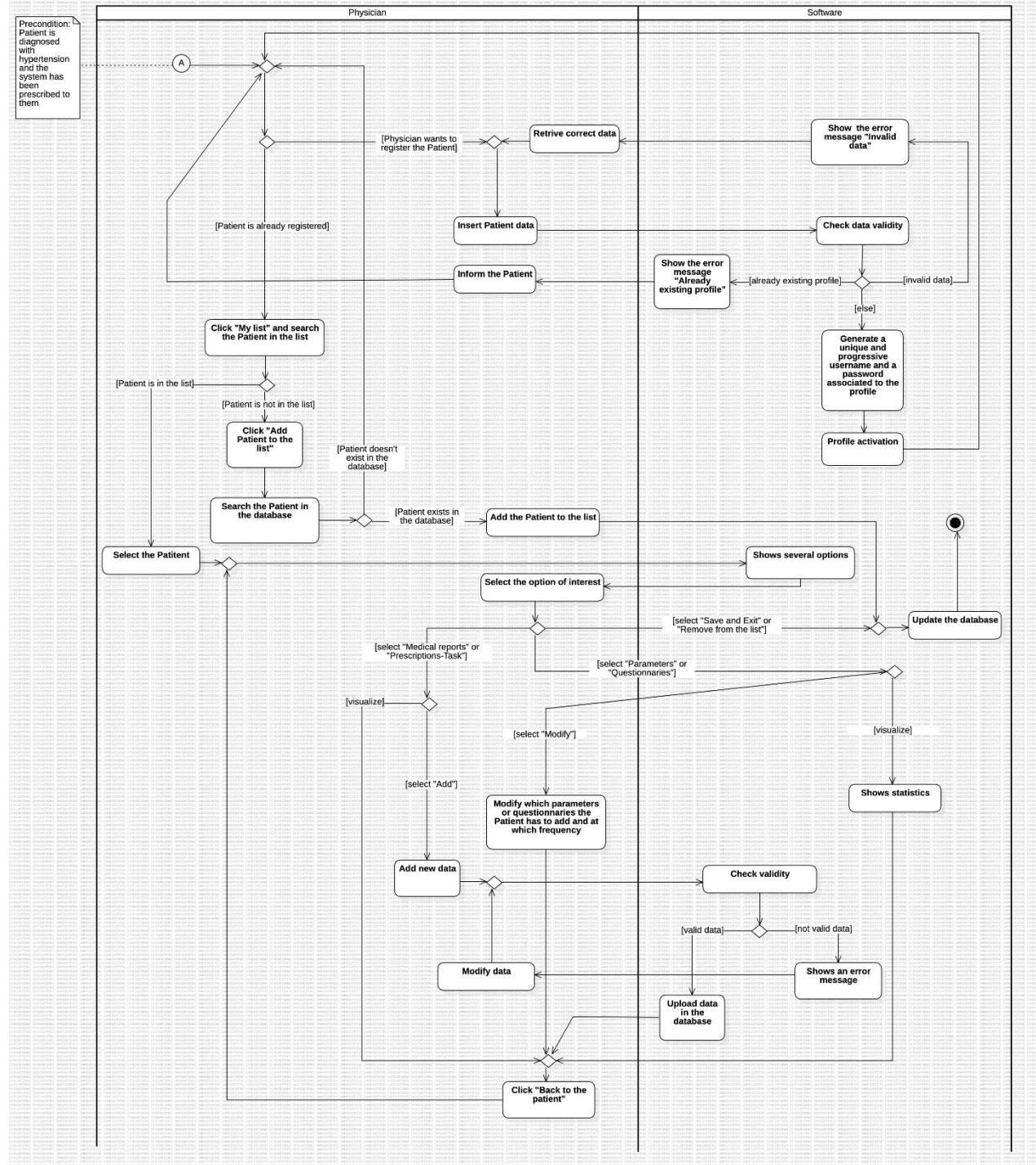


## ACTIVITY DIAGRAMS

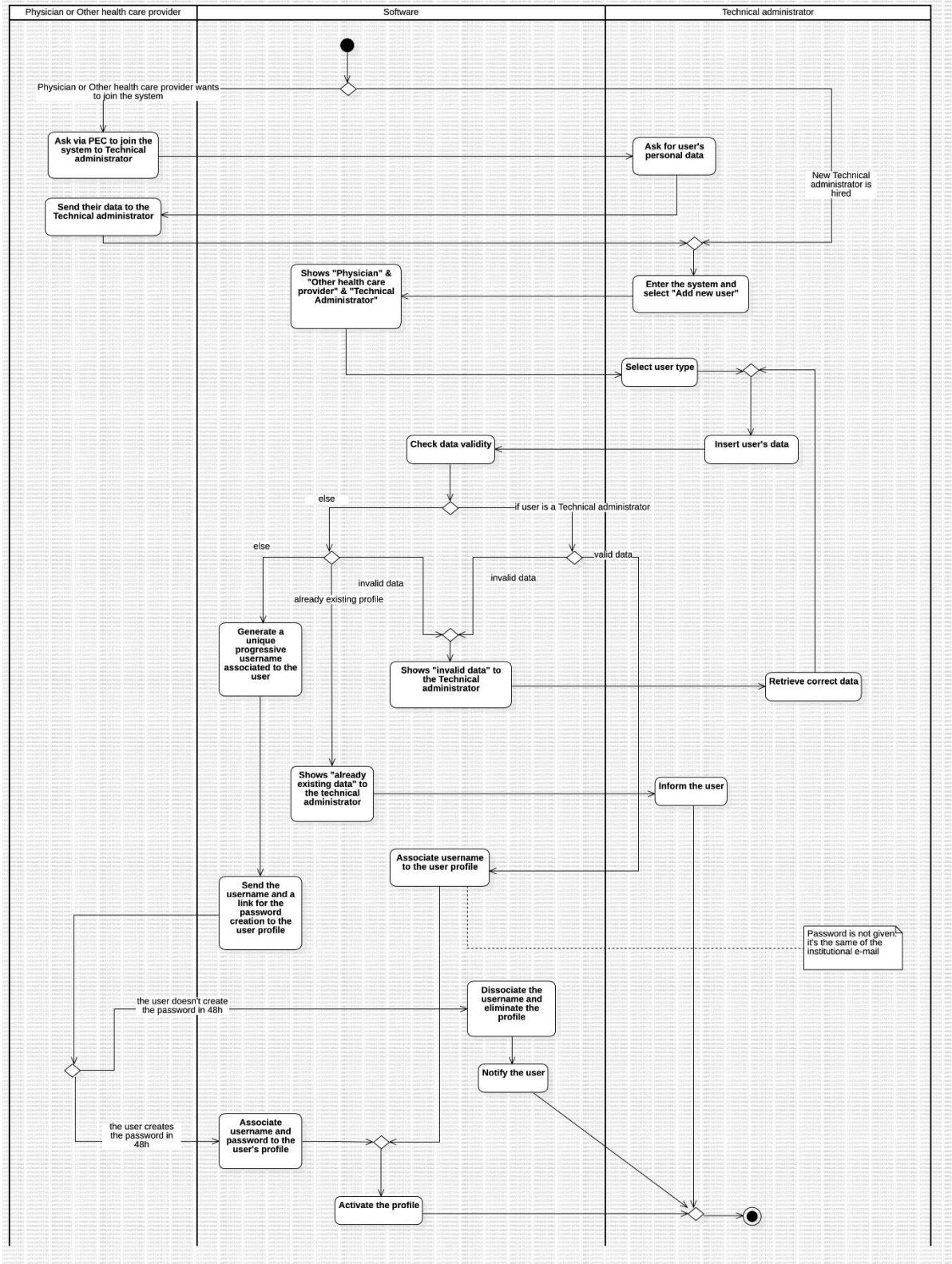
The first activity diagram describes in detail the Log-in procedure that is the same for each type of user, whether they are Patient, Physician, Other health care provider or Technical administrator. We assume that the system is not under maintenance. The activity diagram refers to the textual description titled “Log-in” and ends with an “Edge connector”.



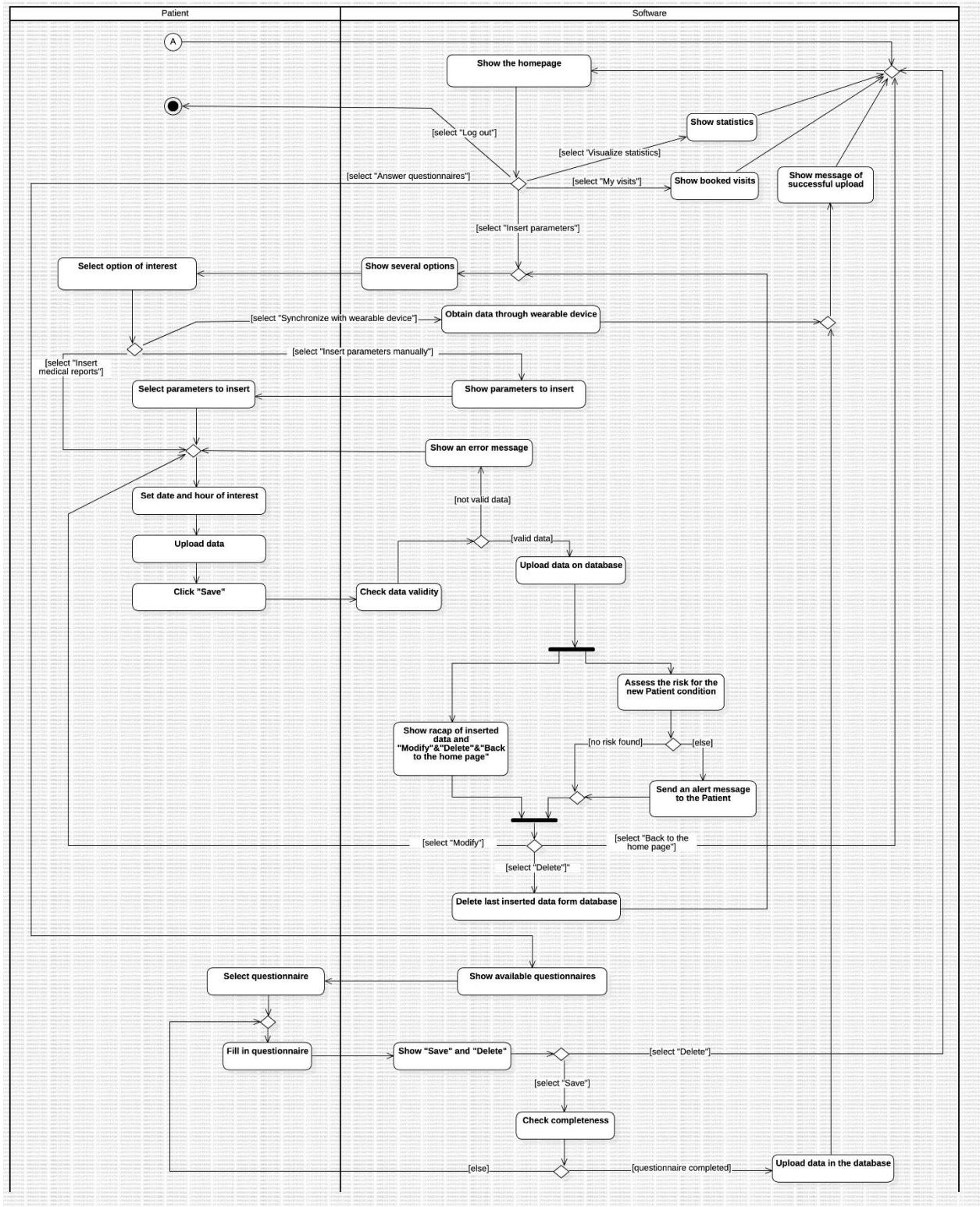
The following activity diagram mainly describes the management of the patient carried out by a physician during a visit. Furthermore, it involves also the patient registration into the database and the possibility to add them to a personal list which contains the patients associated with the physician. We suppose that it is the physician who registers the patient in the database because the first prescribes the telemedicine system to the second one. We assume that once the physician has registered the patient for the first time, at least, wants to add the patient to their own list, in order to monitor their health status. If the patient is already registered, the physician may simply want to add them to the list. Once the patient is in the list, the physician is able to manage patient's data. The activity diagram refers to the textual descriptions titled "New patient's profile activation", "Add/Remove patient from the physician's list", "Management of the patient by the physician", and starts with an "Edge connector" referred to the log-in activity of the physician.



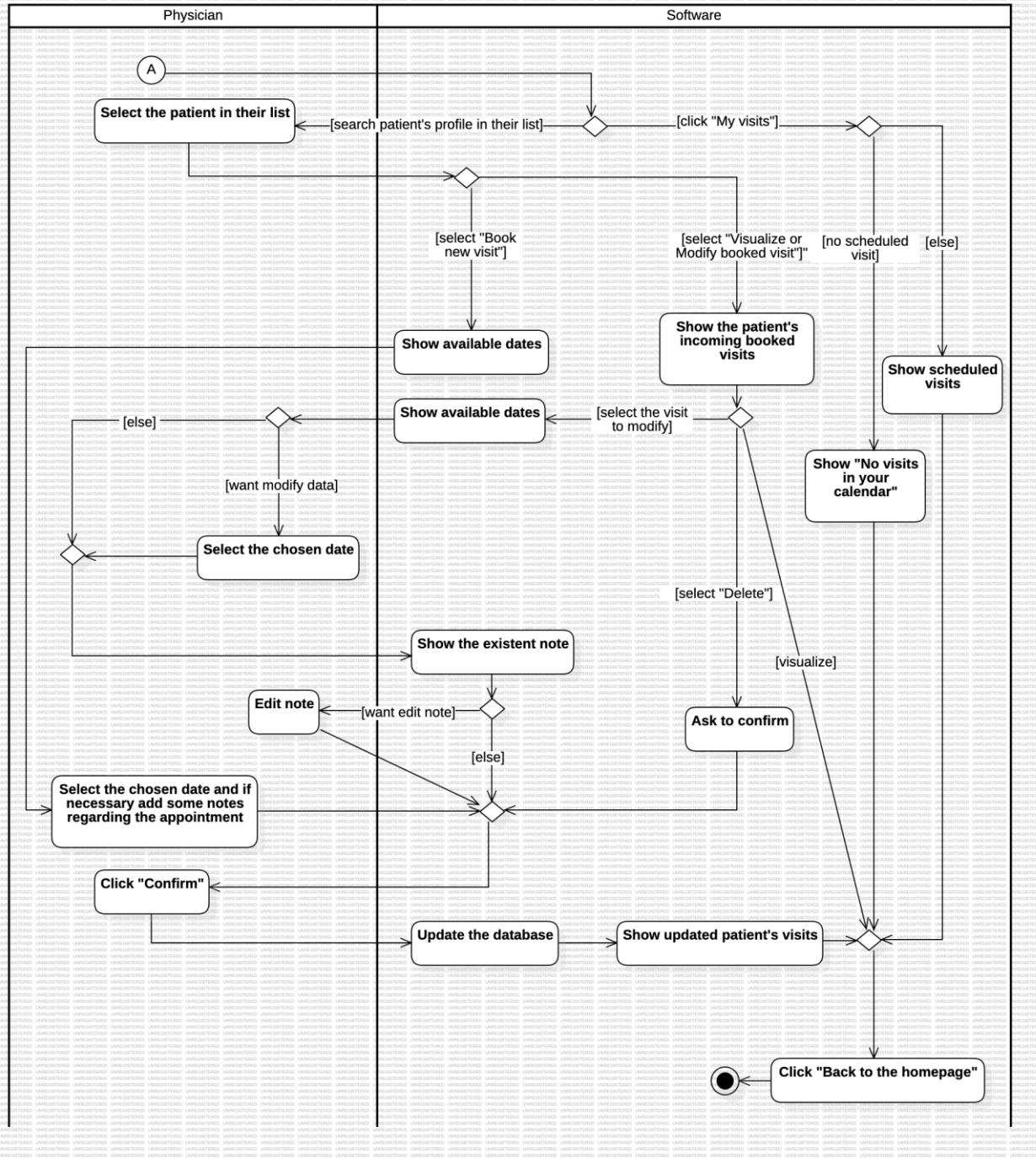
The following activity diagram describes the procedure of profile activation for Physician, Other health care provider or Technical administrator. The starting point can be triggered by two different conditions: the first one regards the willingness of a physician or other health care provider to join the system, while the second one involves the hiring of a new technical administrator who needs to be registered in the system. Such condition should require two different diagrams but for conciseness is summarized in one. The activity diagram refers to the textual descriptions titled “Physician’s or Other health care provider’s profile activation” and “New technical administrator’s profile activation”.



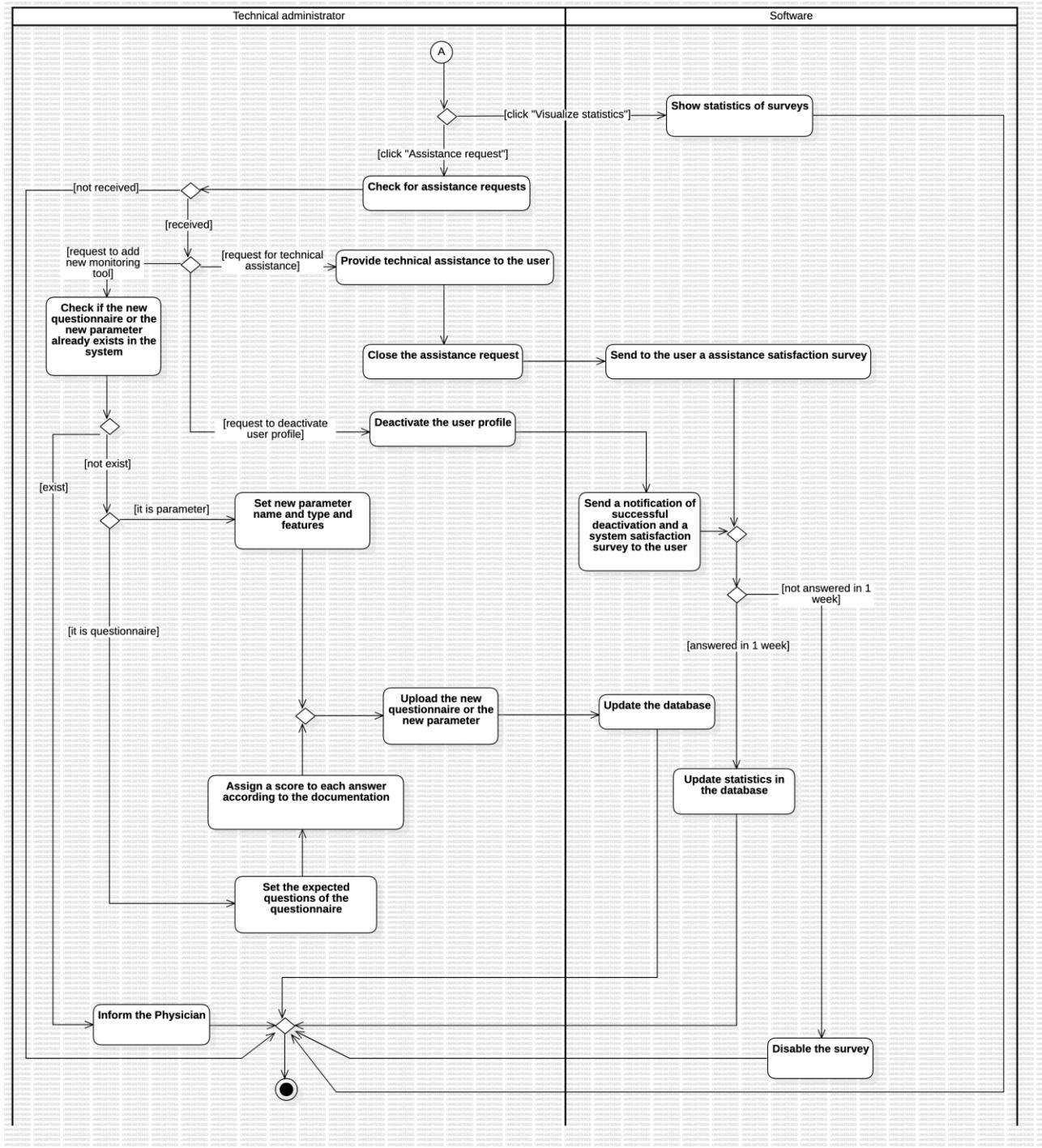
The following activity diagram describes the patient's activities autonomously conducted with the objective of providing useful data to monitor the patient's condition. Furthermore, the patient can also visualize both statistics of inserted parameters and booked visits. Generally, the patient is able to upload self-obtained data, answer questionnaires or insert medical reports produced by a physician who is not registered in the system. The activity diagram refers to the textual descriptions titled "Insert/Upload self-obtained data", "Answer questionnaires", "Visualization of booked visits", "Visualization of statistics", "Risk assessment and management" and starts with an "Edge connector" referred to the log-in activity of the patient.



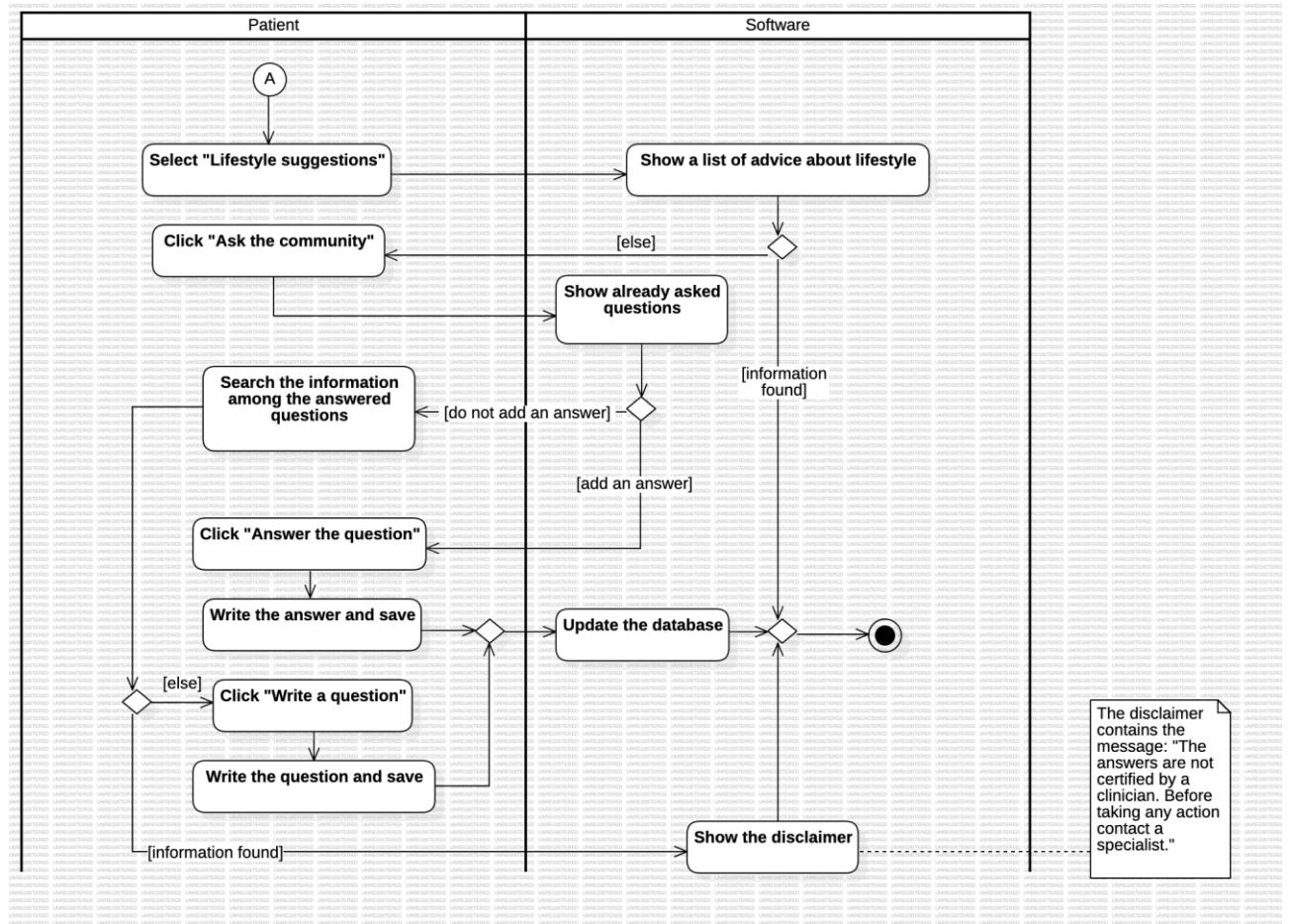
The following activity diagram shows the procedure of booking and eventually modify a visit for a patient or visualize their visits from the Physician side. Hence, there are two different preconditions triggering the starting point: the first regards the willingness of booking a visit for a patient, the second regards the willingness of visualize the Physician's visits calendar. We assume that, to book a visit, the patient has to be in agreement with the physician who is the only one able to book the visit through the system. The physician is able to add notes concerning the visit itself (if something is needed). Also, the modification of the visit is done in agreement between the two users, and it can concern both modification of the date and the notes. The activity diagram refers to the textual descriptions titled "Visualization of booked visits", "Book and manage patient's visits" and starts with an "Edge connector" referred to the log-in activity of the physician.



The following activity diagram describes the main action of the Technical administrator. The Technical administrator can visualize statistics regarding surveys and answer assistance requests coming from all other users, hence the starting point can be triggered by these two different conditions. Assistance requests may concern technical assistance, deactivation of one's profile or uploading new monitoring tool. The latter requires that the Physician has sent documentation regarding that new tool to the Technical administrator. This allows the system to stay on top of state of the art. The activity diagram refers to the textual descriptions titled "Deactivation of user's profile", "Request of technical assistance", "Visualization of statistics", "Upload questionnaires and parameters domain and format", "Schedule maintenance of the system" and starts with an "Edge connector" referred to the log-in activity of the Technical administrator.



The following activity diagram describes the interaction of the patient with the forum. It contains the section regarding evidence-based lifestyle suggestions aimed to inform patients, and the section containing questions and answers aimed to share people experiences enhancing a sense of community. In the latter section each patient is able to ask and answer questions. The focus of the following diagram is both to search an information and interact with the community answering questions. The activity diagram refers to the textual description titled “Forum consultation” and starts with an “Edge connector” referring to the log-in activity of the patient.



## CLASS DIAGRAM

The following class diagram groups all the parts that make the system and highlights the associations among each other. To allow the thorough comprehension of the diagram, some explanations highlighting some specific features will follow.

### Physician:

Physician is a specification of the generalization User. Among many operations, physician is able to “ModifyParametersList()” and “ModifyQuestionnairesList()”. These actions refer to the possibility for the physician to modify the list of parameters that the patient has to insert and the list of questionnaires that the patient has to fill out, in order to satisfy their own needs.

While for parameters it is possible to modify the thresholds, according to the patient condition, through the method “ModifyParameterThreshold()”, for questionnaires all the features are defined through the documentation that the physician has provided to the technical administrator during the questionnaire upload procedure.

### Patient:

Patient is a specification of the generalization User. A part of the Patient class is the DrugTherapy class, which contains the information regarding the medication under current assumption by the patient. Patient-DrugTherapy cardinality is 1 because for each drug therapy we have associated only one patient. The other cardinality is 0..\* since for each patient we may have associated no drug therapies. An attribute of Patient is “FamilyHistory” of type string which contains natural language information regarding pathological conditions of one or more relatives which may be relevant for the hypertensive condition. Another attribute is “OtherInformation” of type string that allows the patient to add further information which can be useful for the physician to know (e.g. intolerances, diets, other types of prescriptions etc.). One of the attributes of the class is “RiskAssessment” of boolean type which informs the viewer (patient, physician or other health care provider) if a risk condition is reached or not, established through the algorithm.

### ParameterStatistics:

ParameterStatistics is a class that allows physician and patient to visualize for a certain parameter the values assumed in a set time slot. These can be shown through several plots such as line plot, which enhance the time trend of the measurements, or boxplot, which displays the distribution of the values of the measurements.

### Questionnaires:

Questionnaires class instances are questionnaire typologies. For example, MMAS-8 for therapy adherence is a questionnaire typology and so a single instance of the class. The class is related to the patient through the association “answer” and the association class Compilation is related to “answer”. As a consequence, Compilation represents all the questionnaires forms filled out by patients. This is the reason why Patient-Questionnaires cardinality is 0..\*, meaning that each questionnaire can be associated from 0 to n patients. The other cardinality is 2..\*, meaning that each patient is associated with at least 2 questionnaires, since each patient must fill out questionnaires related to therapy adherence and quality of life.

### Parameters:

Parameters class instances are parameters typologies. For example, systolic blood pressure is a parameter typology and so a single instance of the class. For each parameter two thresholds are defined, identifying three ranges of measurement. Below the lower threshold, we are in normality range. Between lower and upper thresholds, the measurement is slightly higher with respect to the normal condition. Above the upper threshold, the measurement is in a range that represents a dangerous condition. The class is related to the patient through the association “insert” and the association class Measurement is related to “insert”. As a consequence, Measurement represents all the values assumed by the parameter inserted by patients. This

is the reason why Patient-Parameters cardinality is 0..\*, meaning that each parameter can be associated from 0 to n patients. The other cardinality is 9..\*, meaning that each patient is associated with at least 9 parameters, since each patient must insert systolic blood pressure, diastolic blood pressure, heart rate, weight, circadian rhythms, sleep hours, steps number, physical activity hours and burnt calories.

#### Forum:

Forum is composed by LifestyleSuggestions and Q&A. Each instance of Q&A class is characterized by a question which can be associated from 0 to several answers. LifestyleSuggestions-Forum cardinality is 5..\*, since we assume that in the forum there are at least 5 advice, one for each category of lifestyle suggestion (activity, diet, alcohol consumption, smoking and drugs). The other cardinality is 1, since for each lifestyle suggestion there is only one forum. Forum has “NumberOfVisitors” as attribute, which can be useful, for the technical administrator, to monitor the forum crowd.

#### MedicalReport:

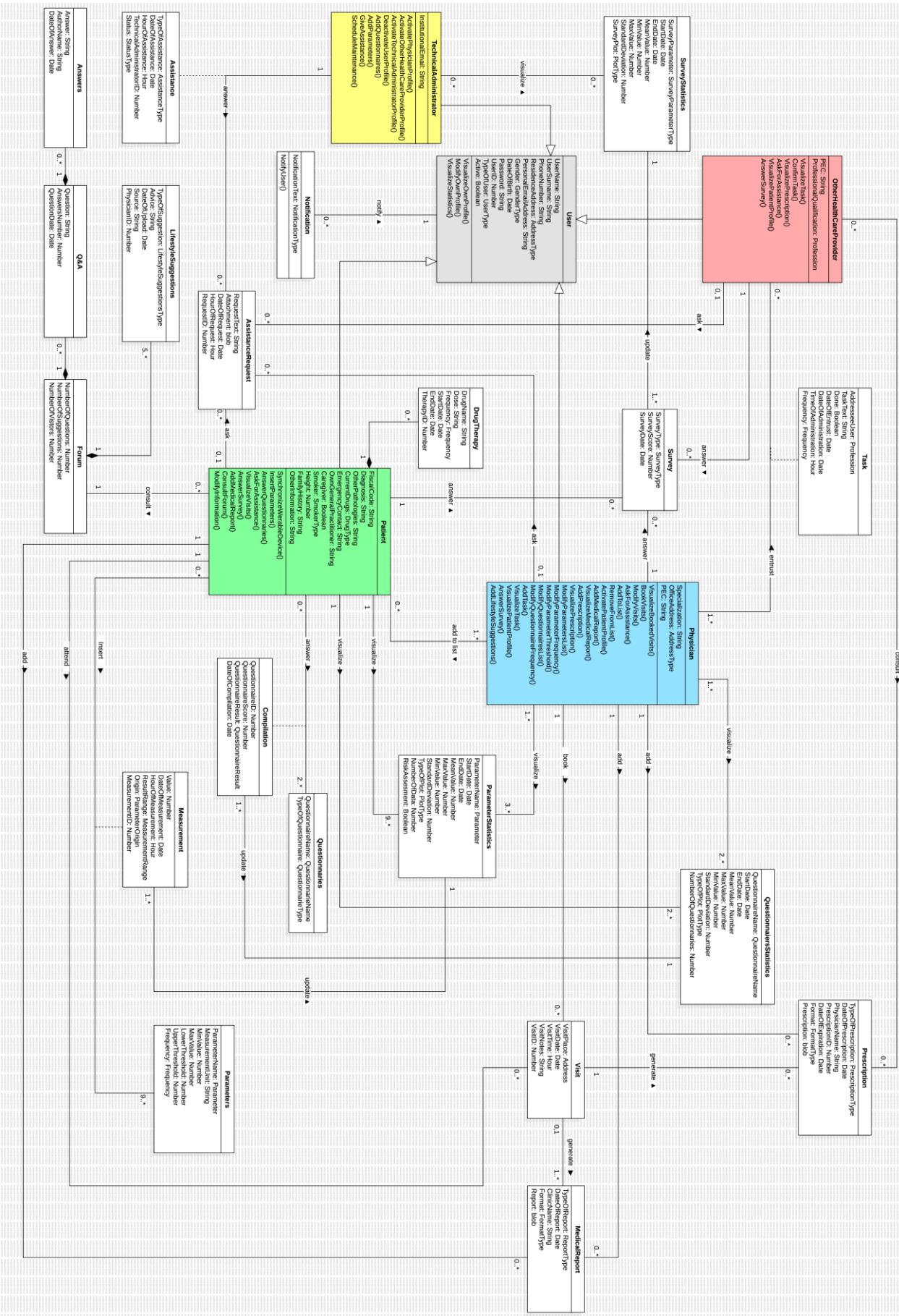
MedicalReport is a class characterized by the attribute “Report” of type blob, that refers to the uploaded document, assuming that the medical report is uploaded in .pdf or .jpeg format. MedicalReport-Visit cardinality is 1..\*, assuming that for each visit is produced at least 1 medical report. The other cardinality is 0..1, assuming that each medical report can be associated with either 0 or 1 visit. That is because one medical report can be generated during a visit programmed through the system, but can also be produced in other clinical contexts independent from the system (e.g. when a physician not registered in the system produces a medical report associated to that patient). In the latter case it is the patient who uploads the medical report, hence the report is not associated with the visit event.

#### Prescription:

Prescription is a class characterized by the attribute “Prescription” of type blob, that refers to the uploaded document, assuming that the prescription is uploaded in .pdf or .jpeg format. Prescription-Visit cardinality is 0..\*, assuming that for each visit is produced from 0 to n prescriptions because a visit may not produce any prescription (e.g. ordinary screening visit). The other cardinality is 1, assuming that each prescription is associated exactly with 1 visit, because a given prescription can only be generated during a precise visit. Patients are not able to edit the prescription section, which is thought to be managed only by physicians registered in the system and that can eventually associate tasks with the prescriptions. If the patient receives a relevant prescription in other clinical contexts independent from the system, they have to upload such an information in his profile section, depending on the type of prescription (medication in DrugTherapy and other prescriptions in natural language in OtherInformation).

#### AssistanceRequest:

AssistanceRequest is different from Questionnaires and Parameters, whose instances refer to typology. Its instances are referred to the single request for assistance, that can contain an attachment in blob type. AssistanceRequest is linked to TechnicalAdministrator through the association “answer”. Assistance is the association class related to “answer”. Indeed, a technical administrator answers to a request for assistance through one instance of Assistance.



## DATATYPES AND ENUMERATION STEREOTYPES

<b>«enumeration» ParameterOrigin</b>	<b>«enumeration» FormatType</b>	<b>«enumeration» GenderType</b>	<b>«enumeration» MeasurementRange</b>	<b>«enumeration» SurveyType</b>
Wearable Device Manually Inserted	.pdf .jpeg	Male Female Not Specified	Normal Slightly above Far above	Assistance satisfaction survey System satisfaction survey
<b>«enumeration» AssistanceType</b>	<b>«enumeration» UserType</b>	<b>«enumeration» QuestionnaireResult</b>	<b>«enumeration» StatusType</b>	<b>«enumeration» Profession</b>
New monitoring tool Technical assistance Deactivation of user's profile	Patient Physician Other Health Care Provider Technical Administrator	Very bad result Bad result Normal result Good result Very good result	Sent Open Closed	Nurse Psychologist Physiotherapist Nutritionist Other
<b>«enumeration» SmokerType</b>	<b>«dataType» AddressType</b>	<b>«enumeration» PrescriptionType</b>	<b>«enumeration» Frequency</b>	<b>«enumeration» PlotType</b>
Non-Smoker Ex Smoker Occasional Smoker Smoker	Country: String City: String Street: String StreetNumber: Number ZipCode: String	Medication Examination Psychological Counseling Physiotherapy Specialized Visit	3 Times a Day Everyday Every week Every month Every two months Every trimester Every semester Every year Once	Line plot Boxplot Histograms Piechart Barplot
<b>«enumeration» QuestionnaireName</b>	<b>«enumeration» ReportType</b>	<b>«enumeration» Parameter</b>	<b>«enumeration» LifestyleSuggestionsType</b>	
MMAS-8 Block FFQ AUDIT CPSS PSQI EuroQol-5D PHQ-9	ECG Blood Analysis Urinalysis Fundus oculi Blood pressure measurement Endocrine analysis Routine Other	Weight Systolic Blood Pressure Diastolic Blood Pressure Heart Rate Sleep Hours Circadian Rhythms Steps Number Physical Activity Hours Burnt Calories Glycemia	Activity Diet Alcohol Consumption Smoking Drugs	
<b>«enumeration» NotificationType</b>	<b>«enumeration» QuestionnaireType</b>	<b>«enumeration» SurveyParameterType</b>		
New questionnaire available Incoming appointment Reminder to insert parameter Request of assistance Request of physician profile activation Reminder Log in within a week Request of deactivation Request of other health care provider profile activation Possible risky condition Scheduled maintenance Parameter overcame the threshold	Therapy adherence Diet Alcohol Stress Sleep quality Health quality of life Psychological state	Time of response Number of assistance requests Evaluation of software Evaluation of technical assistance Number of deactivation Number of activation		

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