

POLITECNICO DI MILANO

School of
Industrial and Information Engineering

Biomedical Engineering
Master Of Science

PROJECT REPORT

of
Medical Informatics

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Chapter 1

Introduction

1.1 Aim of the work

The aim of the system, structured as a database, is to collect information about the pathway of the patients with heart failure and to keep track of the physiological changes for the parameters evaluated at-home and in-hospital.

Some of them are collected in both environments but the primary goal is to assess and classify some indices, to allow a constant activity of monitoring, improving the transmission of information between the patient and the doctor.

Chapter 2

System Design

2.1 Context Analysis

Before developing the project, we looked for information on the pathology of interest, heart failure:

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REFERENCE	IMPORTANT INFORMATION
Gianluigi Savarese - Global Public Health Burden of Heart Failure, 2017	It focus on the global epidemiology of HF, providing data about prevalence, incidence, mortality and morbidity worldwide. The current review reports data from studies with different designs and settings, thus the prevalence, incidence and outcome rates might not be fully comparable.
ESC McMurray - Guidelines for the diagnosis and treatment of acute and chronic heart failure	It reports important data on the main diagnostic and follow-up methods in HF patients. In particular, imaging techniques and blood tests are mentioned to monitor the pathology in relation to the patient's health state and to the symptomatology. Moreover, it reports also the main comorbidities that usually appears with HF, that are a good indicator of HF presence.
Kubica 2017 - Description of different scales to evaluate the patients' "adherence" to HF treatments	Pros and cons of the questionnaires proposed to affected people, according to the application, the pathologies and their acceptance to the therapy. The study specifies how nowadays there isn't a gold standard assessment: all the methods are useful to determine the active participation of patients in a therapy.
Jiang He - Risk Factors for Congestive Heart Failure in US Men and Women	It focus on incidence of HF related to other pathologies and particular practice, such as school education, physical activity, cigarette smoking, overweight, hypertension, diabetes, valvular heart disease, alcohol consumption, hypercholesterolemia.
Mark H. - Prognostic Importance Of Elevated JVP and a Third Heart Sound in Patients With Heart Failure	It shows that elevated jugular venous pressure is associated with an increased risk of hospitalization for heart failure. Also the presence of a third heart sound was associated with similarly increased risks of this outcome.
Gary Nicholls, Mark Richards - Disease monitoring of patients with chronic heart failure	Ovierview of the indexes needed to achieve an optimal treatment and monitoring for patients with HF, which is a burden for health budgets, has unsure and short-term prognosis, sensibly reduces the quality of life.

Harrison, Jameson, Loscalzo - Harrison's Principle of Internal Medicine	It reports all the information about the currently treatment of patient with heart failure. The main recommended exams are: blood count (Hb), electrolytes (Na, K), glycated hemoglobin (HbA1c), lipid structure, liver function, kidney function, ECG, urine analysis, BNP, brain natriuretic peptide. It reports also the pharmacological (RAAS inhibitors, ACE inhibitors, sartans, antialdosterones, furosemide...) and not pharmacological treatment.
Prognostic Importance of Elevated Jugular Venous Pressure and a Third Heart Sound in Patients with Heart Failure (Mark H. D. et al, 2001)	This paper shows that the presence of S3 and elevated jugular venous pressure are independently associated with negative outcomes, including the progression of the heart failure.

Summing up, the heart failure (HF) is a chronic syndrome with a significant clinical and social impact due to its high morbidity and mortality. The prevalence of HF is 2-3% and increases dramatically in the age group around 75 years, reaching 10-20% in patients aged 70-80. In younger subjects, HF is more frequent among male ones; among the elderly, however, the prevalence is similar in both sexes.

The global prevalence of HF is increasing because of the ageing population, the increased survival after a coronary event and the effectiveness of preventive measures for patients at high risk or who survived a first event.

The aetiology is different but the most significant causes are: ischemic heart disease, toxic damage, immune-mediated and inflammatory damages, hypertension, pericardial and endomyocardial pathologies, arrhythmias and genetic abnormalities. Moreover, symptoms are not specific and particularly difficult to be identified for elderly and obese patients. The most commonly detected are dyspnoea, orthopnoea, reduced exercise tolerance, fatigue and ankle swelling.

Historically, there are three main terminology used for HF, and they are based on measurement of the left ventricular ejection fraction (LVEF): HF with preserved EF (HFpEF), HF with reduced EF (HFrEF) and HF with mid-rangeEF (HFmrEF).

The diagnosis of HF can be carried out through several diagnostic tests, the most common are: ECG, chest X-ray, laboratory tests (anemia, hypo or hyperkalemia, creatinine level, electrolytes and thyroid function check-up ...), echocardiography and exercise tests.

The step after the diagnosis includes many treatments for heart failure and they differ according to the triggering cause and severity, which can be established by different classification methods (Killip classification, Forrester classification, NYHA classification, ACC-AHA classification).

In any case, monitoring of the patient is still essential in order to offer a correct therapy, which allows to improve the quality of life, reduces the number of hospitalizations and hospital stay and improves the appropriateness of the interventions. In order to allow this, integrated personal and hospital management is necessary, basing on the needs of the individual patient.

In order to simplify this integration, we want to create a database that allows us to collect all the information of these patients (examination results, physiological parameters, clinical history, symptoms ...). In particular, it will have 3 main actors: the specialized practitioner, the patient and the technical administrator, who have different roles and can access and modify different data.

The doctor mainly deals with the clinical aspects, therefore has access to the data of all the patients, which he can use to create statistics and to modify it, adding new measures, visits or changing the therapy. The patient, on the other hand, can only access to his own information; he can daily update the physiological parameters and visualize visits and medical reports.

Completely different is the role of the technical administrator who manages the creation of user profiles, analyzes the server parameters, inserts into the system all the information necessary for the correct integration of data (models for risk assessment, references for parameters ...).

In the following chapters, the structure and user interactions will be explained in details.

- **Other references:**

- Mechanisms of respiratory sinus arrhythmia in patients with mild heart failure (El Omar et al., 2001)
- Physical activity in patients with heart failure: barriers and motivations with special focus on sex differences (2015)
- Medication adherence and survival among hospitalized heart failure patients in a tertiary hospital in Tanzania (Pallangyo P. et al., 2020)
- The Pittsburgh Sleep Quality Index: A New Instrument for Psychiatric Practise and Research (Buysse D., 1988)
- Percorso assistenziale per la gestione dello scompenso cardiaco (2010)
- Hemodynamic correlates of the third heart sound during the evolution of chronic heart failure (Tatsuji K. et al, 1993)
- The Third Heart Sound for Diagnosis of Acute Heart Failure (Michael J. Et al, 2007)
- The Combined Utility of an S3 Heart Sound and B-Type Natriuretic Peptide Levels in Emergency Department Patients With Dyspnea (Sean P.C. et al, 2006)

2.2 UML [3]

2.2.1 UseCase Diagrams

- Doctor Profile UseCase Diagram

This is the doctor's main activity, visiting a patient and booking a follow-up visit, with its different alternative scenarios.

DOCTOR – MAIN SCENARIO

1. Doctor logs in.
2. System verifies password.
3. System shows homepage.
4. Doctor visualizes daily visit list.
5. Doctor visualizes patient's profile of choice.
6. Doctor adds visit's medical report.
7. Doctor inserts "in-hospital" parameters.
8. Doctor manages patient's therapy.
9. Doctor sets patient's personal thresholds.
10. Doctor visualizes visited patient's graphics and statistics.
11. Doctor saves as PDF graphics and statistics of choice.
12. Doctor opens booking portal to book a visit.
13. Doctor visualizes visit's calendar.
14. Doctor selects day of choice.
15. Doctor selects hour of choice.
16. Doctor confirms booking procedure.
17. System saves booking.
18. Doctor logs out.

DOCTOR – ALTERNATIVE SCENARIOS

1a. *Doctor requests password change:*

1. System sends a request to the technical administrator.
2. Use case ends.

2a. *Password is wrong:*

1. System displays authentication error.
2. Return to step 1.

2b. *Password wrong for third time in a row:*

1. Visualize wrong authentication error.
2. System blocks login for 15 minutes.
3. System sends a notification to the technical administrator.
4. Use case ends.

4a. *Doctor visualizes his own profile:*

1. Doctor manages his own profile.
2. Return to step 3.

4b. *Doctor visualizes patient list:*

1. Doctor visualizes patient's profile of choice.
2. Doctor manages patient's profile of choice.
3. Return to step 3.

4c. *Doctor visualizes default global graphs and stats:*

1. Doctor can manage global graph and stats.
2. Return to step 3.

8a. *Doctor edits patient's priority:*

1. Return to step 8.

8b. *Doctor changes default Risk Evaluation Model:*

1. Doctor chooses a different Risk Evaluation Model.
2. System computes new patient's risk level.
3. System shows new patient's risk level.

4. Return to step 8.

11a. Doctor manages graphics and statistics:

1. Doctor picks parameter of choice.
2. Doctor picks time interval of choice.
3. Doctor chooses possible comparison with a patient or a group of patients.
4. Return to step 11.

11b. Doctor adds notes to graphs and stats:

1. Return to step 11.

12a. Doctor opens booking portal to book an exam:

1. Doctor visualizes exams' calendar:
 - (a) No date available:
 - i. System displays error message.
 - ii. Use case ends.
 2. Doctor selects day of choice:
 - (a) System displays error message.
 - (b) Return to step 12a.
 3. Doctor selects hour of choice.
 4. Return to step 16.

13a. No date is available:

1. System displays error message.
2. Use case ends.

14a. Day fully booked:

1. System displays error message.
2. Return to step 13.



Figure 2.1: Doctors' Use Case Diagram

- Patient Profile UseCase Diagram

The main scenario for the patients lets them log in, check their prescriptions, manage their profile and inserts their parameters in the system.

PATIENT – MAIN SCENARIO

1. Patient logs in.
2. System verifies password.
3. System visualize reminder about the dosage and the type of the medicines he/she is taking daily.
4. Patient closes reminder popup.
5. System shows homepage.
6. Patient visualizes personal profile.
7. Patient manages personal profile.
8. Patient inserts or upload “at-home” parameters. [Parameters can be collected through wearables, medical devices, or mobile apps. The insertion can be manual or made through the upload of formatted files (data streams and temporal trends).]
9. Software sends a notification to the doctor and the patient if there are “out-of-range” parameters.
10. Patient fills in clinical questionnaires.
11. Patient logs out.

PATIENT – ALTERNATIVE SCENARIOS

1a. *Patient requests for password change:*

1. System sends the request to tech admin.
2. Use case ends.

2a. *Password is wrong:*

1. System displays authentication error.
2. Return to step 1.

2b. *Password is wrong for the third time in a row:*

1. System displays authentication error.
2. System blocks log in for 15 min.
3. System sends a notification to tech admin.
4. Use case ends.

6a. *Patient visualizes a list of emergency phone numbers and other contacts related to the hospital:*

1. Return to step 5.

6b. *Patient visualizes visits: [the patient can book, delete or reschedule a visit – All the alternative scenarios in which there are no dates available or the selected date/time slot is already occupied, will be treated as shown in the Doctor’s textual description]*

(a) Patient books visit:

1. Patient visualizes visits’ calendar and choose an available date.
2. CUP confirms the booking.
3. Return to step 5.

(b) Patient deletes visits:

1. System sends a notification to the doctor.
2. Return to step 5.

(c) Patient reschedules visits:

1. Patient visualizes visits’ calendar and choose an available date.
2. CUP confirms the rescheduling.
3. Return to step 5.

6c. *Patient sets up a reminder about the dosage and the type of the medicines he/she is taking daily:*

1. Return step 5.

7a. *Patient visualizes a set of statistics and diagrams regarding the temporal trend of his/her inserted parameters:*

1. Patient chooses parameters of choice.
2. Patient chooses time interval of choice.

3. System shows the graphs.
4. Return to step 6.

7b. *Patient visualizes booked exams and information about them: [the patient checks if he needs a specific preparation before an exam, such as stop taking a prescribed drug, avoid eating or drinking, etc..., and also visualize a general description of the exam, including the price, the location, etc...]*

1. System shows booked exams list.
2. Patient searches with keywords/filters and selects the exam of choice.
3. System shows exam details.
4. Return to step 6.

7c. *Patient prints therapy description:*

1. System shows the print preview.
2. Patient modify default file type.
3. Patient clicks on “print therapy”.
4. Return to step 6.

7d. *Patient prints medical reports:*

1. System shows the medical report list.
2. Patient searches with keywords/filters and selects medical report of choice.
3. System shows the medical report description.
4. Patient clicks on “print medical report”.
5. Return to step 6.

7e. *Patient visualizes exams results:*

1. Patient inserts a key to download the documents related to his/her diagnostic exams.
2. Patient saves the graphs, values or images as .pdf or .csv.
3. Return to step 6.

8a. *Patient manages personal data:*

1. Patient edits personal informations.
2. Return to step 7.

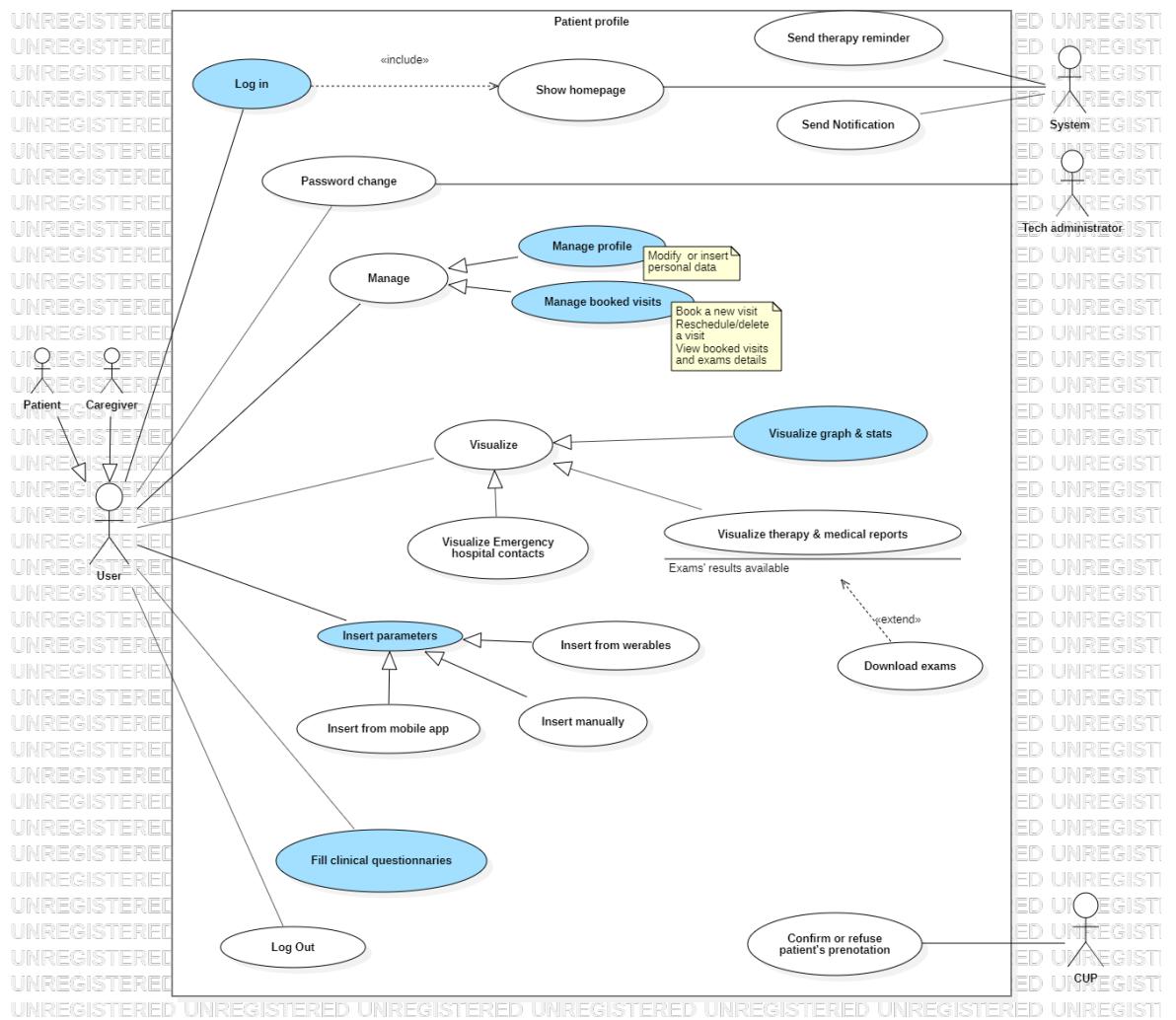


Figure 2.2: Patients' Use Case Diagram

- **Technical Administrator Profile UseCase Diagram**

The main scenario for the technical administrator is the editing of patients' profiles, while other activities such as adding or deleting users, managing Risk Evaluation Models, managing questionnaires and accessing to server statistics, are represented as alternative scenarios.

TECHNICAL ADMINISTRATOR – MAIN SCENARIO

1. Log in
2. System verifies the password.
3. System shows the homepage.
4. System shows the list of users.
5. Technical admin selects a list of existing users.
6. Technical admin chooses a specific user.
7. System shows user's profile.
8. Technical admin selects an attribute to modify.
9. Technical admin enters a new value.
10. Technical admin confirms changes.
11. System saves modifications.
12. Log Out.

TECHNICAL ADMINISTRATOR – ALTERNATIVE SCENARIOS

2a. Password is wrong:

1. System displays authentication error.
2. Return to step 1.

2b. Password wrong for third time in a row:

1. Visualize wrong authentication error.
2. System blocks login for 15 minutes.
3. System notifies other technical administrators.
4. Use case ends.

4a. Technical admin adds new user:

1. Technical admin creates a new user ID.
2. Technical admin inserts a new user password.
3. Technical admin confirms operation.
4. System saves new user.
5. Return to step 3.

4b. Technical admin visualizes server statistics:

1. Technical admin visualizes the daily number of logins.
2. Technical admin visualizes query execution time.
3. Technical admin visualizes user session duration.
4. Return to step 3.

4c. Technical admin accesses to "Manage Risk Evaluation Model" menu:

1. Technical admin creates/visualizes/deletes a model from the list.
2. Technical admin edits model's weight list.
3. Return to step 3.

4d. Technical admin visualizes manages reference thresholds:

1. Technical admin adds/updates/deletes thresholds.
2. Return to step 3.

4e. Technical admin manages questionnaire list:

1. Technical admin adds/updates/deletes questionnaires.
2. Return to step 3.

6a. Technical admin searches specific profile with a keyword (primary key, name, surname, etc...):

1. Technical admin types keyword in a searchbar.
2. Return to step 7.

8a. Technical admin deletes existing user:

1. Technical admin confirms operation.
2. Return to step 3.

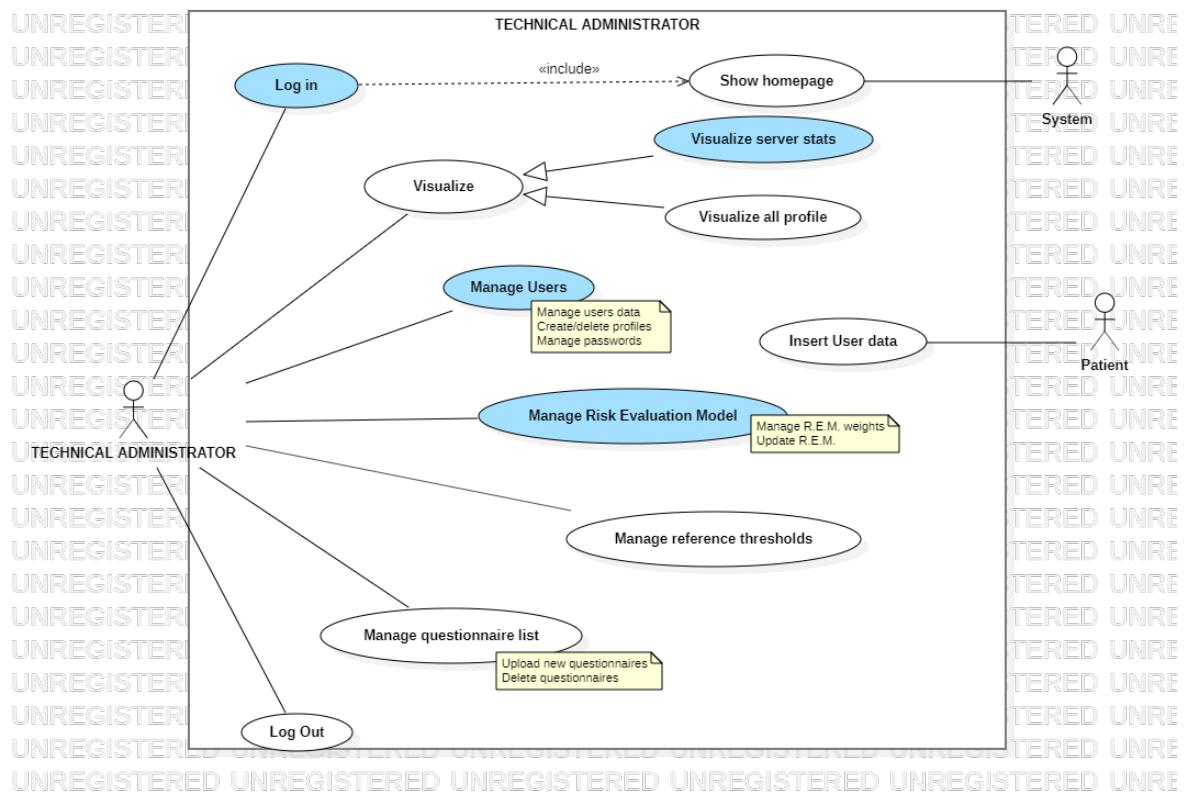


Figure 2.3: Technical Administrators' Use Case Diagram

2.2.2 Activity Diagrams

- ADD PARAMETERS

The diagram describes the activity of adding new parameters by two different points of view: the one of the patient and the one of the doctor.

This activity requires the validation of the access credentials for both the patient and the doctor through the activity of log in, necessarily completed.

Patient's Point of View

After the patient logs in, the system shows the homepage that includes the options to manage his/her personal profile.

The patient selects the field “Parameters’ insertion” and chooses one of the following options, according to the device, the type of parameter and the acquisition frequency considered.

1. Manual insertion (height, weight, BMI, glycemia indicated in Project Specifications).
2. Automatic insertion through the upload of files containing the data streams and the temporal-trends (blood pressure, heart rate, sleep quality index, physical activity indicated in Project Specifications).

The two ways of insertion are parallel actions, each time this diagram is executed the patient runs both, but the order is not mandatory.

These two actions are always associated to a third: the filling of questionnaires, daily or weekly compiled, that produce a score index calculated by the system to highlight peculiarities about the sleep efficiency and the therapy adherence.

It is possible to return to the choice of insertion:

- If the uploaded file is damaged.
- If the recorded parameter is invalid.
- If the questionnaire is incomplete.

After the insertion of the “at-home” parameters and the filling of the questionnaires the system provides a counter of the “out of range” parameters.

- If all the parameters present values included in the range established the activity ends.
- If the system records one or more “out of range” parameters, two different notifications are sent to the doctor and the patient. The activity ends.

Doctor's Point of View

After the doctor logs in, the system shows the homepage that includes the visualization of the list of his/her patients. The doctor chooses a specific patient profile and selects the option “Add medical reports and parameters”. Three actions are run in parallel each time the activity is executed:

- The doctor adds notes about the parameters to highlight “out of range” values or other concerns in his/her medical report.
- The doctor inserts “in-hospital” manual parameters (JVP, blood pressure, blood exam).
- The doctor uploads files containing data streams and the temporal trends recorded by a clinical device.

It is possible to try again whether:

- The parameter’s value is invalid.
- The uploaded file is damaged.

After the three actions are completed successfully the activity ends.

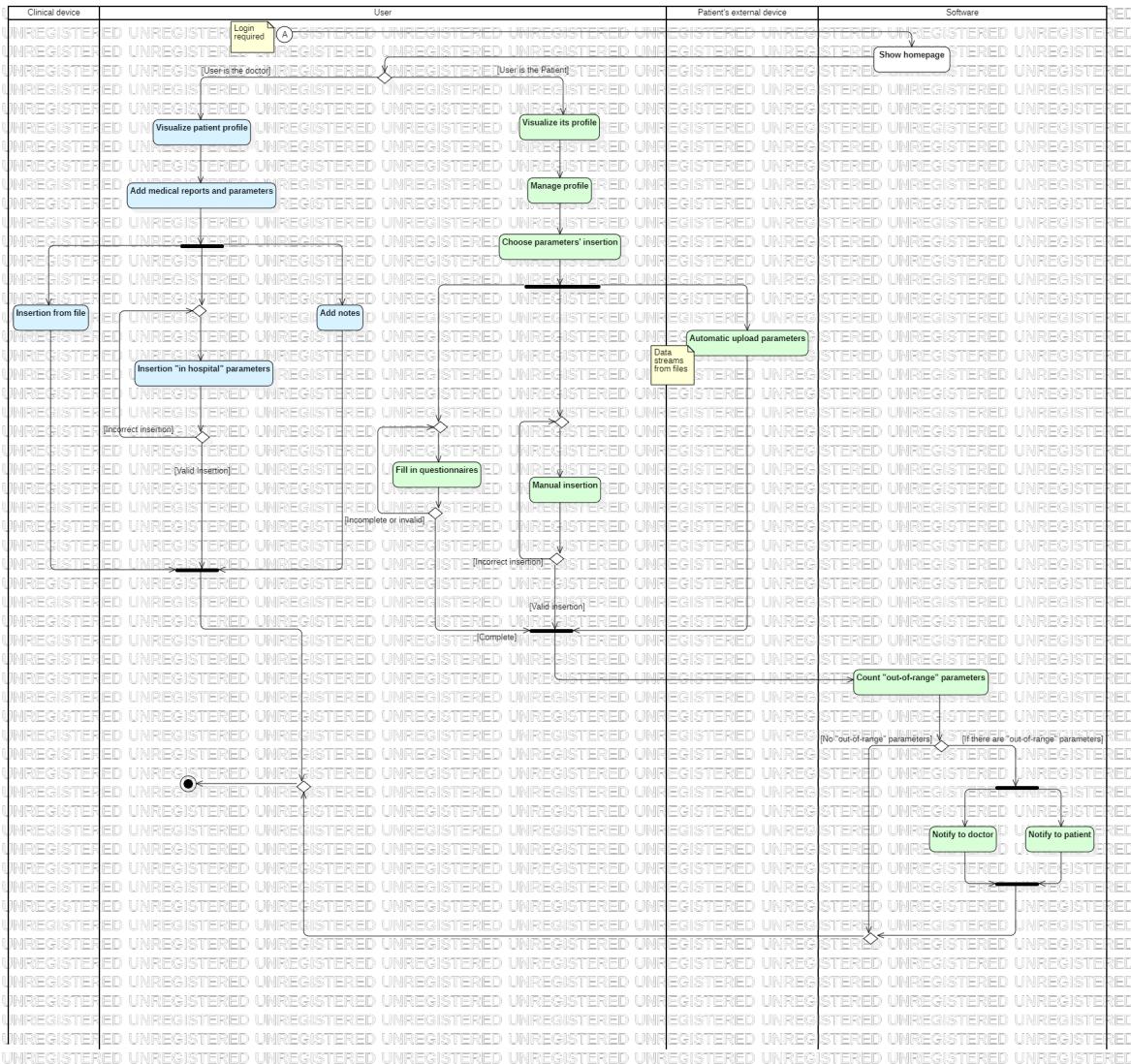


Figure 2.4: "Add Parameters" Activity Diagram

- BOOK MEDICAL PROCEDURE

This activity is named “Book medical procedure” because the steps to book an exam and a visit are essentially the same, based on two different calendars.

After the log in the doctor views the system's home-page and has access to the patient's list. He can manually scroll through the patients list or either search for a specific user by query. Then, after selecting a patient, their profile is shown, and the doctor can perform different actions. In this activity his aim is to book a medical procedure, so he opens the booking portal and consults the calendar of the available dates. From this point he can break the activity at any time and return to the patient's profile. If no dates are available the system notify the doctor with a pop up ("No date available"), the same thing happens if the doctor chooses a fully booked day ("Full timetable") or an occupied time slot ("Occupied").

After a proper choice of date and time for the medical procedure the doctor is asked to confirm the operation, then the activity is completed and a medical procedure is booked for a specific patient.

At this point the doctor can either log out or perform another operation.

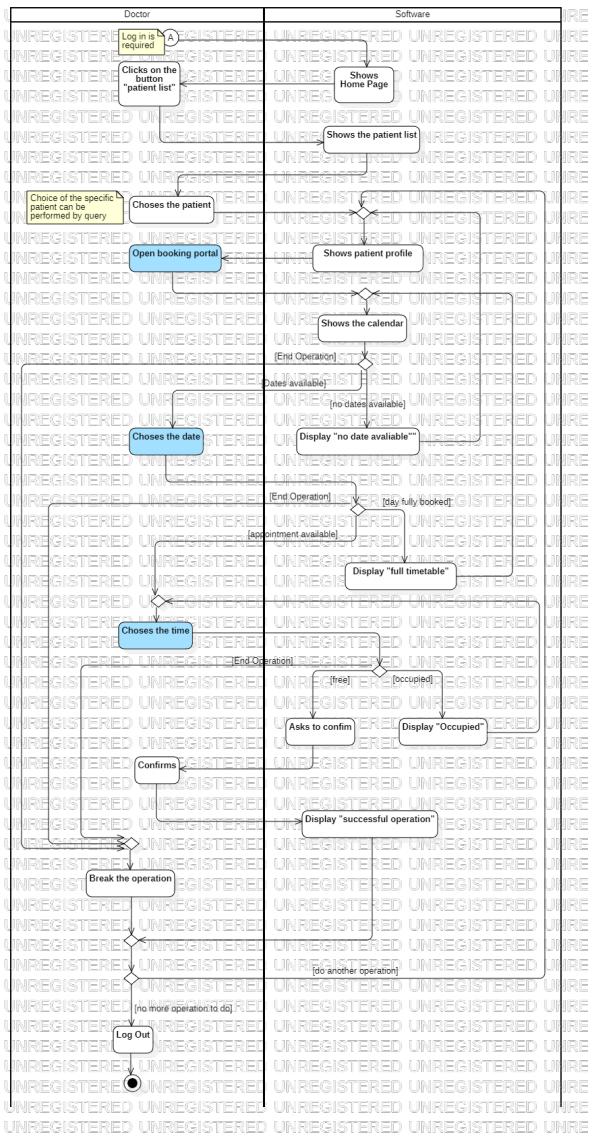


Figure 2.5: "*Book Medical Procedure*" Activity Diagram

• GRAPHS AND STATS

In this activity diagram, after the login, the doctor opens the graphstats application and chooses whether he wants to evaluate plots and statistics:

- About single patients.
- About the whole set of patients.

If single patients are evaluated, the doctor can choose whether:

- He wants to evaluate only one patient.
- He wants to compare said patient with some others.

In order to generate the plots, the doctor is asked to choose a proper time window and a set of clinical parameters of interest, both shown in finite lists by the application.

As the doctor makes the choice, the application generates the plots and statistics, and at this points 3 major paths can be followed:

- The doctor can write annotations on the plots and statistics if they are not clear/ interpretable enough.
- The doctor can save the plots and statistics as a .pdf file in order to easily share them.
- The doctor can go on without modifying or saving the plots and statistics, as once generated they are considered not particularly relevant.

At this point the plots and statistics can be:

- Modified or saved again.
- Generated from the beginning using other patients.
- The application can be terminated.

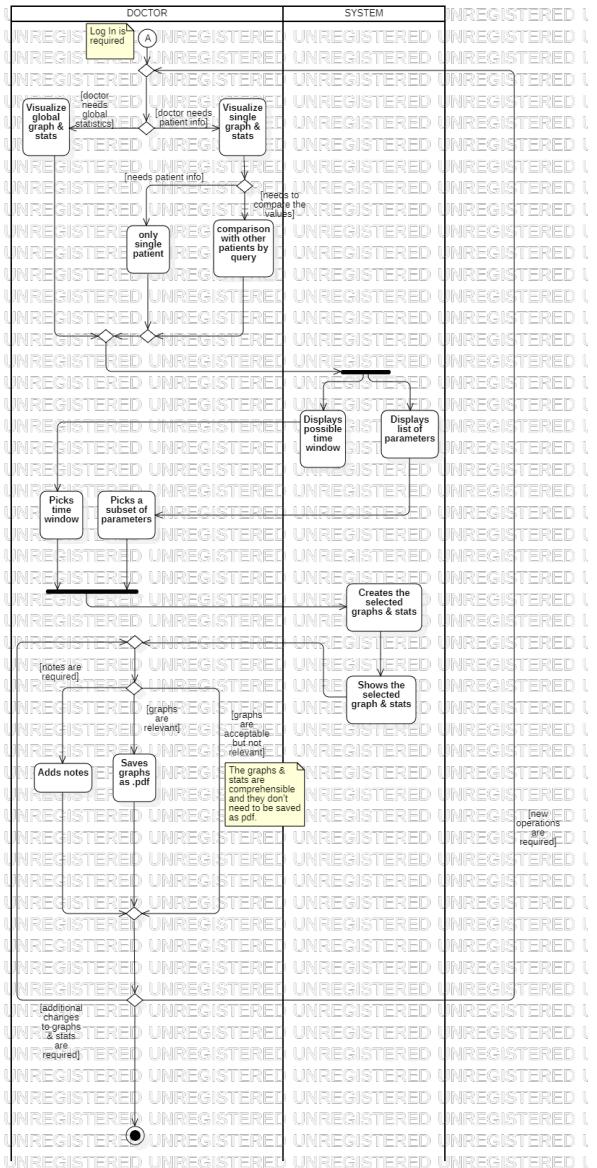


Figure 2.6: "Graph & Stats" Activity Diagram

• RISK EVALUATION

For this activity diagram, it was decided to analyze the methodologies for creating and modifying risk assessment models in patients with heart failure.

First, research has been done on the models currently used in the clinic, in order to identify the elements needed for their formulation. The two most used models are:

- NYHA: Identifies four functional classes, in relation to the activities that the patient, suffering from this pathology, can perform.
- ACC/AHA: Identifies 4 classes based on symptoms and structural cardiac alterations of the subjects.

Given this brief analysis, it was decided to define the structure of the general model as follow:

1. The technician defines a number N of parameters, that can be symptoms, test results, risk factors, pathologies...
2. Each parameter is assigned a weight, which depends on how much it influences the heart.
3. failure The score of each patient is obtained by the weighted summation of the parameters.
4. The technician defines a number M of classes and establishes a score range for each class.
5. Patients are placed in a class based on the score.

The weights and parameters to consider are chosen by the doctor based on the literature.

From an organizational point of view, it was decided to leave only the technician the possibility to insert and manage the models and that there may be multiple models in a repository. The doctor can choose the one to use.

Workflow:

The technician logs into his profile and enters in the risk assessment model area, where the system displays a list containing the models already loaded; this list can also be empty.

The technician can then decide to proceed in 3 ways:

1. Modify a model from the list; in particular, he can change the weights of each parameter.
2. Delete a model in the list; the activity ends.
3. Create model ex novo:
 - Select all the parameters/factors he wants to consider.
 - Select the number of classes to create and the score range of each one.
 - Adds a short description, which summarizes the category of patient contained in the classes.

At the end of these operations, the technician saves the model and the system shows a summary table containing the name, classes, score ranges and descriptions of the new model.

If the job is correct, the technician can proceed to load it into the system, which will simultaneously notify the doctor the update. Otherwise he can go back to the list of models and start over.

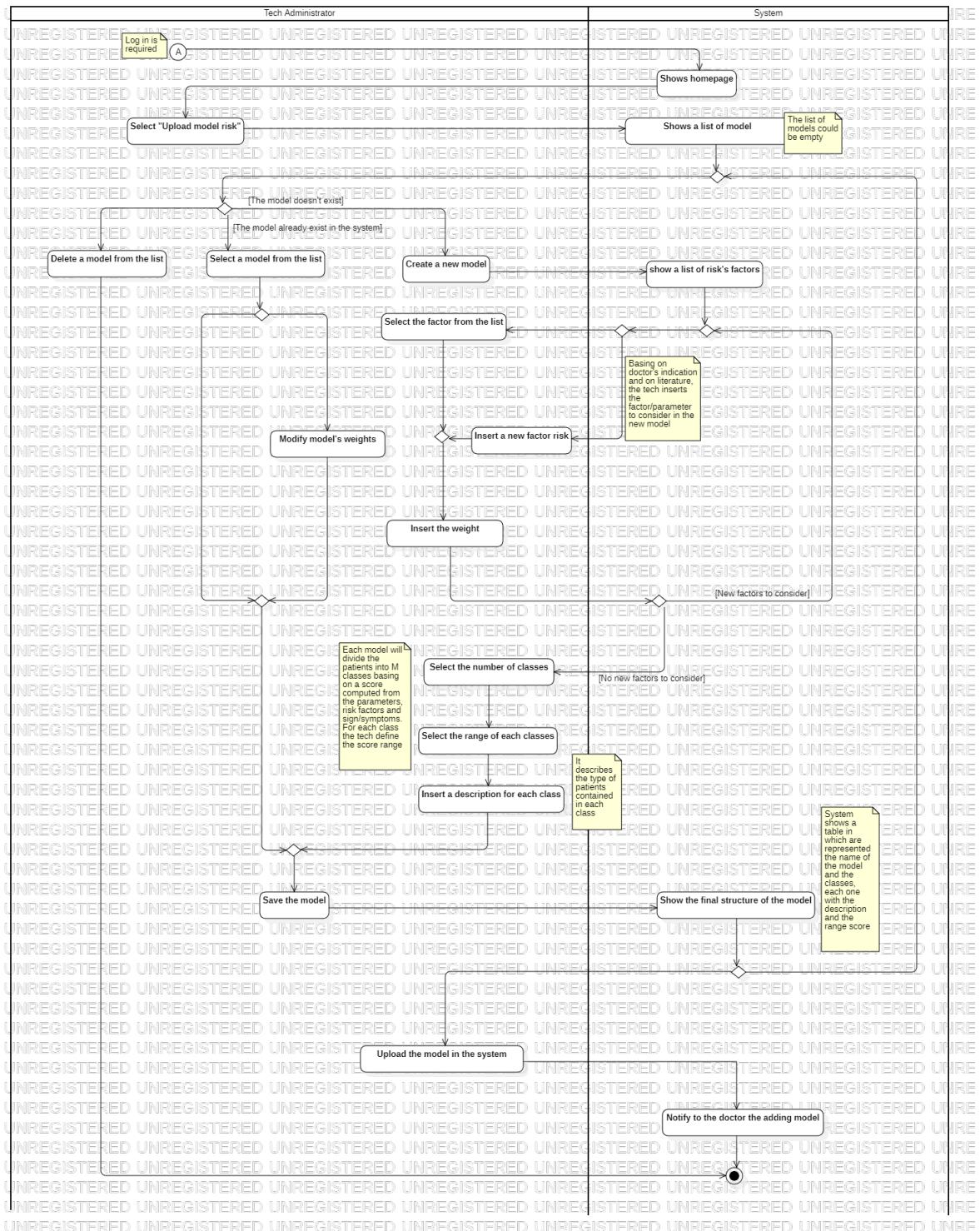


Figure 2.7: "Risk Evaluation" Activity Diagram

- **MANAGE USERS (technical administrator)**

In the activity diagram illustrated is taken into account the assumption that the log-in has just been performed.

Once the log-in has been executed by the Technical Administrator, the System loads the homepage of the application. The decision node that comes afterwards take into account the two options that the Technical administrator can opt to choose:

1. Add new user.
2. Modify/Delete user.

Add new user

The Technical Administrator execute the operation of *adding a new user*, by adding the new user data and generating the new user's password.

Then the Technical Administrator decides whether:

- To confirm the changes made.
- To cancel the operation.

If the Technical Administrator wants to save, he confirms the changes and afterwards the System saves the changes made.

Once the changes are saved, if the Technical Administrator has no other operation to perform he proceeds to Log Out, if he wants to perform a new operation the System returns to the homepage.

Modify/Delete user

When the Technical Administrator wants to modify/delete an user he selects the list of existing users and the System shows such list to him.

Now the Technical Admin can:

- Choose a specific user.
- Perform a refining of the search inserting some keywords filters, and after inserting them the Systems shows the new filtered list.

If the Technical Admin chooses a specific user from the list, the System proceed to show that user's profile.

Here the Technical Administrator can choose between:

- Modify the profile.
- Delete the profile.

If the Technical Admin wants to *modify the profile* he chooses one attribute and assign a new value to it.

After going trough one of this two possibilities the Technical Admin has to decide whether:

- Confirm and save the changes.
- Cancel the operation and go back to the homepage for a new operation.

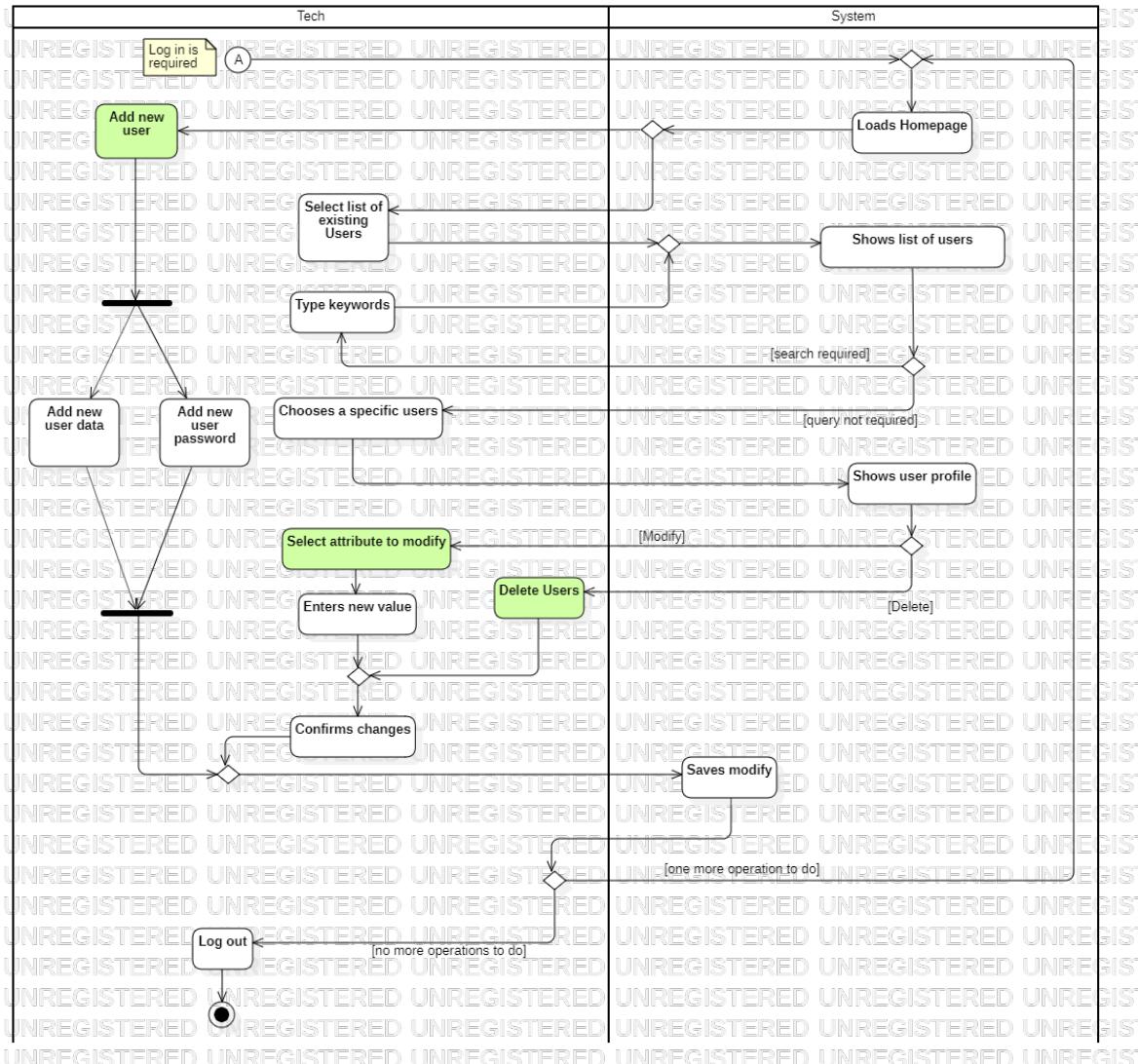


Figure 2.8: "Manage Users" Activity Diagram

- **VISUALIZE MEDICAL REPORTS AND THERAPIES**

This diagram describes two visualization activities performed by a patient profile:

1. The visualization of medical reports.
2. The visualization of therapies.

The diagram overlooks an initial login procedure that the patient must necessarily complete in order to access his/her profile.

As soon as the patient has access to the profile, the system displays a pop-up window in which a small summary of the therapy (if present) is reported, which the patient must daily support. This action occurs regardless of the patient's intentions.

Subsequently, the patient from the home of his profile can select the various viewing actions or he can choose to log out:

- If the patient selects the possibility of viewing the medical reports, the system shows the list of reports (if any). The patient also has the option to search for keywords to facilitate the search within the medical report list. If the patient selects the desired medical report, the system shows the description with any attachments. From here you can then cancel the operation or download the medical report. The download activity is carried out as a description for the therapy. Once the operation is finished, the patient can go back to the home and log out.
- If the patient chooses to view the therapy assigned to him, he will have the possibility to download it in various formats (pdf, txt, etc). Whenever the patient is given the opportunity to choose what action to take, it can also be canceled. Once the action is completed, the system returns to the Home from which it is possible to log out.

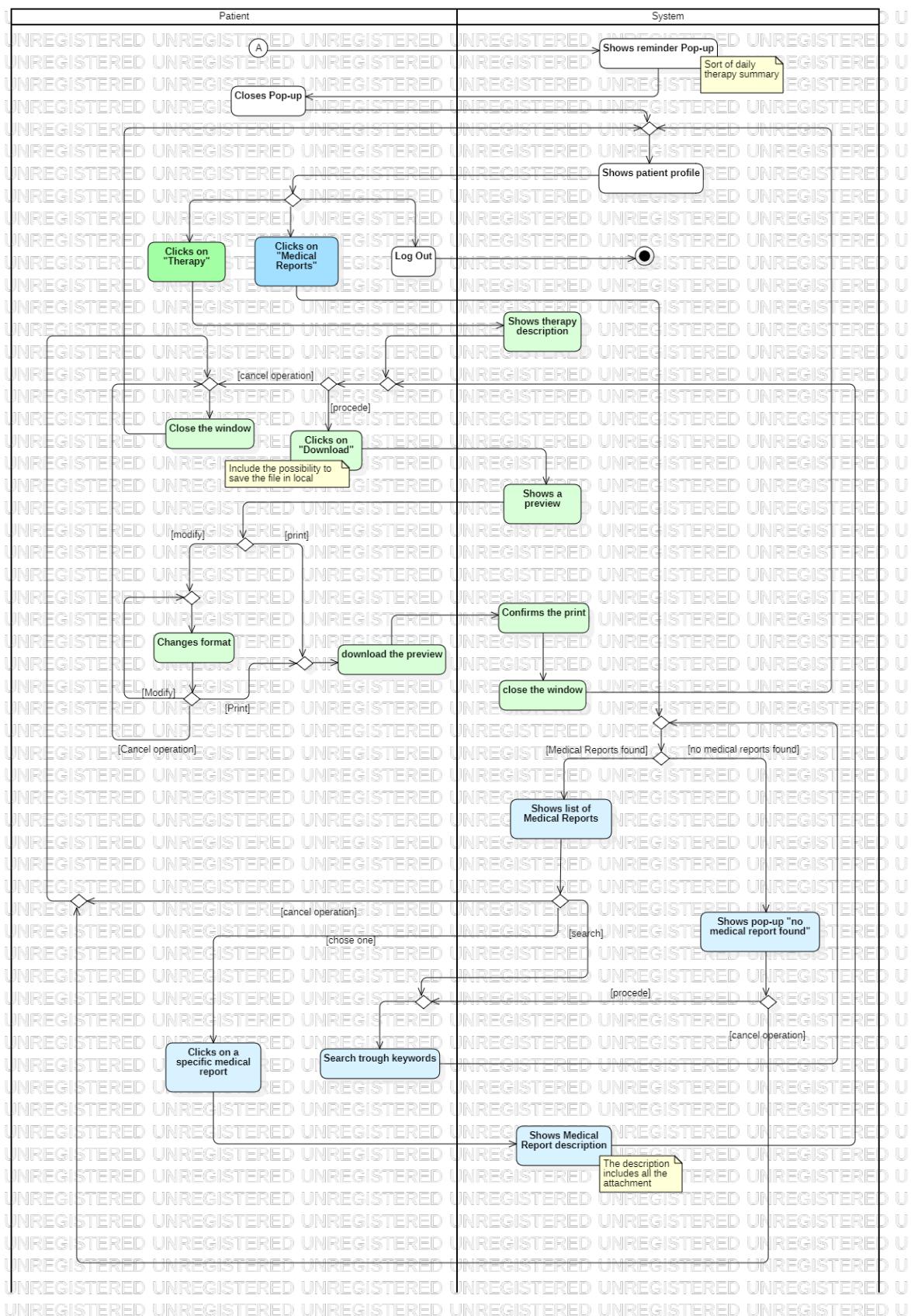


Figure 2.9: "Visualize Medical Reports and Therapies" Activity Diagram

2.2.3 Class Diagram

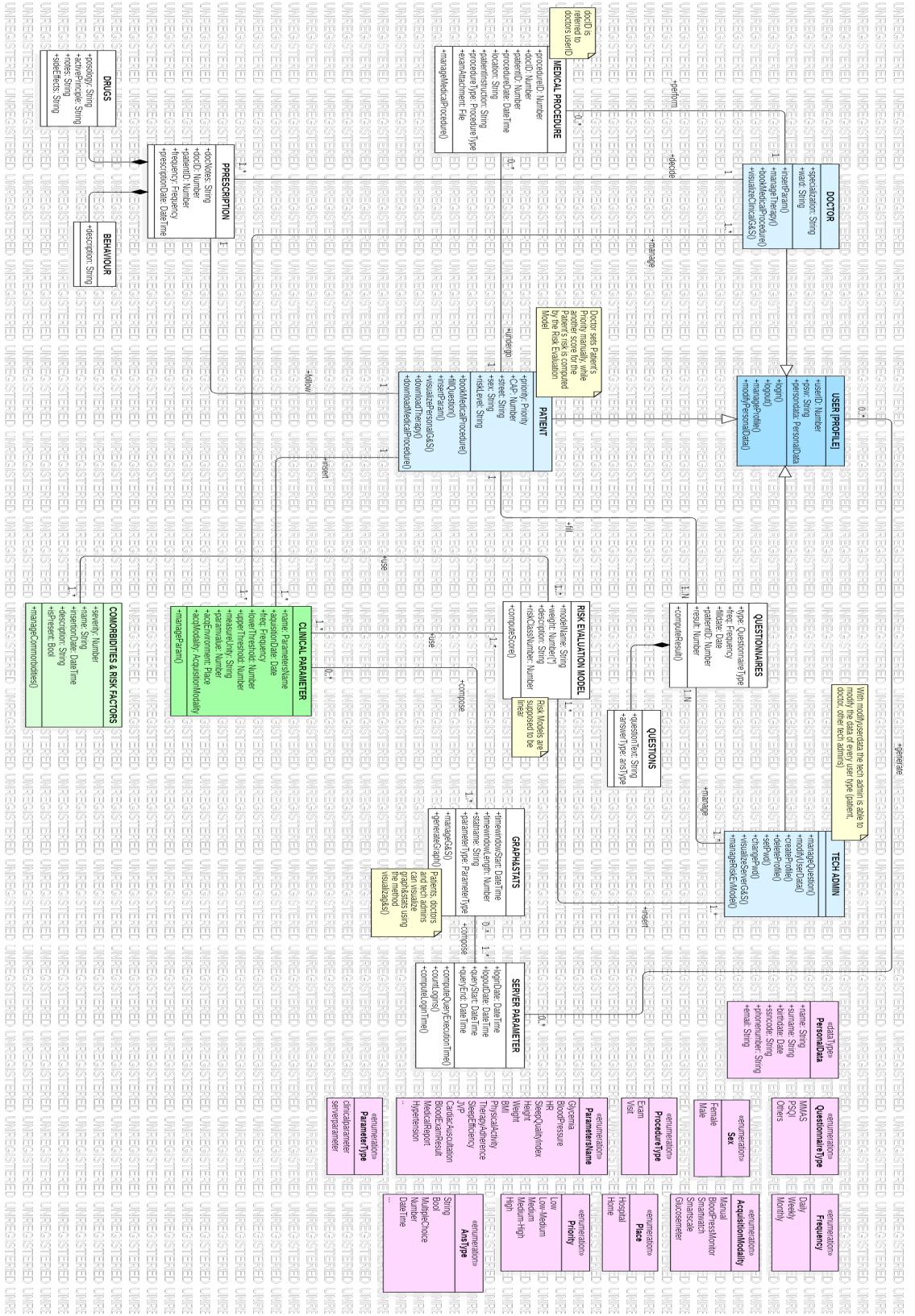


Figure 2.10: ER complete

In this section we will illustrate the Class Diagram of our system, that shows the entities taken into consideration with their own methods and relationships between various entities.

- **Medical Procedure**

As most of the actions that revolves around medical exams and visits are identical, it seemed adequate to imagine a class that could represent both of them.

So *Medical Procedure* has been used: to properly discern whether a visit or an exam are requested, the attribute "procedureType" can assume two values in the "ProcedureType" enumeration class, that are "visit" and "exam".

Other than that, this class reports the identifiers of the involved specialized practitioner and patient, and an incremental ID that identifies the visit.

There are also informations about the date, time and location at which the medical procedure took place.

In the end, some instructions in preparation to the medical procedure are reported, and in the case in which the procedure is an exam, a file with biosignals or bioimages can be attached. Any of these attributes can be visualized and modified trough the "manageMedicalProcedure()" method.

- **Prescription**

This class should represent the precautions that the patient must follow. With two compositions we tried to highlight the fact that a prescription is composed by a pharmaceutical part and a behavioural one.

A general prescription has the IDs of the doctor that wrote it down, and of the patient that needed it; it also reports its issuing date, the frequency at which it must be applied and some annotations by the specialized practitioner.

The pharmaceutical subclass, called *drugs*, also reports the posology, active principle and side effects of prescribed drugs; also there are some notes about them.

The behavioural subclass, called *behaviour*, is characterized only by the description of beneficial habits.

- **Graph & Stats**

This class refers to the graphs and statistics that can be generated from Clinical Parameters and Server Parameter, both connected to it by the relation *compose*.

Graph&Stats class is mainly characterized by a time window – starting date plus some pre-set length of the period to analyse – and a parameter of choice, used to generate the graphs.

Patient, Doctor and Technical Administrator can visualize different instances of Graph&Stats using the method *visualizeG&S()*.

- **Risk Evaluation Model**

This class represent the Risk Evaluation Model computed through a weighted sum of different inputs, Clinical Parameter and Comorbidities Risk Factors, which are connected by the relationship *use*.

Each Risk Evaluation Model has a name, an array of weights, a textual description and a number of risk class to assign to the different Patients.

The method *computeScore()* allows the calculation of the risk class, which will constitute the *riskLevel* of the Patient.

Technical Administrator can add new Models through the relationship *insert*.

- **Risk Evaluation Model**

The class questionnaire can interact with the patient that fill-in such questionnaire and the technical administrator that can manage(create/update/delete) the questionnaires. As composition we have the questions that compose the questionnaire and which existance is reliant on the existance of the questionnaire.

2.3 The Database

2.3.1 ER Diagram

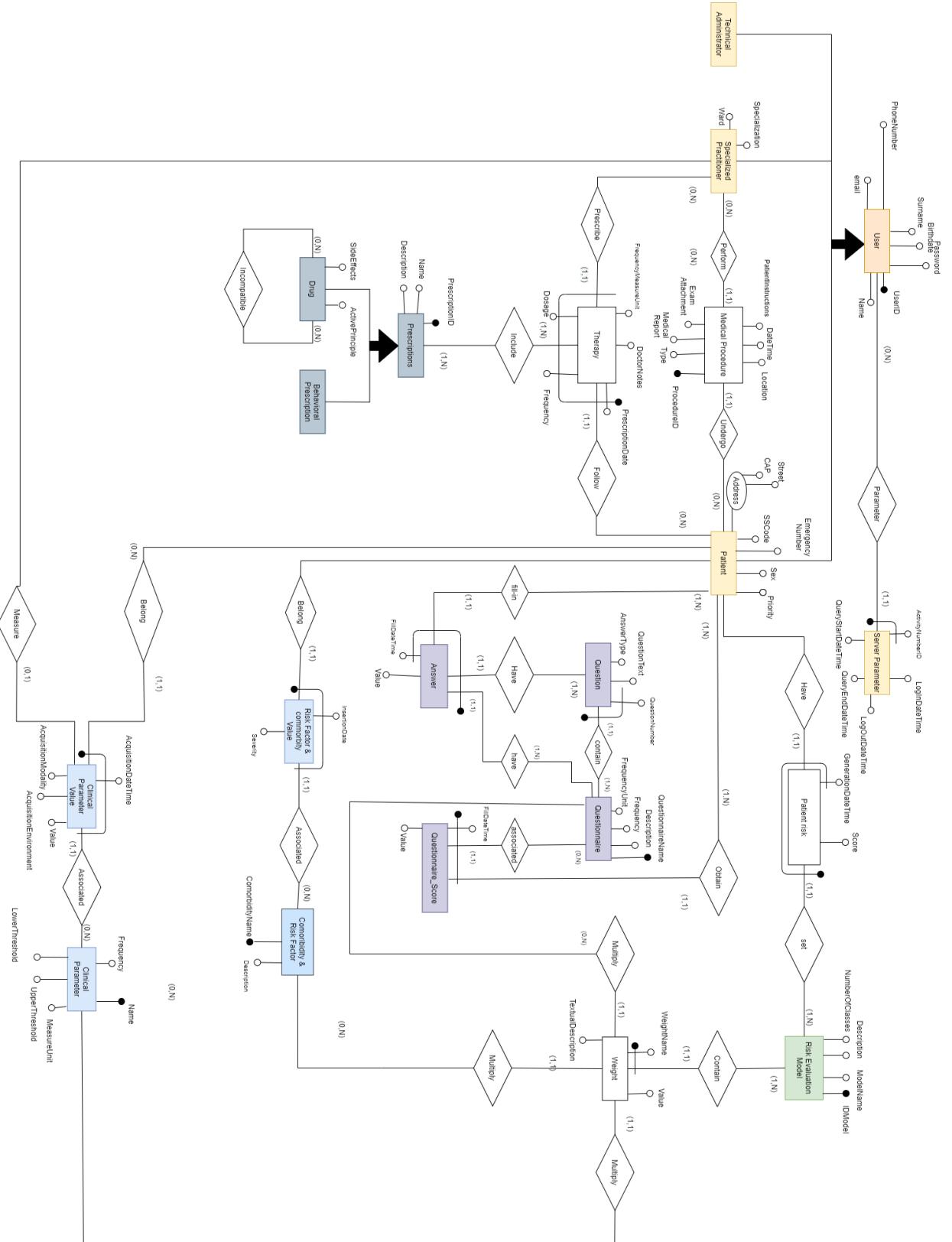


Figure 2.11: ER complete

Description of single parts

- **Users and Server Parameters**

In this section we decided to use a generalization to represent each users' category and its attribute. We have the technical administrator, who has only the attributes of the parent class, the specialized practitioner, characterized also by specialization and ward; and last the patient. For the patient we underlined a specific attribute, the priority, which represents his risk level.

The doctor can set it in order to identify patient with worsening symptoms or who needs special attention. This attribute is different from the class risk, set by the systems through the application of the model risk, since it is optional and not fix automatically.

Connected to the user, we have created another entity, called server parameter in which all data, used to create server statistics, are recorded. We have created the relation parameter to match each parameter with its corresponding user.

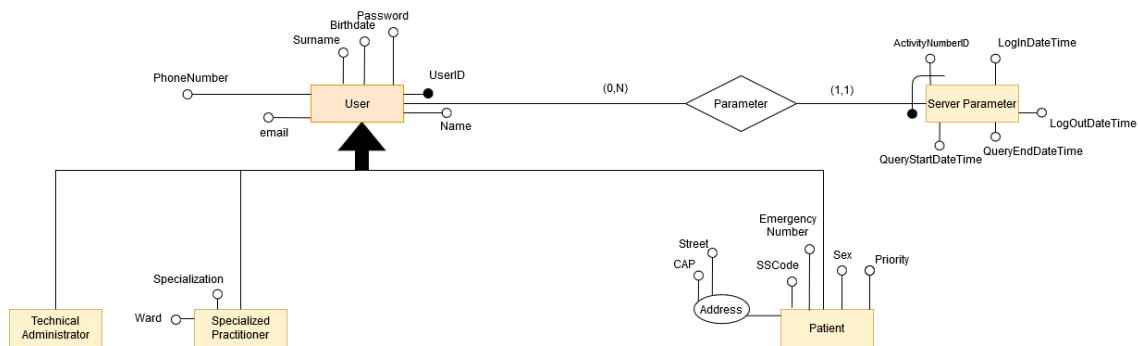


Figure 2.12: Users and Server Parameters

- Risk Evaluation Model Part

As far as the risk evaluation model is concerned, we thought of modeling it through an entity that has the modelID as its primary key. Each model will also have a name, a description and a set number of classes.

We also thought of grouping all the weights in a proper entity by giving it as attribute a name and the ID of the model, together they can identify a single weight. Each weight is associated with a textual description and the value of the weight.

The diagram links to the weight all the possible terms that can be multiplied by a weight, so clinical parameters, comorbidities and results obtained from the questionnaires.

The results of the risk evaluation models are contained in a entity that we have called "patient risk". This entity will have Score and GenerationDateTime as attribute, the latter in combination with foreign PatientID and ModelID can identify an instance. This entity therefore makes possible to monitor the progress of the theoretical risk of the patient over time

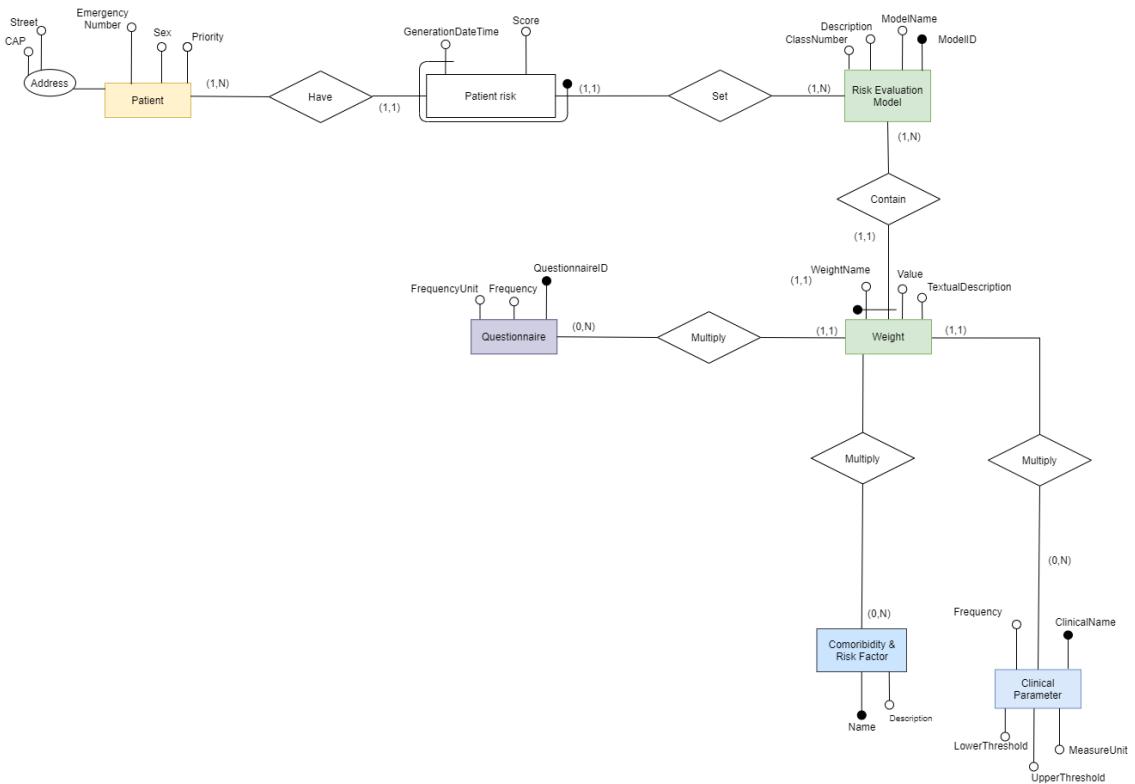


Figure 2.13: Risk Evaluation Model

- **Parameters, Comorbidities and Risk Factors**

In this section we have six main entities: Clinical Parameter, Clinical Parameter Value, Patients, Specialized Practitioners, Comorbidities&RiskFactors and Comorbidities&RiskFactors Value. The entity Clinical Parameter represents a catalogue of each kind of parameter that can be recorded in the database. It has ClinicalName as primary key, MeasureUnit, LowerThreshold, UpperThreshold and Frequency (daily, weekly, monthly, at each visit...) as attributes. It is linked by the relation Associated to the entity Clinical Parameter Value, in which every parameter is associated to a patient and the date of the measurement. The primary key of this entity is: the acquisition DateTime with external identifiers name of the parameter and patient ID. These data can be collected both in hospital and at home, as represented by the AcquisitionEnvironment attribute. Then we have the entity Comorbidity and Risk Factor; also in this case it represents a general list of the problematic and diseases that can affect the patient. It is linked by the relation associated to Comorbidity and Risk Factor Value, which collects all the comorbidities and risk factor of each patient, with an attribute that represents the severity of the disease and one representing the date of insertion. This entity has as primary key the name of comorbidity or risk factor, the patient ID and InsertionDate.

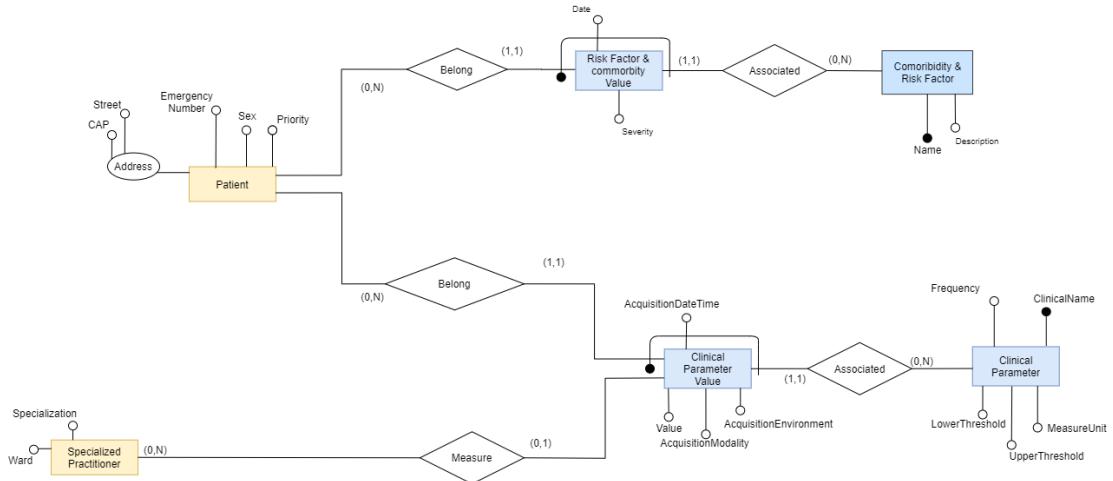


Figure 2.14: Parameters, Comorbidities and Risk Factors

- **Questionnaires**

In this section we have created 4 main entities: Question, Answer, Questionnaire and Questionnaires_Score. The first one represents the catalogue of all questions that composed the questionnaires. Each of them is univocally recognized by the QuestionnaireName and the QuestionNumber. It has also other attributes, such as the text of the question and the answer type (multiple choice, single answer and so on).

Connected to this entity, there is the entity Answer, through the relation Have. It is a list of the answer of each patient to each question. They are univocally recognized by the primary key of the questions, the one of the patient, the FillDateTime and QuestionnaireName. Also the entity Questionnaire is linked with Question and the Answer; it represents the list of the possible questionnaires, characterized by the QuestionnaireName, the Frequency, the FrequencyUnit and a description.

It is connected by the relation Associate with the Questionnaires_Scores, that is a table in which the Score obtained by each patient in each questionnaire is recorded. This value is univocally recognized by the QuestionnaireName, the PatientID and the FillDateTime, as represented by the foreign key notation.

The entity Questionnaire is also linked to the Weights of the model risk, because it can be used inside a given Risk Evaluation Model; is not represented in this sub diagram but visible in the full one.

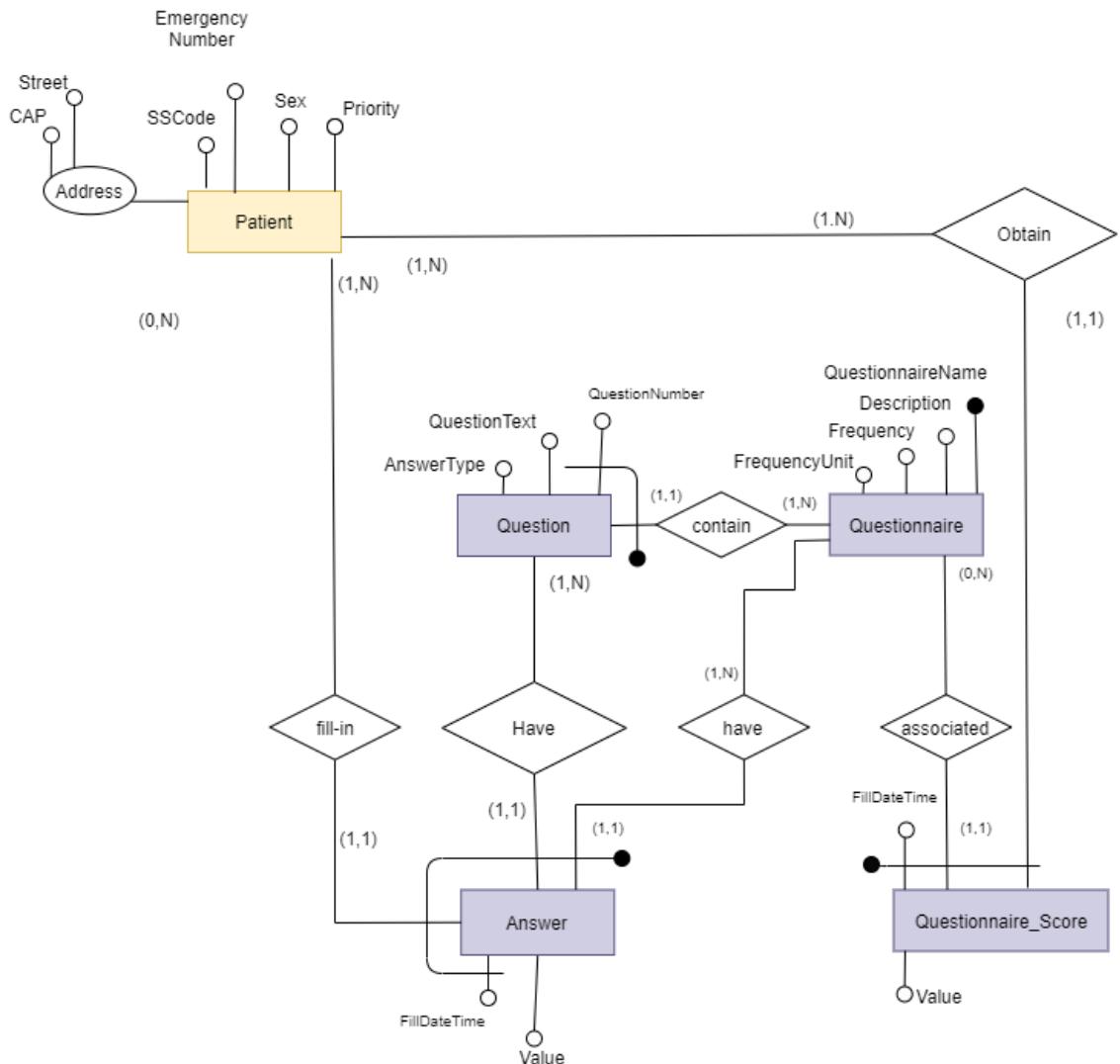


Figure 2.15: Questionnaires

- **Therapy and Medical Procedure**

We have created an entity Medical Procedure connected both to the patient and the specialized practitioner. It represents visits and exams, identified by the Procedure ID, that is unique for each instance.

The single procedure has a date and a time as a single attribute, the location, a type to identify if we are considering a visit or an exam, some patient instructions: if, for example, the patient has to behave in a specific way before the examination and an attached file to download the result of a particular exam. The doctor has also the possibility, through the medical report, to comment the results of the examinations. The specialized practitioner can perform from 0 to N procedures and on the contrary, a single procedure can be performed by one and only one doctor. The same is for the opposite side between the patient and the medical procedure, this time the action involved is “undergo”.

The second entity “therapy” is a list of therapies prescribed by the doctor, including some notes, the frequency and the dosage of a single prescription, but also a date to keep track of the chronology of prescriptions. The therapy is uniquely identified by the ID of the doctor, the ID of the patient, the one of the single prescription and the PrescriptionDate. It is connected to the entity “Prescription” through the relationship “include”, this last is the parent entity of the generalization between drugs and behaviours. For each drug are specified the active principles and the side effects. A relationship with itself shows a limitation if the active principles of different drugs are incompatible with each other.

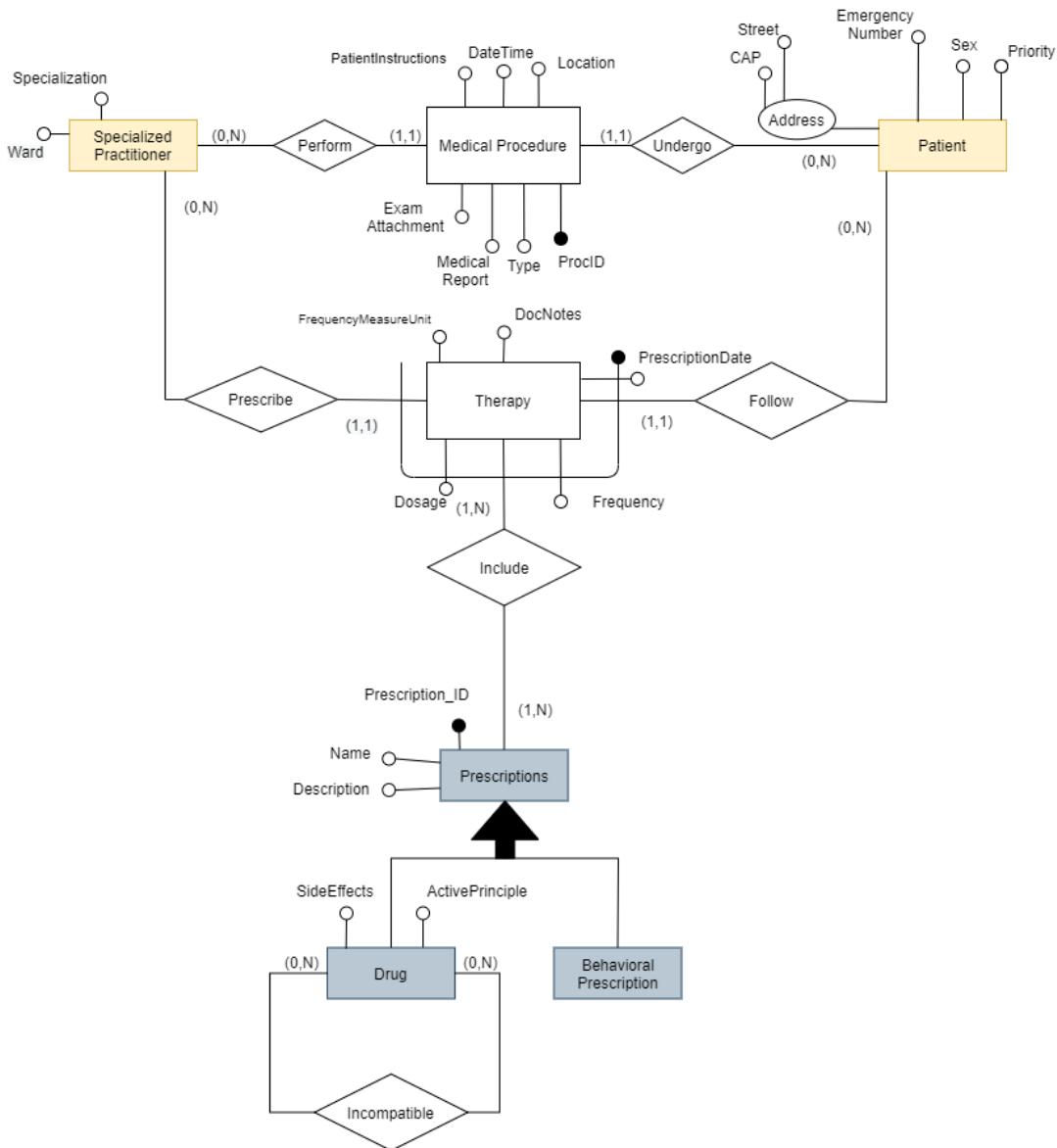


Figure 2.16: Therapy and Medical Procedure

• ER Restructured

Finally we have adapted the ER diagram to allow translation into a relational schema. The main changes concern generalization and compound attributes. The USER generalization collapses downwards leaving its attributes to the three daughter entities (TECH, PATIENT and DOCTOR). The primary key attribute, which previously was ID, has been changed to 3 specific primary keys. The other attributes were inherited from the daughter entities without changes.

The only compound attribute present was the patient's ADDRESS of residence. This has been removed by reporting the various sub-attributes of ADDRESS directly to the patient.

The generalization on Prescription has been collapsed towards the parent entity.

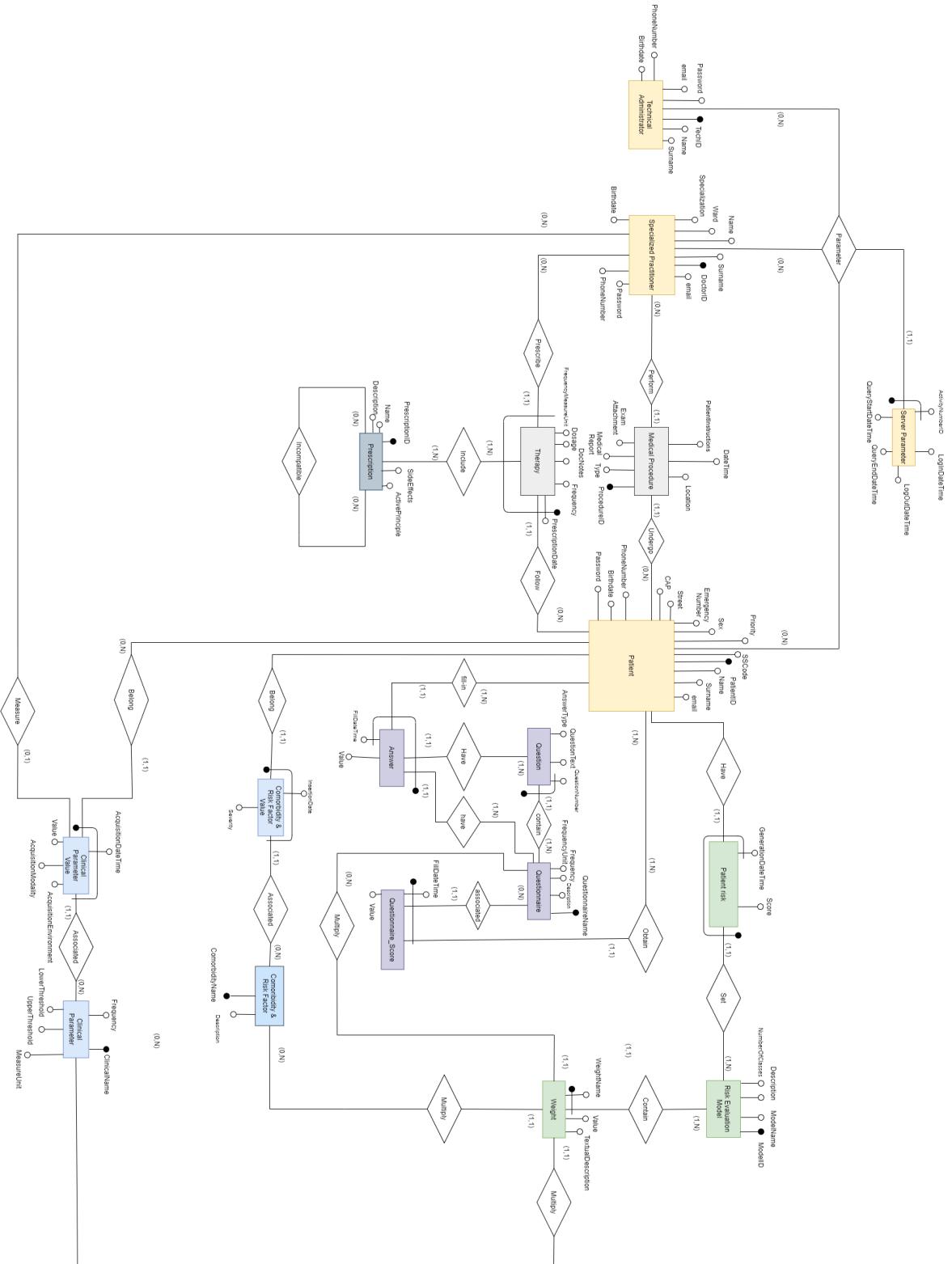


Figure 2.17: ER diagram prepared for the conversion

2.3.2 Translation into relational scheme

From the restructured ER diagram we can proceed with the translation to relation schema, that is reported below.

In the next page we reported the diagram of the relation schema with the referential integrity constraints highlighted.

PATIENT(PatientID, Name, Surname, Password, Birthdate, PhoneNumber, email, SSCode, EmergencyNumber, Sex, Priority, Street, CAP)

SPECIALIZED_PRACTITIONER(DoctorID, Name, Surname, Password, Birthdate, PhoneNumber, email, Specialization, Ward)

TECHNICAL_ADMINISTRATOR(TechID, Name, Surname, Password, Birthdate, PhoneNumber, email)

MEDICAL_PROCEDURE(ProcedureID, PatientID, DoctorID, PatientInstructions, DateTime, Location, ExamAttachment, MedicalReport, Type)

Therapy(PrescriptionDate, PrescriptionID, PatientID, DoctorID, Dosage, Frequency, FrequencyMeasureUnit, DoctorNotes)

PRESCRIPTION(PrescriptionID, Name, Description, SideEffects, ActivePrinciples)

INCOMPATIBLE(Prescription1ID, Prescription2ID)

CLINICAL_PARAMETER(ClinicalName, LowerThreshold, UpperThreshold, Frequency, MeasureUnit)

CLINICAL_PARAMETER_VALUE(AquisitionDateTime, ClinicalName, PatientID, DoctorID, AquisitionModality, AquisitionEnvironment, Value)

COMORBIDITY_AND_RISK_FACTOR(ComorbidityName, Description)

COMORBIDITY_AND_RISK_FACTOR_VALUE(InsertionDate, PatientID, ComorbidityName, Severity)

QUESTION(QuestionNumber, QuestionnaireName, QuestionText, AnswerType)

ANSWER(QuestionNumber, QuestionnaireName, FillDateTime, PatientID, Value)

QUESTIONNAIRE(QuestionnaireName, Description, Frequency, FrequencyUnit)

QUESTIONNAIRE_SCORE(QuestionnaireName, PatientID, FillDateTime, Value)

WEIGHT(WeightName, ModelID, Value, TextualDescription, QuestionnaireName, ComorbidityName, ClinicalName)

SERVER_PARAMETER(ActivityNumberID, PatientID, TechID, DoctorID, LogInDateTime, LogOutDateTime, QueryStartTime, QueryEndTime)

RISK_EVALUATION_MODEL(ModelID, ModelName, Description, NumerOfClasses)

PATIENT_RISK(ModelID, PatientID, GenerationDateTime, Score)

For a better comprehension

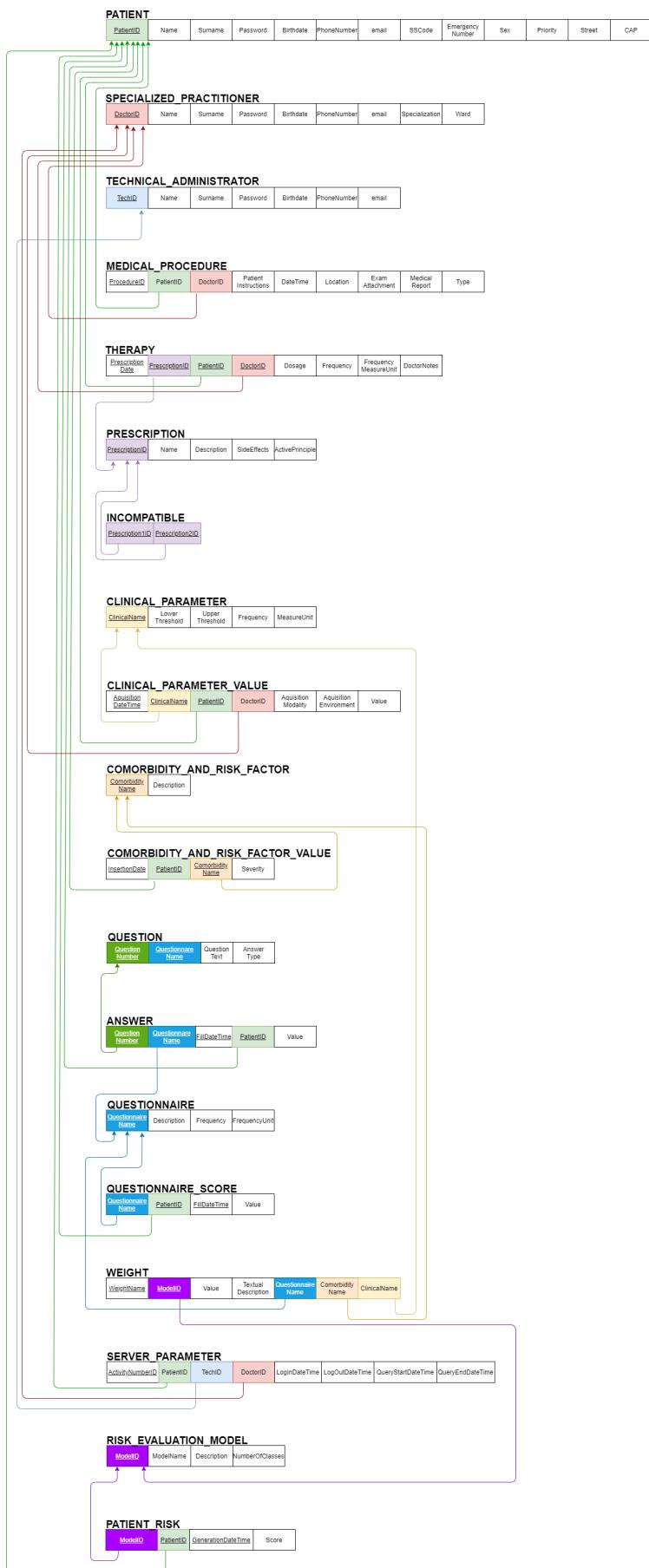


Figure 2.18: Relational scheme with referential integrity constraints ³⁴

Chapter 3

System Implementation [1, 2]

3.1 Technical description of the tables

These are the tables used in the DataBase:

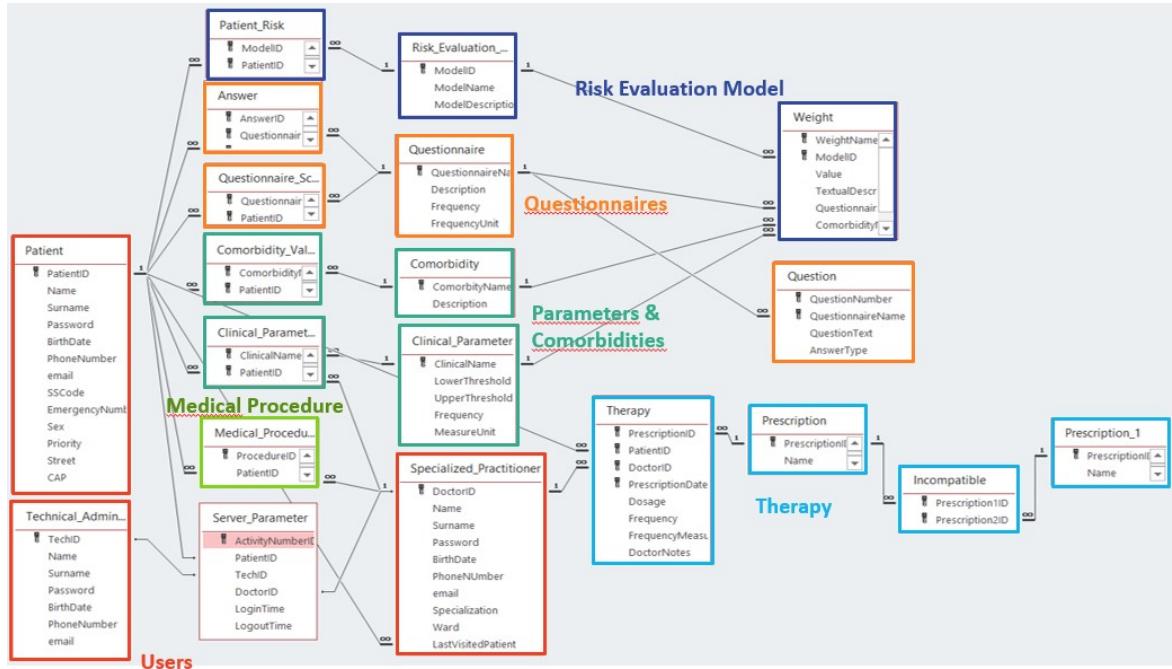


Figure 3.1: Final Tables

Answer

This table is used to record all the values of the answers from the questionnaires filled by the patient. It also contains the ID of the answer, the number of the question associated, the name of the questionnaire, the date when the questionnaire was filled and the ID of the patient who filled it.
 (Primary keys: AnswerID, QuestionnaireName, QuestionNumber, PatientID)

	Nome campo	Tipo dati	Descrizione (facoltativa)
1	AnswerID	Numerazione automatica	
2	QuestionnaireName	Testo breve	
3	QuestionNumber	Numerico	
4	PatientID	Numerico	
5	FilledDateTime	Data/ora	
6	Value	Testo breve	

Figure 3.2: In figure the table Answer

Clinical_Parameter

In this table are classified all the possible parameters estimated (some of them by the patient and some by the specialized practitioner). The list contains the name of the parameters, their upper and lower thresholds, the frequency of measurement and the measure unit.
(Primary key: ClinicalName)

Clinical Parameter		
Nome campo	Tipo dati	Descrizione (facoltativa)
LowerThreshold	Numerico	
UpperThreshold	Numerico	
Frequency	Testo breve	
MeasureUnit	Testo breve	Unit: [Daily, Weekly, At Each Visit]

Figure 3.3: In figure the table Clinical Parameter

Clinical_Parameter_Value

This table is used to record the values of the parameters measured at home by the patient, who can choose the insertion modality as “manual” and in hospital by the specialized practitioner who can measure them through clinical devices. For each value are specified the related DoctorID, PatientID and the acquisition environment.

(Primary keys: ClinicalName, PatientID, AcquisitionDate)

Clinical_Parameter_Value		
Nome campo	Tipo dati	Descrizione (facoltativa)
ClinicalName	Testo breve	
PatientID	Numerico	
DoctorID	Numerico	
AcquisitionDate	Data/ora	
Value	Numerico	
AcquisitionModality	Testo breve	List: [Manual Insertion, Clinical Device, Wearable Device]
AcquisitionEnvironment	Testo breve	List: [At Home, In Hospital]

Figure 3.4: In figure the table Clinical Parameter Value

Comorbidity

This table shows the list of comorbidities that may occur in the group of pathologies associated to the patients.

(Primary keys: ComorbidityName)

Comorbidity		
Nome campo	Tipo dati	
ComorbidityName	Testo breve	
Description	Testo lungo	

Figure 3.5: In figure the table Comorbidity

Comorbidity_Value

This table contains the name of the comorbidities listed in the previous table, the related PatientID, the date of insertion and a level of severity selected by the specialized practitioner among five choices between low and high.

Comorbidity_Value		
Nome campo	Tipo dati	Descrizione (facoltativa)
ComorbidityName	Testo breve	
PatientID	Numerico	
InsertionDate	Data/ora	
Severity	Numerico	Values from 1 to 5 [1=Low, 2=Medium-Low, 3=Medium, 4=Medium-High, 5=High]

Figure 3.6: In figure the table Comorbidity Value

CUP

This table is designed to record the visits and exams booked by the patient with his PatientID established at a precise day and time and the related DoctorID of the specialized practitioner who will perform the visit.

(Primary key: ID)

	Nome campo	Tipo dati	Descrizione (facoltativa)
1	ID	Numerazione automatica	
	DateVisit	Data/ora	
	Hour	Data/ora	
	DoctorID	Numerico	
	Type	Testo breve	List: {Exam, Visit}
	VisitName	Testo breve	

Figure 3.7: In figure the table CUP

Incompatible

This table is introduced to make possible the identification between the prescribed drugs that are “incompatible” because of their active principles. The only fields inserted as primary keys are the ID of the two prescriptions.

	Nome campo	Tipo dati	Descrizione (facoltativa)
1	Prescription1ID	Numerico	First incompatible prescription
	Prescription2ID	Numerico	Second incompatible prescription

Figure 3.8: In figure the table Incompatible

Medical_Procedure

This table contains all the fields associated to the prescriptions made by the specialized practitioner after a specific visit or exam: the instructions for the patient (if there are), name, date and hour of the visit, the type: “visit” or “exam”, a medical report in which the doctor can insert the summary of that consultation, the field “ExamAttachment” to insert a document related to the exam and the ID related both to the doctor in charge and the patient.

(Primary key: ProcedureID)

	Nome campo	Tipo dati	Descrizione (facoltativa)
1	ProcedureID	Numerazione automatica	
	PatientID	Numerico	
	DoctorID	Numerico	
	Instructions	Data/ora	Instructions to prepare the patient for a visit or an exam
	VisitType	Data/ora	
	MedicalReport	Testo lungo	
	Type	Testo breve	List: {Exam, Visit}
	ExamAttachments	Testo lungo	Link to exam attachments
	NameID	Testo breve	
	VisitHour	Data/ora	

Figure 3.9: In figure the table Medical_Procedure

Orari

This table lists the possible hours of the day in which the patient could book a visit or an exam. The only field is “Hours”.

	Nome campo	Tipo dati	Descrizione (facoltativa)
1	Hours	Data/ora	

Figure 3.10: In figure the table Orari

Patient

This table contains all the patient’s personal information related to the address, the contacts to call in case of emergency and his priority, modifiable by the specialized practitioner among five possible levels.

(Primary key: PatientID)

	Nome campo	Tipo dati	Descrizione (facoltativa)
1	PatientID	Numerazione automatica	
	Name	Testo breve	
	Surname	Testo breve	
	Password	Testo breve	
	BirthDate	Testo breve	
	PhoneNumber	Testo breve	
	email	Testo breve	
	SSCode	Testo breve	
	EmergencyNumber	Testo breve	Emergency contact List: Female (1), Male (M)
	Sex	Testo breve	Values from 1 to 5 (1=low, 2=Medium-Low, 3=Medium, 4=Medium-High, 5=high)
	Priority	Testo breve	
	Street	Testo breve	
	City	Testo breve	

Figure 3.11: In figure the table Patient

Patient Risk

This table is edited to include the patient's level of risk measured by the different model risks available. It includes the date of the measurement and the related score. All the records are associated to the patient ID and the one of the model used.

(Primary keys: ModelID, PatientID, GenerationDateTime)

Patient_Risk		
	Nome campo	Tipo dati
ModelID	Numerico	
PatientID	Numerico	
GenerationDateTime	Data/ora	
Score	Numerico	
	Risk class computed by the model	

Figure 3.12: In figure the table Patient Risk

Prescription

This is the list of the drugs that the specialized practitioner may insert in a patient's therapy, including the name the description of the drug, the active principles and the side effects.

(Primary keys: PrescriptionID)

Prescription		
	Nome campo	Tipo dati
PrescriptionID	Numerico	Numerazione automatica
Name	Testo breve	
Description	Testo lungo	
SideEffects	Testo lungo	
ActivePrinciple	Testo breve	

Figure 3.13: In figure the table Prescription

Question

This table collects all the questions proposed to the patient from all available the questionnaires. The fields include the name of the related questionnaire, the number of the question, the text and an answer type.

(Primary keys: QuestionNumber, QuestionnaireName)

Question		
	Nome campo	Tipo dati
QuestionNumber	Numerico	
QuestionnaireName	Testo breve	
QuestionText	Testo lungo	
AnswerType	Testo breve	
	List: []	

Figure 3.14: In figure the table Question

Questionnaire

This table contains the list of all the possible questionnaires to insert, including the Questionnaire-Name, a brief description and the filling-in frequency with its unit.

(Primary keys: QuestionnaireName)

Questionnaire		
	Nome campo	Tipo dati
QuestionnaireName	Testo breve	
Description	Testo lungo	
Frequency	Numerico	
FrequencyUnit	Testo breve	

Figure 3.15: In figure the table Questionnaire

Questionnaire_Score

In this table are recorded all the measured questionnaires' scores calculated through the value of the answers that the patient gives. It includes the related date of filling, the name of the questionnaire, the PatientID as primary keys and the answers' values.

Questionnaire_Score		
	Nome campo	Tipo dati
QuestionnaireName	Testo breve	
PatientID	Numerico	
FillingDateTime	Data/ora	
Value	Numerico	

Figure 3.16: In figure the table Questionnaire_Score

Risk_Evaluation_Model

This table classifies all the risk models inserted by the technical administrator to assess the risk of

the patient. It includes the name, the description and an ID number.
(Primary keys: ModelID)

Nome campo	Tipo dati	Descrizione (facoltativa)
ModelID	Numerazione automatica	
ModelName	Testo breve	
ModelDescription	Testo lungo	

Figure 3.17: In figure the table Risk_Evaluation_Model

Server_Parameter

This table is designed to keep track of all the login and logout activities of the different users, including the related date and time, an ID number to distinguish the number of the activity and the associated DoctorID, PatientID, TechID of the user who logged in.

(Primary keys: ActivityNumberID)

Nome campo	Tipo dati	Descrizione (facoltativa)
ActivityNumberID	Numerazione automatica	
PatientID	Numerico	
TechID	Numerico	
DoctorID	Numerico	
LoginTime	Data/ora	
LogoutTime	Data/ora	

Figure 3.18: In figure the table Server_Parameter

Specialized_Practitioner

As the previous one, this table collects the personal data of a user, in addition to the one related to the patient, here there are information about the doctor's specialization and the ward.

(Primary keys: DoctorID)

Nome campo	Tipo dati	Descrizione (facoltativa)
DoctorID	Numerazione automatica	
Name	Testo breve	
Surname	Testo breve	
Password	Testo breve	
BirthDate	Data/ora	
PhoneNumber	Testo breve	
email	Testo breve	
Specialization	Testo breve	
Ward	Testo breve	
lastVisitedPatient	Numerico	

Figure 3.19: In figure the table Specialized_Practitioner

Technical_Administrator

This table includes basic personal data of the technical administrators including the email and the phone number.

(Primary keys: TechID)

Nome campo	Tipo dati	Descrizione (facoltativa)
TechID	Numerazione automatica	
Name	Testo breve	
Surname	Testo breve	
PhoneNumber	Testo breve	
BirthDate	Data/ora	
PhoneNumber	Testo breve	
email	Testo breve	

Figure 3.20: In figure the table Technical_Administrator

Therapy

This table includes all the useful information related to the therapy of a patient: the dosage of a particular drug, the date of the prescription, the frequency of administration with the related unit and a field containing the doctor's notes.

(Primary keys: PrescriptionID, PatientID, DoctorID, PrescriptionDate)

Nome campo	Tipo dati	Descrizione (facoltativa)
PrescriptionID	Numerico	
PatientID	Numerico	
DoctorID	Numerico	
PrescriptionDate	Data/ora	
Dosage	Testo breve	Dosage and its measure unit
Frequency	Numerico	
FrequencyMeasureUnit	Testo breve	
DoctorNotes	Testo lungo	List: [Daily, Weekly, Monthly, Yearly]

Figure 3.21: In figure the table Therapy

Weight

This table reports all the weights used by the Risk Evaluation Model; in particular, with the weights numerical value, is reported the ID of the model in which they are used, the clinical parameter, questionnaire score or comorbidity that they weight and possibly a brief textual description.
(Primary keys: WeightName, ModelID)

Weight	Tipo (tip)	Descripción (descripción)
WeightName	Texto breve	
ModelID	Numerico	
Value	Numerico	
TextualDescription	Texto largo	Brief weight description
QuestionnaireName	Texto breve	
ComorbidityName	Texto breve	
ClinicalName	Texto breve	Clinical Parameter name

Figure 3.22: In figure the table Weight

3.2 Description of the queries (with some examples)

3.2.1 Specialized Practitioner queries

Query used in Specialized Practitioner interfaces:

Doc_drug_incompatibility

this query is used in the form with the same name and it shows all the information regarding the drug (ID, name, description, side effects, active principle, Incopatable drug). It is the results of the INNER JOIN between the table **Incompatible** and **Prescription**.

Doc_EditProfile

This query shows all the doctor's personal data that can be updated by the doctor.

Doc_Graph and Doc_Graph1

This query allows you to obtain two columns: Date and Value. They are the result of the filters imposed by the user in the **Doc_preGraph** form. These filters allow you to choose: the patient to whom the parameters belong, the parameter and any time interval during which the parameters were recorded. These two columns will then be plotted in the graphs of the **Doc_Graph** Report as x axis (data) and y axis (value).

Doc_Graph_info and Doc_Graph_info1

These queries are used to show the patient's personal information before each chart in **Doc_preGraph** form

Doc_Graph_OverTheLimit

This query shows how many times the parameters showed in the graph exceed the thresholds fixed for each parameter.

Doc_Graph_Mean_AgeMin-AgeMax

This query compute the mean of the parameter values considered in the form **Doc_preGraph** for a specific age range.

Doc_Graph_StDev_AgeMin-AgeMax

This query compute the standard deviation of the parameter values considered in the form **Doc_preGraph** for a specific age range.

Doc_Stats_Mean

This query compute the mean of all the parameter values considered in the form **Doc_Stats**

Doc_Stats_StDev

This query compute the standard deviation of all the parameter values considered in the form **Doc_Stats**

Doc_Stats_Chart

This query aggregate the two previous results in order to visualize the in the chat showed in form **Doc_Stats**.

Doc_Stats_Var

This query compute the variance of all the parameter values considered in the form **Doc_Stats**.

Doc_Therapy_info

This query extrapolates all the personal of the patient data that appear in the form **Doc_Stats**.

Doc_Therapy_modify

This is the query used in the form with the same name and report all the field needed in order to allow the user to modify the existing records of the table "Therapy"

Doc_TherapyTable

This query extrapolates all the useful information for the doctor in order to visualise properly all the therapy belonging to a specific patient.

VisitBooking

The query extrapolates all the future procedures involving the logged in doctor.

PastVisitList

The query extrapolates all the procedures involving the logged in doctor.

PatientList

The query extrapolates all the patients excluding sensible information like passwords.

BookingRequery

The query extrapolates all the medical procedure in a given day inserted in the visit booking form

BookingRequeryExam

The query extrapolates all the medical procedure in a given day inserted in the exam booking form

AvailableHour

The query extrapolates all the available appointment hour in a day, using data from the booking visit form

AvailableHourExam

The query extrapolates all the available appointment hour in a day using data from the bookin exam form

VisitPatientSelection Daily visit list for the logged in doctor.

PatientRiskVisualization Extrapolates the list of the evauluation of our risk evaluation models associated with the corresponding patient.

DoctorModelLookup Extrapolates the description of the selected risk evaluation model in the DoctorModelLookup form

Many SQL statements were declared and executed directly in the VBA code related to the different forms. For further detail see the Access file.

3.2.2 Patient queries

Query used in Patient interfaces:

EditProfilePatient

This query extracts the patient's personal data from the Patient table. In particular, select the phone number and address from the line where Patient.email is the same as the one with which the log-in was made. It is used as the data source of the PatientEditProfile form.

Questionnaire Query

This query is the origin source for the form "Pat_Questionnaire", it allows to visualize the list of the questionnaires' names, so that the patient can choose one of it through the combo box named "NomeQuestionario".

Question Query

This query allows to visualize, in the subform "Question Query", the only texts of the questions associated to the questionnaire chosen in the combo box, with the related numbers.

Answer Query

This query allows to visualize in the subform "Pat_answer" the box of the questions' numbers related to the questionnaire chosen, the box for the value to fill and today's date, with the possibility for the patient to add a new record that will be recorded in the table "Answer".

SleepEfficiencyA

This is a query used to select the value of the first answer from the questionnaire "Sleep Efficiency" saved in a variable called "A".

SleepEfficiencyB

This query was also used as a contribute to compute the final score of the questionnaire "Sleep Efficiency", in particular it saves in a variable called "B" the sum of the value from the answer 2, 3, 5 and 6 of the questionnaire "Sleep Efficiency".

SleepEfficiencyScore

This is the final query to compute the score from the questionnaire "Sleep Efficiency". It gets the variables "A" and "B" from the previous two queries described, calculates the final score based on the project specifications and saved it in a variable called "ScoreSE" that will appear in the form "FinalScoreSleepEfficiency", after the patient presses the button "Compute score".

Final Score

This query allows to compute the score for the questionnaires "MMAS-8" and "Therapy Adherence" as a sum of the values filled in the "Pat_Answer" subform. This number is saved in a variable saved as "Score" that will be shown in the form "FinalScore" after the patient presses the button "Compute Score".

MedicalProcedure

This query extracts the patient's visits already made with the related data and reports from the Medical_Procedure table; extracts information regarding: Name, Date, Medical Report, Exam Attachment. It is used as the data source of the MedicalReport mask.

VisitList2

This query is a simple query of selection that allows to extract from the Medical_Procedure table the visits booked by a patient, univocally recognized by the PatientID, on the dates following today's one. It is used as the data source of the read-only mask VisitList. A very similar code is also used in the next mask, VisitList3, to select only those with the ProcedureID selected by the patient from the visits extracted from VisitList2.

CUP_Prenotabile

This query allows to select visits from the CUP table that are not present in Medical_Procedure. The selected records are therefore those that represent bookable visits. It is created with a LEFT JOIN.

VisitAvailable

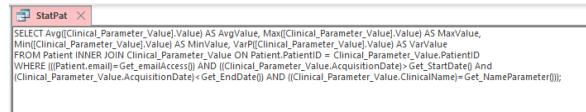
This query allows you to select from CUP_prenotabile only visits that meet certain conditions. In particular, it is used to allow the patient to see the dates available for the type of visit he wants to anticipate/ postpone in the Medical_Procedure mask.

TherapySelection

Allows to select all therapies for a particular patient from the Therapy table. It is used as the data source of the "Therapy" report.

StatPat

This query allows to calculate patient statistics, in particular the average, maximum, minimum and variance of a clinical parameter in a specific time period, chosen by the patient.



```
StatPat
SELECT Avg([Clinical_Parameter_Value].Value) AS AvgValue, Max([Clinical_Parameter_Value].Value) AS MaxValue,
Min([Clinical_Parameter_Value].Value) AS MinValue, VarP([Clinical_Parameter_Value].Value) AS VarValue
FROM Patient INNER JOIN Clinical_Parameter_Value ON Patient.PatientID = Clinical_Parameter_Value.PatientID
WHERE ((Patient.email)=Get_emailAccess)) AND ((Clinical_Parameter_Value.AcquisitionDate)>Get_StartDate) And
(Clinical_Parameter_Value.AcquisitionDate)<Get_EndDate) AND ((Clinical_Parameter_Value.ClinicalName)=Get_NameParameter());
```

Figure 3.23: In figure the query StatPat

3.2.3 Technical Administrator queries

Query used in Specialized Practitioner interfaces:

EditTechProfile

This query collects all personal information about technical administrators where the technical administrator ID coincides with a temporary variable called *techID* that coincides with the ID of the tech admin that logged into the system. This query acts as a data source for the Tech_EditProfile form.

STATAvgAccessTime

This query outputs the average of system usage duration (in seconds) over all users, in a given time window defined by an initial time and and a final time.

This query and the three following it are used as data source for the Tech_ServersStats form.

STATAvgDoc

This query outputs the average of system usage duration (in seconds) for the specialized practitioners, in a given time window defined by an initial time and and a final time.

STATAvgPat

This query outputs the average of system usage duration (in seconds) for the patients, in a given time window defined by an initial time and and a final time.

STATAvgTech

This query outputs the average of system usage duration (in seconds) for the technical administrators, in a given time window defined by an initial time and and a final time.

STATQueryGlobal

This query collects the day-by-day login-logout count over all users, in a given time window defined by an initial time and and a final time.

This query and the three following it are used as data source for the plots in the Tech_ServersStats form.

STATQueryDoc

This query collects the day-by-day login-logout count for specialized practitioners, in a given time window defined by an initial time and and a final time.

STATQueryPat

This query collects the day-by-day login-logout count for the patients, in a given time window defined by an initial time and and a final time.

STATQueryTech

This query collects the day-by-day login-logout count for technical administrators, in a given time window defined by an initial time and and a final time.

GetQuestions

This query is used to collect the questions related to a specific questionnaire, that can be chosen by writing down its name in an apposite textbar in the Tech_EditQuestionnaire form, so that they can be visualized and modified in other sections of that form.

Many SQL statements were declared and executed directly in the VBA code related to the different forms. As an example, the linear combination between the Risk Evaluation Model factors and their respective weights is carried out in the Visual Basic environment, trough the usage of commands that can run SQL statements.

3.3 Description of the Graphical User Interface (GUI)

3.3.1 Log-In GUI

These are the graphical interfaces used during the Log In procedure:

Login_choice

This is the first form that appears when you open the application. It ask you to select what kind of actor you are or if you need, you can quit the application directly.

LoginForm_Doc or LoginForm_Pat or LoginForm_Tech

This form ask you to insert your credentials. If they are wrong It indicates you what it is wrong as showed in Table 3.25

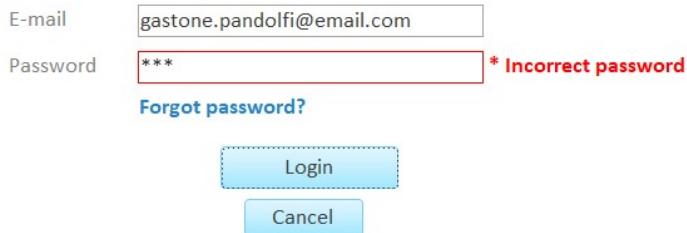


Figure 3.24: Wrong Password

Forgot_Pssw

If the User does not remember the password It have the possibility to click on the "Forgot Password?" label. The Forgot_Pssw form will pop up giving the user all the necessary contacts for technical assistance.

If you have forgotten your password or
need technical assistance, write to:
techsupport@email.com



Figure 3.25: Wrong Password

3.3.2 Specialized Practitioner GUI

These are the graphical interfaces used for a specialized practitioner account:

DoctorHomePage

After logging in, the doctor finds this form which offers the possibility to access all possible actions. All of these options will be covered in detail later in this section.



Figure 3.26: In figure the form DocParameterChoice

DoctorParameterTypeChoice

This form is a brief menu that offers to the specialized practitioner a series of actions regarding the clinical parameters and similar areas like comorbidities.



Figure 3.27: In figure the form DocParameterChoice

InHospitalInsertion

This is a form that allows the doctor to insert a new clinical parameter measured in an In Hospital setting. With the first combobox you can choose the wanted measured parameter, with the second combobox you can measure the patient subjected to the measure. In the last textbox you have to insert the measured value, a summary of the clinical parameters and the associated unit of measure can be found at the bottom of the form. Once everything is inserted by pressing "Add New Value", you add the new measure to the system. By pressing "Back to Homepage" you return to the doctor Homepage and by clicking on "Return to Visit Shortcut" you can go to the Form "VisitManagement" useful during a visit.

Insert a new clinical parameter measure (InHospital setting)

The form consists of three input fields: "Clinical Parameter Name" (text input), "PatientID" (text input), and "Measured Value" (text input). To the right of each input field is a blue button: "Add New Value", "Back to Homepage", and "Back to Visit Shortcut" respectively. Below these fields is a table titled "Clinical Parameters Information" with the following data:

ClinicalName	LowerThreshold	UpperThreshold	Frequency	MeasureUnit
BMI	18	25	Weekly	bpm
Clinical Heart Rate	0	0	At each vist	mg/dl
Glycemia	0	0	Daily	bpm
Heart Rate	55	80	Daily	cm
Height	0	0	Weekly	cmH2O
JVP	0	0	At each vist	mmHg
Maximum Blood Pressure	90	130	Daily	

Figure 3.28: In figure we can see the InHospitalInsertion form

DoctorLoad

In this form the doctor can import the parameters from the blood pressure monitor. With the button "Browse File" he can select the .csv file to import from his computer, once selected by pressing "Load" he can upload the data in the system. By pressing "Cancel" he can return to "DoctorHomepage"

Choose the file generated by the blood pressure monitor

The form has two input fields: "FileName to import" (text input) and "Patient Examined" (text input). Below these fields are three blue buttons: "Browse File", "Load", and "Cancel".

Figure 3.29: In figure we can see the DoctorLoad form

ThresholdSetting

In this form the doctor modify the thresholds for clinical parameters. From a combobox he can select the parameter of choice and with two textboxes can set the lower and upper threshold of the parameter. Clicking on "Update Thresholds" the user can update the system. With another button the doctor can go back to the Homepage.

Modify the clinical thresholds for a clinical parameter



Clinical Parameters Resume

ClinicalName	LowerThreshold	UpperThreshold	MeasureUnit
BMI	18	25	
Clinical Heart Rate	0	0	bpm
Glycemia	0	0	mg/dl
Heart Rate	55	80	bpm
Height	0	0	cm
JVP	0	0	cmH2O
Maximum Blood Pressure	90	130	mmHg
Minimum Blood Pressure	60	85	mmHg
Physical Activity	0	0	
Sleep Quality Index	0	0	

Select Parameter

Update Thresholds

Set Lower Threshold

Set Upper Threshold

Go back to Homepage

Figure 3.30: In figure we can see the ThresholdSetting form

DoctorComorbidities

In this form the doctor can insert new comorbidities for a given patient. With the comboboxes he can select the comorbidity name, the patient ID and the severity of such comorbidity. 1 is the lowest severity in the system and 5 is the highest. With cancel we can go back to the Homepage.

Insert a new comorbidity and its severity (1 = low severity - 5 = high severity)



Comorbidity Name

Patient Name

Severity

Register New Comorbidity

Cancel

Figure 3.31: In figure we can see the DoctorComorbidities form

MedicalReport

In this form the doctor can insert or overwrite the medical report and the link to an attachment into a medical procedure (either a visit or an exam). He can filter the list of procedures with the date and then find the ID of the procedure of interest.

Medical Report Insertion

ProcedureID	VisitHour	PatientID	Name	Surname	PatientInstructions	VisitDate	NameVisit	Type	MedicalReport	ExamAttachments
78	08:00	2 Piero	Lucchi	Don't eat before the exam.	Be at hospital 15 minutes before	29/05/2020	Blood Exam	Exam	Everything regular	www.demo.com/me...
80	17:00	3 Claudia	Lacca			29/05/2020	Cardiologist	Visit	Stable situation, no	
91	16:30	1 Gianluca	Roffia			05/06/2020	Cardiologist	Exam		
92	15:00	2 Piero	Lucchi			05/06/2020	Routine Check	Visit		
93	11:30	3 Claudia	Lacca			05/06/2020	Cardiologist	Exam		
94	10:30	4 Luigi	Rossi			05/06/2020	Routine Check	Visit		
95	17:00	5 Carlo	Bianchi			05/06/2020	Cardiologist	Exam		
96	09:00					12/06/2020	Routine Exam	Visit		

Record: 1 di 23 ▶ ▷ Nessun filtro | Cerca | 4 | ▶

ProcedureID Link to Exam Attachment

Medical Report/Notes

Figure 3.32: In figure we can see the MedicalReport form

PatientList

In this form the doctor can see the overall list of patients and can filter such list with anagraphic informations. The last visited patient is displayed at the bottom. From this form we can open a form dedicated to visualize patients risks.

PATIENT LIST

PatientID	Name	Surname	BirthDate	PhoneNumbe	email	SSCode	EmergencyNum	Sex	Priority	city	St
1	Gianluca	Roffia	04/11/1967	+393345656789	gianluca.roffia@email.com	RFFLGH87R04G443G	+394456757558	M	3	Milano	via d...
2	Piero	Lucchi	13/03/1969	+395578899567	piero.lucchi@email.com	LCCLSN69G13G445K	+397786782119	M	1	Milano	cors...
3	Claudia	Lacca	26/06/1964	+393364567889	claudia.lacca@email.com	LCCRTG64B26D446L	+393385645338	F	3	Cesena	piazz...
4	Luigi	Rossi	13/10/1954	+392345678956	luigi.rossi@email.com	QWVER54V13V554K	+392345678578	M	4	Torino	via d...
5	Carlo	Bianchi	10/09/1945	+39872654964	carlo.bianchi@email.com	SFGHHHJJG7BNJ899J	+393456789007	M	1	Brescia	via d...
6	Franco	Verdi	06/06/1975	+394567865458	franco.rossi@email.com	MHNFGDFHGFDGF6	+390987654327	M	2	Pavia	via d...
7	Lucia	Santucci	02/02/1982	+394568745658	lucia.santucci@email.com	DU657RDRD9E9865E	+393547667985	F	3	Verona	via d...

* (Nuovo)

Record: 1 di 7 ▶ ▷ Nessun filtro | Cerca | 4 | ▶

FILTERS

PatientID <input type="text"/>	Name <input type="text"/>	Surname <input type="text"/>	SSCode <input type="text"/>	<input type="button" value="Back to Homepage"/>
<input type="button" value="Clear Filters"/>				

Last Visited Patient

PatientID	Name	Surname
5	Carlo	Bianchi

Figure 3.33: In figure we can see the PatientList form

DoctorPatientRiskVisualization

In this form the doctor can see the patient risks calculated by the various risk evaluation models. He can lookup to a specific patient with the use of the available filters.

Patient Risks levels



PatientID	Name	Surname	ModelName	ModelDescription	GenerationDateTir	Score
1	Gianluca	Roffia	DEFAULT	Linear Model adapted from Jacobs (2017)	30/05/2020	13
1	Gianluca	Roffia	DEFAULT	Linear Model adapted from Jacobs (2017)	31/05/2020	13
1	Gianluca	Roffia	DEFAULT	Linear Model adapted from Jacobs (2017)	01/06/2020	10
2	Piero	Lucchi	DEFAULT	Linear Model adapted from Jacobs (2017)	01/06/2020	8
3	Claudia	Lacca	DEFAULT	Linear Model adapted from Jacobs (2017)	01/06/2020	0
1	Gianluca	Roffia	QUEST_VARIANT	Linear Model in which questionnaires score is weighte	30/05/2020	2
1	Gianluca	Roffia	QUEST_VARIANT	Linear Model in which questionnaires score is weighte	31/05/2020	2
1	Gianluca	Roffia	QUEST_VARIANT	Linear Model in which questionnaires score is weighte	01/06/2020	0
2	Piero	Lucchi	QUEST_VARIANT	Linear Model in which questionnaires score is weighte	01/06/2020	0
3	Claudia	Lacca	QUEST_VARIANT	Linear Model in which questionnaires score is weighte	01/06/2020	0
2	Piero	Lucchi	DEFAULT	Linear Model adapted from Jacobs (2017)	02/06/2020	3
2	Piero	Lucchi	QUEST_VARIANT	Linear Model in which questionnaires score is weighte	02/06/2020	7
2	Piero	Lucchi	CARDIO_VARIANT	Linear Model in which cardiovascular factors weigh mo	02/06/2020	13
2	Piero	Lucchi	DEFAULT	Linear Model adapted from Jacobs (2017)	02/06/2020	3

Record: 1 di 25 | Nessun filtro | Cerca

FILTERS

PatientID	Name	Surname	Clear Filters	Model Lookup	Back to Patient List
<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="button" value="Clear Filters"/>	<input type="button" value="Model Lookup"/>	<input type="button" value="Back to Patient List"/>

Figure 3.34: In figure we can see the DoctorPatientRiskVisualization form

DoctorModelLookup

In this form the doctor can see the description of the model if he doesn't remember about a particular model.

Model Name	<input type="text"/>	<input type="button" value="Back"/>	<input type="button" value="?"/>
Model Description			
<div style="border: 1px solid #ccc; padding: 10px; height: 150px; width: 100%;"></div>			

Record: 1 di 1 | Nessun filtro | Cerca

Figure 3.35: In figure we can see the DoctorModelLookup form

VisitManagement

This form is useful during a visit, the form contains shortcuts to all the operation that may be needed during a visit. We can visualize the daily visit list and select the visited patient with the combobox in order to save the last visited patient into the system.

Daily Visits					
ProcedureID	PatientID	Name	Surname	VisitHour	NameVisit
106	1	Gianluca	Roffia	08:00	Routine Examination
107	2	Piero	Lucchi	09:30	Routine Examination
108	7	Lucia	Santucci	11:00	Routine Examination
109	6	Franco	Verdi	12:30	Routine Examination

Select Patient to Visit

▼

Insert Clinical Parameters
Book Followup Visit
Insert Medical Report
Therapy
Homepage

Figure 3.36: In figure we can see the VisitManagement form

BookingChoice

This form ask which kind of medical procedure the doctor wants to book.

[Book a Visit](#)

[Book an Exam](#)

[Return to Homepage](#)

Figure 3.37: In figure we can see the BookingChoice form

BookingVisit

This form allow the doctor to book a visit for a patient. On form opening he has a general list of his appointments in the subform, but can filter them with the date, after filtering the available appointments will be available in the combobox in right top. Once selected the patient ID, inserting the name of the visit and eventually writing down some notes/instruction for the patient he can book the visit and register it into the system.

VISIT BOOKING

Date Chosen	Available Appointments														
Schedule	<table border="1"> <thead> <tr> <th>ProcedureID</th> <th>VisitHour</th> <th>PatientID</th> <th>Name</th> <th>Surname</th> <th>PatientInstructions</th> <th>VisitDate</th> </tr> </thead> <tbody> <tr> <td>*</td> <td>(Nuovo)</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table>	ProcedureID	VisitHour	PatientID	Name	Surname	PatientInstructions	VisitDate	*	(Nuovo)					
ProcedureID	VisitHour	PatientID	Name	Surname	PatientInstructions	VisitDate									
*	(Nuovo)														
Record: 1 di 1 Nessun filtro Cerca															
PatientID	VisitName	<input type="button" value="Book Visit"/> <input type="button" value="Go Back"/> <input type="button" value="Back to Visit Shortcut"/>													
PatientInstruction															

Figure 3.38: In figure we can see the BookingVisit form

BookingExam This form is equal to the previous one but allows the doctor to book a medical exam

EXAM BOOKING

Date Chosen	Available Appointments														
Daily Schedule	<table border="1"> <thead> <tr> <th>ProcedureID</th> <th>VisitHour</th> <th>PatientID</th> <th>Name</th> <th>Surname</th> <th>PatientInstructions</th> <th>VisitDate</th> </tr> </thead> <tbody> <tr> <td>*</td> <td>(Nuovo)</td> <td></td> <td></td> <td></td> <td></td> <td></td> </tr> </tbody> </table>	ProcedureID	VisitHour	PatientID	Name	Surname	PatientInstructions	VisitDate	*	(Nuovo)					
ProcedureID	VisitHour	PatientID	Name	Surname	PatientInstructions	VisitDate									
*	(Nuovo)														
Record: 1 di 1 Nessun filtro Cerca															
PatientID	ExamName	<input type="button" value="Book Exam"/> <input type="button" value="Go Back"/>													
PatientInstruction															

Figure 3.39: In figure we can see the BookingExam form

Doc_preTherapy

This is a pop-up window that is used by the doctor to choose the patient he wants to consider.

Chose the patient:

Patient	<input type="text"/>	<input type="button" value="▼"/>
<input type="button" value="Show Therapies"/>		

Figure 3.40: In figure we can see the DoctorComorbidities form

Doc_Therapy

This window mainly shows some data of the chosen patient and the therapies he is following. The doctor also has the possibility to change the patient's priority (the priority is a subjective value that the doctor assigns to the patient and which is added to the information that the doctor can visualize) or manage the therapies through buttons that lead to other forms.

Therapy

PatientID	<input type="text" value="1"/>	<input type="button" value="Close"/>
Name	<input type="text" value="Gianluca"/>	<input type="button" value="Change Patient"/>
Surname	<input type="text" value="Roffia"/>	
BirthDate	<input type="text" value="04/11/1967"/>	
SSCode	<input type="text" value="RFFLGH87R04G443G"/>	
Sex	<input type="text" value="M"/>	<input type="button" value="Delete/Modify Therapies"/>
Priority	<input type="text" value="5"/>	<input type="button" value="Add Therapy"/>

Current therapies

Name	Prescription Date	Dosage	Frequency	Notes
Zestril	20/03/2020	20 mg	3 Daily	line 1 line 2
Aldactone	05/01/2020	5g	2 Daily	General comments about the therapy

Figure 3.41: Doc_Therapy Form

Doc_Therapy_create

In case the doctor chooses to add therapy to a patient then this window opens. All fields in the window must be filled in to add therapy to the list.

Doc_Therapy_modify

From this form the doctor has access to modify all the therapies of the patient in question. If necessary, the doctor can view the list of drugs by pressing the "Drugs Code" button.

Doc_drug_incompatibility

Pressing the "Drugs Code" button displays the list of drugs containing all the information available for the drug: ID, name, description, incompatibilities with other drugs, side effects and active principle.

Drug Codes					
ID	Name	Description	Side Effects	Active Principle	Incompatibility with
1	Coreg	medication used to treat high blood pressure, congestive heart failure (CHF),	dizziness, drowsiness, diarrhea, nausea	Carvedilol	Aldactone
2	Zestril	medication of the angiotensin-converting enzyme (ACE) inhibitor class		Lisinopril	Aldactone

Figure 3.42: Doc_drug_incompatibility

Doc_preGraphStats

This is a pop-up window that is used to choose whether to display Graphs of specific patients or general statistics of all patients who use the software.

Doc_preGraph

If you choose to view the statistics, the application shows an introductory window to choose the characteristics of patients to be studied. You have to choose the patients, the parameters, and the date range during which the parameter were measured.

Doc_Graph

This report shows two graphs that can be set thanks to the "Doc_preGraphs" form. An example of graph is in figure 3.43.

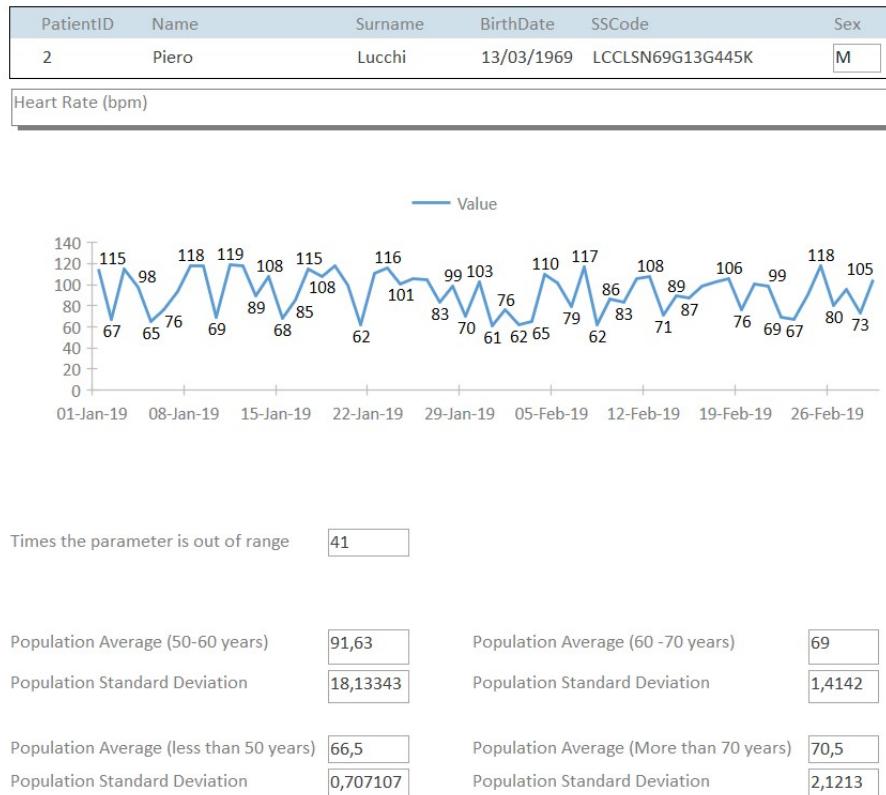


Figure 3.43: Doc_Graphs

The graph indicates the average of the parameter chosen for each day. There is a dotted line that indicates the linear trend. On the top, some patient personal data are reported. The lower part shows some generic statistical values divided by age groups.

Doc_preStats

If you choose to view the statistics, the application shows an introductory window to choose the characteristics of the population to be studied. You have to choose the parameter, and the age range of the population.

Select the stats you want to see:

Parameter	<input type="text"/> <input type="button" value="▼"/>
Minimum Age	<input type="text"/> Years
Maximum Age	<input type="text"/> Years

Figure 3.44: Doc_preStats

Doc_Stats

This form shows the statistics for the parameter and population considered.

3.3.3 Patient GUI

These are the graphical interfaces used for a patient account:

PatientHomePage

After logging in, the patient gets in his personal area, which offers the possibility to access to all the other sections, described in detail below. When opening this HomePage, a MsgBox is displayed to remind the patient to take his/her therapy. We decided to insert this reminder to increase the adherence to the therapy, which is one of the determining factors for the control of the heart failure. In this way, indeed, the patient visualizes the reminder, more or less, everyday.

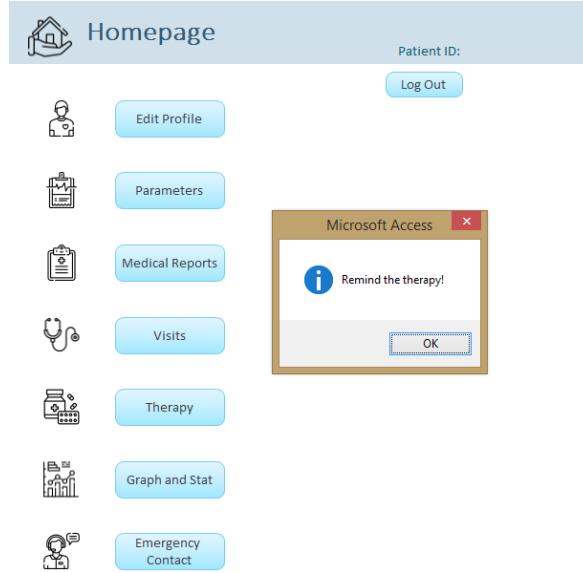


Figure 3.45: In figure the form PatientHomePage

PatientEditProfile

In this section the patient can modify his personal data, in particular he can change the address and the contacts. It was decided not to leave the patient the possibility to change the password, as required by the project, and the data necessary for his correct identification (Name, Surname, Tax Code). After modification, the patient can save the new data by directly editing the Patient table. If, on the other hand, he decides not to change anything, he can return to the Home Page using the "Cancel" button.

A screenshot of a Windows application window titled "Patient profile:". Inside, there is a table with six rows and two columns. The first row has "City" in the first column and "Bergamo" in the second. The second row has "Street" in the first column and "corso garibaldi, 8" in the second. The third row has "CAP" in the first column and "20136" in the second. The fourth row has "PhoneNumber" in the first column and "+395578899567" in the second. The fifth row has "EmergencyNumber" in the first column and "+397786782119" in the second. At the bottom right are two buttons: "Save" and "Cancel".

Figure 3.46: In figure the form PatientEditProfile

Parameter Insertion

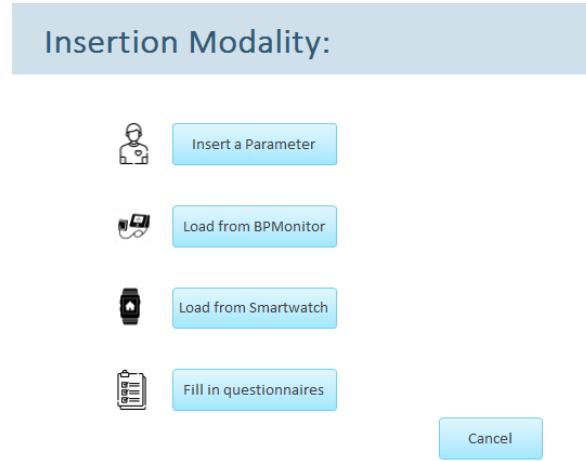


Figure 3.47: In figure the form PatientParameterMenu

This section allows the patient to enter parameters both manually and from a device. It also contains the possibility to insert questionnaires.

In detail, the patient can get into:

- **Manual Insertion:** open a form in which the patient-specific data are already entered (PatientID, AcquisitionEnvironment, Data). Using a drop-down menu, he can choose the parameter to be entered and insert the corresponding value. The page leaves the possibility of entering multiple parameters during the same section.

The screenshot shows the 'AtHomeInsertion' form. At the top, there is a dropdown menu labeled 'Clinical Parameter Name' with a placeholder 'Select Clinical Parameter Name' and a '▼' arrow. To its right is a 'Add New Value' button. Below this is another dropdown menu labeled 'Measured Value' with a placeholder 'Select Measured Value' and a '▼' arrow. To its right is a 'Cancel' button.

Below these dropdowns is a table listing various clinical parameters with their respective values and units:

ClinicalName	LowerThreshold	UpperThreshold	Frequency	MeasureUnit
BMI	18	25	Weekly	bpm
Clinical Heart R	0	0	At each vist	mg/dl
Glycemia	0	0	Daily	bpm
Heart Rate	55	80	Daily	cm
Height	0	0	Weekly	cmH2O
JVP	0	0	At each vist	mmHg
Maximum Bloc	90	130	Daily	mmHg
Minimum Bloc	60	85	Daily	mmHg
Physical Activit	0	0	Daily	
Sleep Quality	0	0	Daily	
Standing Blood	0	0	At each vist	

Figure 3.48: In figure the form AtHomeInsertion

- **Select the device to import data (SmartWatch, BP_Monitor):** this button allows automatic data import and access to a second area, through which the patient can save the data in Clinical.Parameter_Value table. The same type of form is used for the insertion from a SmartWatch device.

The screenshot shows a user interface for importing files. At the top is a text input field labeled "FileName to import". Below it are three blue rectangular buttons with white text: "Browse File", "Load", and "Cancel".

Figure 3.49: In figure the form BPMonitorLoadPatient

- **Fill in questionnaires:** This button allows the opening of a form in which the patient can choose the different questionnaire to fill, through a drop-down menu. On the left of this form he can visualize the questions related to the questionnaire he has chosen while on the right he can fill the answers with appropriate values (each questionnaire is supposed to be filled at most one time a day). After completing his answers, he can press the button “Compute score” to see his final score in a pop-up window, calculated in different ways according to the type of questionnaire. Then he can turn back on the page of the questionnaires to fill-in another one or go back to the parameter form where he can choose the different actions previously explained.

The screenshot shows a "Questionnaire" form. At the top, there is a dropdown menu labeled "Questionnaire Name" set to "MMAS-8" and a "Description" text area containing the text "To record your level of adherence to the therapy.". Below these are two buttons: "Compute score" and "Close".

The main area is titled "Question" and contains a table with two rows of questions. The first row has a "Number" column (1), a "QuestionText" column ("Do you sometimes forget to take your prescribed medicines? Select [0] for 'yes', [1] for 'no'"), and a "Value" column (empty) under the heading "Fill with the number of the question and the related value of the answer". The second row has a "Number" column (2), a "QuestionText" column ("Over the past two weeks, were there any days when you did not take your prescribed medicines? Select [0] for 'yes', [1] for 'no'"), and a "Value" column (empty).

Figure 3.50: In figure the form Pat_Questionnaire

Medical Report

This section allows the patient to see the carried-out visits and the corresponding outcomes. In particular, it offers the possibility to download the report documents and view the doctor's notes. The page is structured as a report to not allow the patient to modify the data in it.

The screenshot shows a "Medical Procedure" form. At the top, there is a timestamp "03 June 2020 18:15:50". Below it is a table with four columns: "NameVisit" (Blood Examination), "MedicalReport" (High glycemia.), "ExamAttachment" (www.ResultExam/1.com), and "VisitDate" (29/05/2020).

Below the table is another row with four columns: "ECG Exam" (empty), "All It's ok." (empty), "www.ResultExam/2.com" (empty), and "29/05/2020" (empty).

At the bottom right is a blue "Close" button.

Figure 3.51: In figure the form MedicalProcedure

Visit

This section allows the patient to edit or delete his visits. In particular, by accessing this page he can visualize all the details related to a visit or an exam. Through a text box, he can select the specific visit and, on the next page, decide whether to delete it, modify it or return to the previous section.

The screenshot shows a web-based application interface titled "Visit List". At the top, there is a header with a small icon and the text "Visit List:". Below the header is a table with columns: ProcedureID, NameVisit, Type, VisitDate, VisitHour, Doctor, PatientInstruction, and PatientID. Two rows are visible: one for a "Cardiologist" visit on 05/06/2020 at 15:00 with Doctor ID 3 and Patient ID 2; and another for a "Cardiologist" visit on 08/06/2020 at 16:30 with Doctor ID 3 and Patient ID 2. Below the table is a text input field labeled "Insert the ProcedureID of the visit:" followed by a "ProcedureID" input box and a "Select" button. In the bottom right corner, there is a "Close" button.

Figure 3.52: In figure the form CopiaVisit_List2

- Delete:** Using this button, the patient deletes the examination record from the Medical_Procedure table. It is an irreversible operation.
- Modify:** This button allows to the patient to enter in a new section where all the available dates are showed for the same type of visit or exam that can be modified, with the related doctor. This information are extracted through the query "Query2". Thanks to different combo boxes in sequence, the patient can choose one of the date and, only later, one of the specific hours for that date. After the selection of the date, a summary form of the booking is showed to the patient to allow the final save. This operation is reversible until the patient clicks the button "Save".

The screenshot shows a web-based application interface titled "Selected Visit". At the top, there is a header with a small icon and the text "Selected Visit:". Below the header is a table with columns: ProcedureID, NameVisit, VisitDate, VisitHour, DoctorID, Type, PatientID, and PatientInstructions. One row is visible: a "Cardiologist" visit on 05/06/2020 at 15:00 with Doctor ID 3, Patient ID 2, and instructions "Nothing". Below the table are three buttons: "Modify", "Delete", and "Back".

Figure 3.53: In figure the form VisitList3

The screenshot shows a web-based application interface titled "Choose Date". At the top, there is a header with a small icon and the text "Choose Date:". Below the header is a table with columns: DATE, DOCTORID, and HOUR. Four rows are visible: 04/06/2020 at 08:00:00, 10:00:00, 10:30:00, and 14:30:00, all associated with Doctor ID 3. To the right of the table are two dropdown menus: one for "DATE" containing "04/06/2020" and another for "HOUR". Below the dropdowns are two text input fields with placeholder text: "Insert one of the table's date" and "Insert one the corresponding hour". At the bottom are "Select" and "Back" buttons.

Figure 3.54: In figure the form Corfirm_Prenotation

Therapy

This section allows to the patient to visualize all the details related to his own therapy (Dosage, frequency, notes by the doctor...). It's a report and the only permission for the patient is to visualize it without changing the information.

Therapy:					
PrescriptionID	Name	Dosage	Frequency	MeasureUnit	DoctorNotes
2	Zestril	25 mg	1	Daily	Nothing
1	Coreg	5 mg	2	Weekly	Take before sleeping

03 June 2020
18:21:40

Close

Figure 3.55: In figure the report Therapy

GraphsStats

This section can be used by the patient to visualize ONLY his own parameters' values through graphs and statistics. In particular, the button opens a pop-up window, in which is possible to select the period of interest (start and end date) and the name of the parameter, through a drop-down window. In the form there's a control, that prevents the patient selecting a previous acquisition date than the start date.

Choose the period within which you want to see your health data:

Start Date

End Date

Parameter

Show Graphs

Figure 3.56: In figure the form Pat_preGraphs

After the selection of the parameter he wants to visualize, the patient can see the graph showing the trend of the value over time and the related statistics (average value, maximum value, minimum value, variance). Then the patient can turn back to the homepage or insert a new parameter, going back to the pop-up window.

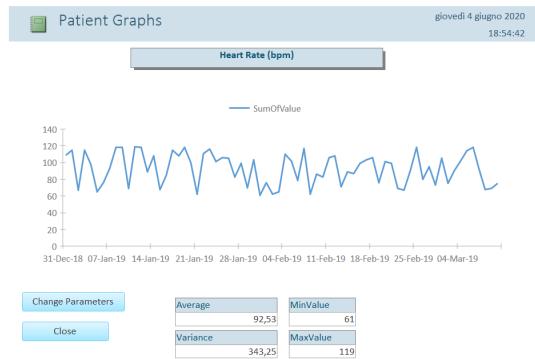


Figure 3.57: In figure the report Pat_Graphs

Emergency Contact

This section is dedicated to the visualization of emergency numbers (911 or the one of the hospital) that the patient can use each time is needed. We decide to let him these information due to the instability of the heart failure.

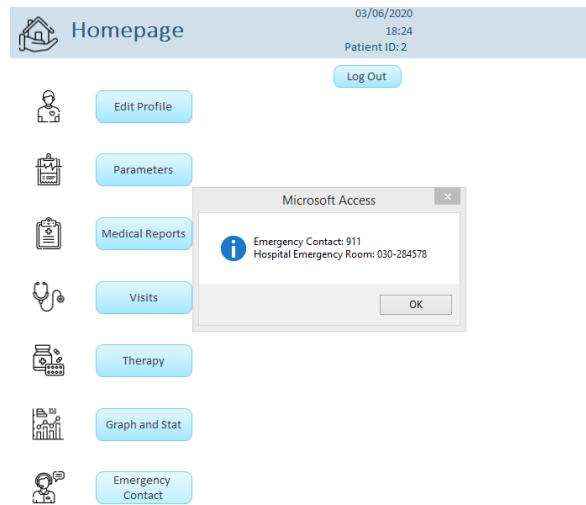


Figure 3.58: In figure the window Emergency Contact

3.3.4 Technical Administrator GUI

These are the graphical interfaces used for a specialized practitioner account:

TechAdminHomePage

After the login, the Technical Administrator has access to the list of possible actions, which will be covered in detail one by one.

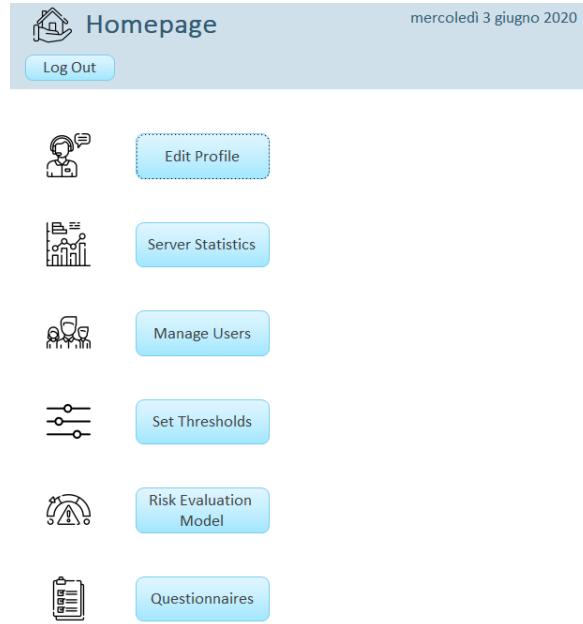


Figure 3.59: In figure is reported the technical administrator homepage.

Tech_EditProfile

This form allows editing of personal data (Name, Surname, Birth date, Email, Password, Telephone Number) with no restriction, since the user is the Technical Administrator.



The form is titled "Personal Profile" and contains fields for Name, Surname, BirthDate, Email, Password, and Phone Number. The Name is Piero, Surname is Pelù, BirthDate is 12/12/1980, Email is +394454656778, Password is masked as ****, and Phone Number is piero.pelu@email.com. There are "Close" and "Save" buttons at the bottom.

Name	Piero
Surname	Pelù
BirthDate	12/12/1980
Email	+394454656778
Password	****
Phone Number	piero.pelu@email.com

Close **Save**

Figure 3.60: In figure is reported the technical administrator personal profile editor.

Tech_ServerStats

This interactive form provides a general view of the users' interactions with the database, plotting the number of logins in a selected time window and the average time spent on the application. Additional buttons allow to access the plot and the statistics for each category of user, such as Specialized Practitioner, Patient, Doctor. Login DateTime is saved in the table **Server_Parameters** for each user every time a login is performed, while Logout DateTime is stored both for intentional logouts and accidental database closures.

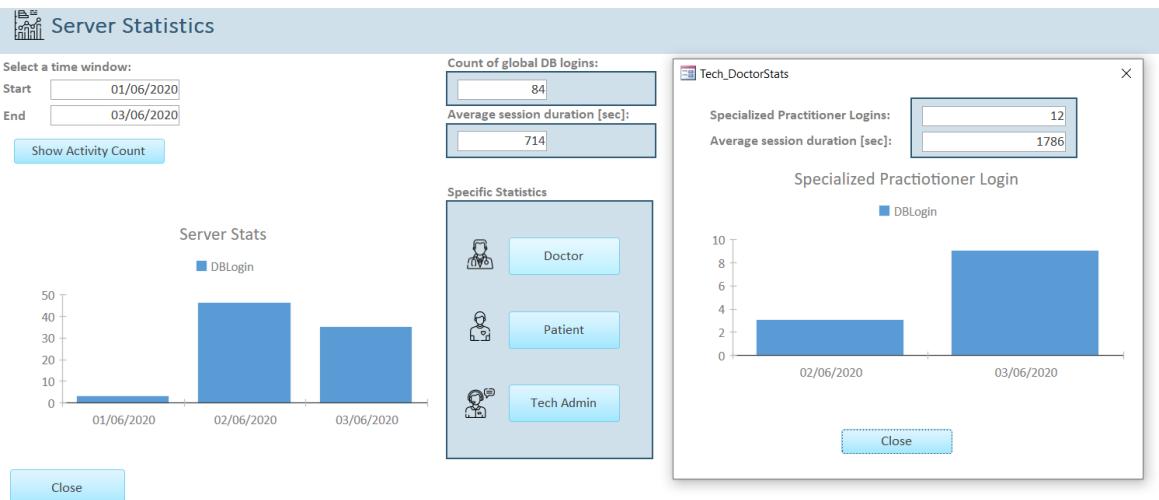


Figure 3.61: In figure are reported the global server stats and those referring to the specialized practitioners.

Tech_ManageUsers

This is an introductory form to select the type of user list, either Patient or Specialized Practitioner, to manage and access. The buttons lead to two distinct forms, **Tech_ManageDoc** and **Tech_ManageUsers**. The default view is a list of all the users belonging to that specific category and the basic operations are the same: deleting, updating, adding a new profile, filtering by name, surname or email.

We decided to avoid erasing completely the users' data from the database, since many information could be reused for statistical purposes. Instead, the *delete* button provides an anonymization. Here lies the main difference between managing Patients and Specialized Practitioners: for first ones relevant data are kept, such as ID, gender, age and priority, while for the latter group only the ID remains visible.

Specialized Practitioners								
DoctorID	Name	Surname	Password	BirthDate	PhoneNumber	email	Specialization	Ward
2	Gastone	Pandolfi	****	12/03/1970	+390876678678	gastone.pandolfi@email.com	Cardiology	Cardiology
Delete	Update							
3	Filippo	Lotti	****	03/12/1963	+393365674889	filippo.lotti@email.com	Vascular Surgery	Cardiology
Delete	Update							
4	####	####	****			####	####	####
Delete	Update							
(New)								
Delete	Update							

Patients									
PatientID	Name	Surname	Password	BirthDate	PhoneNumber	email	SSCode	EmergencyNumber	Sex
1	Gianluca	Roffia	****	04/11/1967	+3933450065789	gianluca.roffia@email.co	RFFLGH87R04G443G	+394456757558	M
Delete	Update								
2	Piero	Lucchi	****	13/03/1969	+395578899567	piero.lucchi@email.com	LCCLSN69G13G445K	+397786782119	M
Delete	Update								
3	Claudia	Lacca	****	26/06/1964	+393364567889	claudia.lacca@email.com	LCCTR064B26D446L	+393385645338	F
Delete	Update								
4	Luigi	Rossi	****	13/10/1954	+3932345678956	luigi.rossi@email.com	QNWERS4V13N554K	+392345678578	M
Delete	Update								
5	Carlo	Bianchi	****	10/09/1945	+398726548964	carlo.bianchi@email.com	SFGHHHJU67BNJ899J	+393456789007	M
Delete	Update								
6	Franco	Verdi	****	06/06/1975	+394567865458	franco.rossi@email.com	MHNFGD9HGDFDFGF6	+399987654327	M
Delete	Update								
7	####	####	****	02/02/1982		####	####		F
Delete	Update								
(New)									
Delete	Update								

[Close](#)

Figure 3.62: In these figures are reported patient and doctor data, that can be added, modified or deleted by the Tech Admin; we can observe that in deleted records demographic infos are not totally erased.

Tech_SetThresholds

This interface allows an easy editing of the clinical parameters, their measure unit, the acquisition frequency and their global thresholds, taken from literature or from consultation with experts.

Clinical Parameters						
ClinicalName	LowerThreshold	UpperThreshold	Frequency	MeasureUnit		
BMI	18	25	Weekly	kg		
Clinical Heart Rate	0	0	At each visit	bpm		
Glycemia	0	0	Daily	mg/dl		
Heart Rate	55	80	Daily	bpm		
Height	0	0	Weekly	cm		
JVP	0	0	At each visit	cmH2O		
Maximum Blood Pressure	90	130	Daily	mmHg		
Minimum Blood Pressure	60	85	Daily	mmHg		
Physical Activity	0	0				
Sleep Quality Index	0	0				
Standing Blood Pressure	0	0	At each visit	mmHg		
Supine Blood Pressure	0	0	At each visit	mmHg		
Therapy Adherence	0	0	Weekly			
Weight	0	0	Weekly	kg		
*	0	0				

[Close](#) [Update](#)

Figure 3.63: In figure is reported the interface that ensures threshold managing.

Tech_ManageModel

This form provides an easy way to upload, update or delete records from the Risk_Evaluation_Model table (which reports the model name, a brief description of what it weighs in, and the progressive identifier), and an analogous way to assign some weights to the existing models.

Both of this operation are carried trough text-boxes or combo-boxes for models and weights insertion, while to modify and delete existing records two subforms that reports the respective tables can be used.

Manage Risk Evaluation models						
Add a model:		Risk Evaluation Models:				
New Model Name	<input type="text"/>	ModelID	ModelName	ModelDescription		
Model Description	<input type="text"/>	1 DEFAULT	Linear Model adapted from Jacob			
		2 QUEST_VARIANT	Linear Model in which questionna			
		3 CARDIO_VARIANT	Linear Model in which cardiovasci			
		(New)				
Record: 1 of 3 First Previous Next Last No Filter Search						
Model Weights:						
WeightName	ModelID	Value	TextualDescription	QuestionnaireName	ComorbidityName	ClinicalName
BMI 1	1	0,0329				BMI
BMI 2	2	0,0329				BMI
BMI 3	3	0,0329				BMI
Diabetes 1	1	0,346			Diabetes	
Diabetes 2	2	0,346			Diabetes	
Diabetes 3	3	0,346			Diabetes	
Heart Rate 1	1	0,0203				Heart Rate
Heart Rate 2	2	0,0203				Heart Rate
Heart Rate 3	3	0,05				Heart Rate
Maximum Blood Pressure 1	1	0,0000				Maximum Blood Pressure

Figure 3.64: In figure is reported the form that can insert, update or delete R.E.M.s and their relative weights.

Tech_ManageQuestionnaire

This form allows multiple interactions with the questionnaires. By a simple combobox filter details and description of the different records are accessible and can be edited with ease.

The button *Edit Questions* provides access to the questions present in the selected questionnaire,

which can be managed (add, delete, update) just like the different users. Here the *delete* button provides a definitive elimination of the records related to the selected questionnaire. *New Questionnaire* leads to a window in which the creation of the basic structure for a new questionnaire is possible. Required inputs are name, a brief description, frequency and frequency unit. Once created the record, the Administrator may proceed to edit and insert questions with the usual procedure.

The screenshot displays a user interface for managing questionnaires. The main window, titled "Manage Questionnaires", contains fields for QuestionnaireName (MMAS-8), Description (To record your level of adherence to the therapy.), Frequency (1), and FrequencyUnit (Monthly). It includes buttons for Update, Delete, Edit Questions, Close, and New Questionnaire. A modal window titled "Tech_InsertQuest" is overlaid, prompting for Name, Description, Frequency, and Frequency Unit, with Save and Cancel buttons.

Figure 3.65: In figure is reported the form that can display existent questionnaires and insert new ones; existent questionnaires can also be modified or deleted, and questions belonging to the questionnaires can also be managed through this form.

Chapter 4

Conclusions

4.1 Future work & Limitations

Here are some aspects that can be improved for future developments.

Communication with mobile devices

Create one or more applications for mobile devices that allow you to communicate with the system quickly and effectively. This implementation, for example, can improve the process for daily upload of the "At-Home" parameters.

Notification System

Create a system of notifications that allows communication for actors and between actors. For example, the notification system can be used to indicate to the patient which parameters are still to be entered or the system could notify the doctor if the patient decides to cancel or modify a visit.

Improve graphics

It has been shown that a pleasant and easy-to-use interface increases the patient's propensity to follow the therapy imposed by the attending specialist. Some aspects of the proposed system are not very pleasing to the eye. In this regard, future developments can be carried out with regard to the graphic interface in order to increase patient therapy adherence.

Create video tutorials

Many users may not be familiar with the system. This is why it may be useful to produce videos showing how to use the software. Furthermore, these videos can be linked to specific links in the user interface.

Security Improvements Our system is vulnerable to SQL injection in the login, in the future some controls on the login input character could be useful. Action to take are reducing the type of characters admitted, excluding special characters like quotation marks and also limit the maximum length of admittable password. Also hashing the passwords with an hash function has to be done.

Multi-user session

The system presented in this report offers the possibility of access to only one user at a time. Multi-user use could be an important feature to add through the use of Access Web.

Risk level computation

On the issue of the Risk Evaluation Model: the paper that has been utilized [4] in order to use some approved weights didn't report boundaries that defined different risk levels. This issue can be tackled by having a dedicated team that integrates informations from different papers, so that the limitations of a model can be fixed with some aspects from another one. Moreover, even if this model cannot evaluate absolute risk, it can still assess relative risk between patients with different characteristics.

Implement educational guidelines The knowledge of the disease from the patient is fundamental for therapy adherence, good outcome of treatment and reduce rehospitalization. For this reason we think that a new section of the patient homepage can be created and oriented towards

educating the patient about his disease, what are correct behaviours and what to avoid. A sort of gamification of such can improve a lot the therapy adherence.

Privacy issue A potential problem in our database could be the possibility for each specialized practitioner to visualize the data of all the patients inside the system. On one side this solution was adopted to facilitate the communication between different specialists and the patient treatment itself but on the other, it causes problems related to the privacy. This could be avoided with the insertion of a special authorization required to the patient, at the time of the registration, which authorizes all the doctors to get access to his/her the data. This document should be created with a legal support and then inserted into the system.

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