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Online Medical Appointment Scheduling System

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Resumen

La accesibilidad a los servicios de una empresa a través de la web es de suma importancia para el éxito de cualquier empresa. Internet es un gran medio para conseguir que una clínica médica sea conocida por un gran número de personas que potencialmente podrían estar interesados en los servicios que la clínica puede proporcionar. Por lo tanto, la creación de una página web que proporcione toda la información necesaria sobre la clínica y permita la gestión de citas online puede beneficiar de muchas maneras a una clínica.

Con el fin de minimizar los costos y el tiempo necesarios para desarrollar, implementar y mantener el sitio web para las citas, hemos realizado diferentes investigaciones hasta encontrar las tecnologías óptimas a utilizar. Durante la investigación nos dimos cuenta de la existencia de sistemas CMS que potencialmente reducen el costo. Las diferentes tecnologías, como servidor web, lenguaje de programación y base de datos a utilizar, se eligieron a partir del sistema CMS elegido: WordPress. El sistema resultante permite que los pacientes actuales y futuros realicen fácilmente las citas con los doctores de la clínica 24 horas al día, los 365 días del año. Esto además permite descargar de mucho trabajo a los trabajadores de la clínica.

Palabras clave: CMS, clínica, citas, sitio web, base de datos

Abstract

The accessibility to services of web clinic is of utmost importance for success of any companies. Internet is a great way to make a clinic known to a large number of people that might potentially be interested in the services that the clinic might provide. Therefore, a creation of a website that would provide different information about the clinic and allow the management and scheduling of appointments online might benefit in many ways to an existing clinic.

In order to minimize the costs and time needed to develop, deploy and maintain the website for appointments, different researches have to be conducted until finding the optimal technologies to be used in the process. While researching we found out the existence of CMS systems that potentially reduce the cost and time spent of all the three steps spoken before. The different technologies, such as webserver, programming language and DBMS to be used, were chosen in base of what CMS was chosen. The interest fell on WordPress, one of the most used systems worldwide, which is very easy to use and maintain. The resulting system allows current and future patients to easily make appointments with different doctors of the clinic 24 hours a day, 365 days of the year. In addition, this allows to unload the clinic's staff from a lot of work that had to be done before the website creation.

Keywords: CMS, clinic, appointments, website, DBMS



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1 Introduction

1.1 Objective

The main objective of this project is to develop a website for a medical clinic to provide an efficient and economical way of making appointments and help in all the related tasks: clinic and doctor time table management, queue management, and patient appointments exportation.

It is wanted that patients have a fast and easy access to clinic's services and administering of all the appointments made.

Meanwhile, it is also required that doctors can easily see all the upcoming appointments and give the results to these appointments to the patients.

1.2 Motivation

The high level of competition in the provision of health services requires not only the provision of high quality health care but also constant work with patients who are the main customers of health centers.

In case of manual appointment scheduling, there are many disadvantages [1]:

- **Constant phone calls that lower productivity:** patients, to make appointments and not come to a clinic personally, will be calling the clinic's phone. That might cause quite a number of problems:
 - There might be missed calls because the line would be occupied at that moment. That also signifies a loss of one customer.
 - A receptionist can be occupied quite often by phone calls and being unable to attend patients in the lobby waiting. This means that, in order to have a proper service, at least two receptionists would be necessary which might be quite expensive for small clinics.
- **Limited by office hours:** potential customers that can only come or call to a clinic at one particular time are lost customers if, at that time, a clinic is not working.
- **More staff needed:** Like we stated before, more personal might be needed (especially receptionists), that means an increase in monthly expenses. Small/medium medical clinics might struggle with such an increase of expenses.

Therefore, small-medium clinics can and should have an online website which will permit many different advantages:

- **Online appointment scheduling:** potential clients (patients) will be able to make appointments online. They won't need to come physically to a clinic or call a phone anymore.



- **Less interaction needed with staff:** since the appointments can be made online now, receptionist will be freer during the day and will be able to manage their time much more effectively.
- **Reminders:** with online appointment scheduling system, it is possible to develop a plugin that will send notifications to all the patients that have appointments scheduled in some number of days.
- **Automatic holiday and non-working days management:** Receptionist can easily add all the non-working days for both clinic and/or different doctors. The appointment making system will take into account these while patients make appointments.
- **Automatic appointment confirmation:** Every time a patient makes an appointment online he will receive an email confirming that he made an appointment successfully.
- **Easy appointment management:** patients, when logged in their accounts, can easily consult the upcoming appointments and do several operations around them.
- **Easier appointment management for doctors:** doctor will be able to see all the appointments made with him and manage them accordingly.
- **Faster queue times:** receptionist can manage easier the appointments making waiting times faster.

1.3 Company overview

In this section, we describe the main characteristics of the fictional company that we are going to use as target of this project.

MedClinic S.L is a clinic founded in April of 2014 that specializes in health care, situated in Madrid, Spain founded by 3 businessmen with experience in healthcare field. The clinic specializes in providing fast, high quality and affordable services to anyone.

The clinic has 2 receptionists that are in charge of customer service. They are in charge of making appointments, making changes in patient profiles, managing holidays and communication with patients, preparing all the documents for the doctors (medical histories, list of appointments, ...).

There are several doctors in the clinic. Each doctor has its own schedule and its own specialization. They don't necessarily work full-time in the clinic. They are the ones who set the time they can come each week. This kind of system is applied in several clinics worldwide and it proves its successfulness.

1.3.1 Provided services

Over the period of 2 years, the company steadily increased the number of services and specializations provided. Nowadays, MedClinic provides a wide range of services to their patients:

- Allergy and immunology
- Cardiology
- Psychotherapy and psychiatry
- General practice for adults and kids

- Gynecology
- Pediatrics
- Orthopedics
- Pulmonology
- Aesthetic services
- Dietists

The list can still increase with time.

Currently, to start using our services, patients have to show up in the clinic or phone our clinic in order to make an appointment. After setting the date and time of an appointment and with whom he will have it, he is required to attend the clinic at the assigned time.

MedClinic accepts all types of patients whose problems are covered by a clinic. The clinic focuses on outpatients, that are the patients that don't need hospitalization for more than 24 hours. The clinic accepts private health insurances in case a patient is in possession of one. The patient will have to give the number of insurance before their appointment in the clinic to the receptionist

In order to control the development of any company, be it medical clinic or not, it is of utmost importance to set the objectives and aims of a company beforehand every certain time. Setting the objectives may help the company to identify necessary actions/steps to reach these goals and clarify the company's purpose.

1.3.2 Clinic general objectives

In this part, we are going to set the clinic's goals for the year of 2018. As can be seen in the company's lifetime, we consider important the increase of the services provided so we could attract more customers with various health problems. Therefore, one of the goals is to increase the services provided by at least 2.

- They expect an increase in company's revenue in at least 15 percent.
- By creating a website, they expect to increase employee productivity by at least 50 percent.
- The increase in productivity could allow them to decrease the number of receptionists from 2 to 1.
- The customer satisfaction is of utmost important to increase the number of clients of the company. They want a customer satisfaction of at least 90 percent.
- Within a period of 10 years they want to expand our company and buy at least one more branch in another city.

1.3.3 Clinic's objectives related to this project

We should set the objectives and goals that we want to accomplish just by developing the website.

- The company wants to improve accessibility to customers increasing their patient quota by at least 30%.



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- Improve appointment management and overall time management - Allow customers to make appointments without coming to the clinic or phoning by phone.
- They want their website to be truly useful, therefore preferably at least 30% of appointments should be made online.
- Allow for easier patient management for both doctors and receptionist.

Until now the company's receptionists were the one taking all the phone calls and talking with patients. It was time consuming and often the client support was not the best quality since there could be missed phone calls or two clients were at the same time talking with receptionist.

Therefore, an option of creating a website is the obvious solution since the number of people currently using the Internet has increased drastically and has been increasing steadily for years.

2 Project plan

2.1 Competitive environment analysis

The high level of competence in the medical field makes it hard to get new customers and make a relatively new clinic stand out from the rest. In order to attract attention to those new clinics we should analyze other successful clinics and see how exactly they became the now worldwide known hospitals and clinics. This analysis will be conducted from the perspective of a user's using the different functionalities of those websites. We will analyze their application in comparison to ours and will make a decision on what functionalities we should also make use of.

Bumrungrad International Hospital

One of the most successful Thai medical centers is [Bumrungrad International Hospital](#). This website was chosen because, despite it being not in Europe, it has several functionalities that we are interested in implementing, such as Doctor Search.



Figure 1 Bumrungrad hospital logo

We enter to their website and check the different content and functionalities that they provide to their users

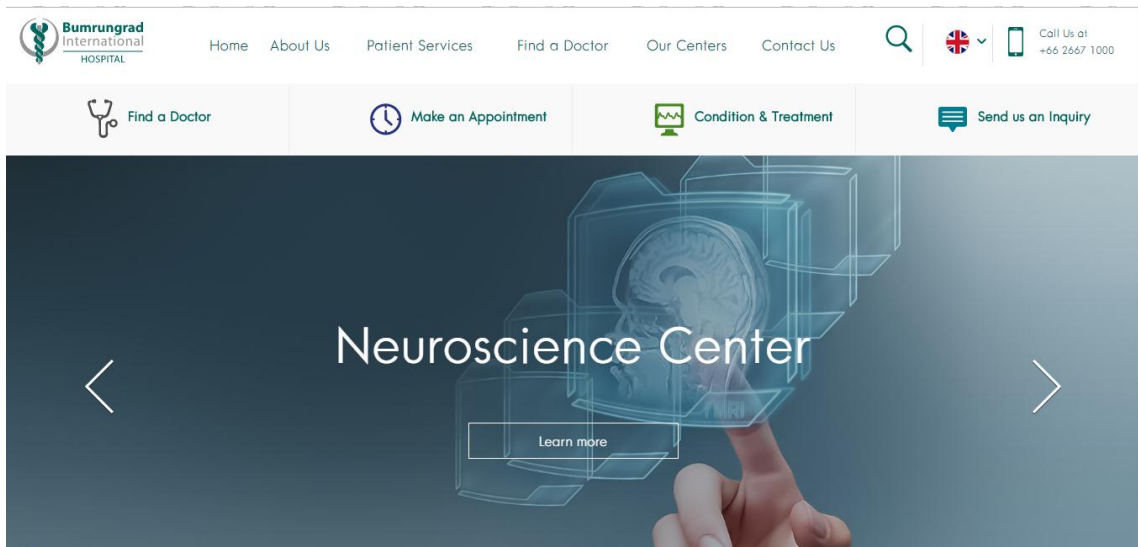


Figure 2 Bumrungrad Hospital home page

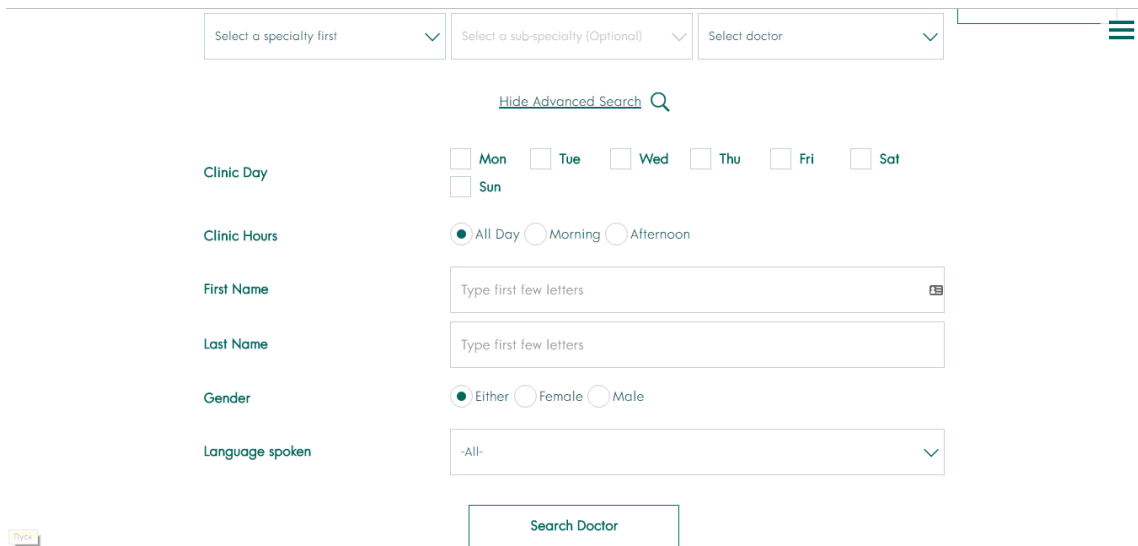


Figure 3 Bumrungrad hospital "Find a doctor" page

A first impression of their website is that it has a professional and attractive look.

We can observe that it is very easy to access all the information about the clinic, such as the different clinic locations and different services they provide and specializations.

The key appointment schedule application features are easily spotted such as Doctor Search, Make Appointment, Make an inquiry and Treatment list. They made sure they are easily spotted.

While making an appointment, you can either choose by yourself the doctor with which you want to make an appointment with or let the system choose a doctor for them depending on what specialty they want an appointment for. It's an important thing since a user can choose

who he/she wants to have an appointment with if others are not compatible for him/her in some way.

This application doesn't provide user registration on their website. Therefore, every time a user wants to make an appointment, he/she must input all the contact information such as email, name, date of birth and phone. If it's a frequent patient, it might be a waste of time to introduce this information every time he wants to make an appointment.

After making an appointment, the patient will be contacted to confirm it within 3 days. This is a measure to prevent false appointments scheduling. It also means that all the appointments made online must be looked by one employee who will have to contact the patients. The spam prevention can be achieved by using different techniques that don't need any human intervention.

After an appointment was made, the only things that can be done is to cancel it or reschedule the appointment to another day.

Moving to Search for Doctors feature, doctors can be searched by different criterions such as working day of the week and time of the day, gender, name or specialty. It's a very nice system since it's very specific and anyone can find a perfect doctor match.

If a user has any kind of inquiry, he/she can easily contact the clinic using a contact form. Once again, the user will have to fill their contact information every time they will want to contact a clinic. If it's an inquiry for another person, the user will have to put his/her contact information too.

The clinic provides a detailed information about different frequent questions that might arise, such as insurance, services, patients' reviews, prices, etc.

In summary, this website provides their users the following features:

- A professional looking website
- A detailed info about them: description, awards and clients' reviews about them among other things
- A detailed page to find a doctor depending on client's needs and availability
- Online appointment making
- Detailed list of provided services
- Contact form
- Info about all their facilities
- Multi-language website (Thai, English, Japanese and Arabic)
- Prices and packages
- Social medias (Facebook, Youtube, Twitter and Google+)

In general, it's a very good website with an easy and intuitive appointment scheduling application.

Clínica San Martín.

As a second candidate, we took into account a Spanish medical clinic located in Valencia called [Clínica San Martín](#).





Figure 4 San Martin logo



Figure 5 San Martín home page

Clinica San Martín is a clinic that provides several general services to its clients, very similar to what MedClinic focuses on and, therefore, it's very interesting to analyze what features they provide their users in their application.

A first impression of their website is that it is very simple with just the minimal information needed for users to get by.

They don't allow registration on their website. Every time a user wants to make an appointment, he/she will have to introduce all his/her contact information, specialty and, optionally, his/her insurance company. In case of frequent patients, that causes a waste of time.

One of this website disadvantages is that the position of the contact form is not very intuitive. In order to contact the clinic, clients have to access the "More information about..." menu which is not a perfect Contact form location.

Another of this website disadvantages is that there is no way to cancel or edit an appointment online in any way. In order to do that, a patient will have to contact the clinic which will make it for him. This is a loss of time for both patients and clinic. All this functionality can be developed in an appointment making application.

There is no way to choose a doctor for a specific specialty or a day of the appointment while making an appointment online. Looks like all the made appointments will have to be revised afterwards by one of the workers. If a user is interested in being attended by a female

doctor instead of a male or he will want to have an appointment one particular day, he/she will have to contact a clinic first.

The list of specialties and doctors are represented using a sortable table under “Cuadro medico” menu. No way of knowing their schedule or what languages they speak.

Other information is not well organized: some of the information is under “More information about...” and other is somewhere else. This website kind of needs a reordering of its content.

In summary, this clinic provides the following features:

- Online appointments
- Some offers it provides
- Blog
- List of all services
- Detailed info about them
- Contact form
- Social media: Facebook
- Reviews with help of Doctoralia widget
- A little bit of information about aging therapies

Hirslanden Private Hospital

We’ll also analyze one of the most renown clinics in Europe for its cardiology field: [Hirslanden Private Hospital](#).



Figure 6 Hirslanden Hospital logo

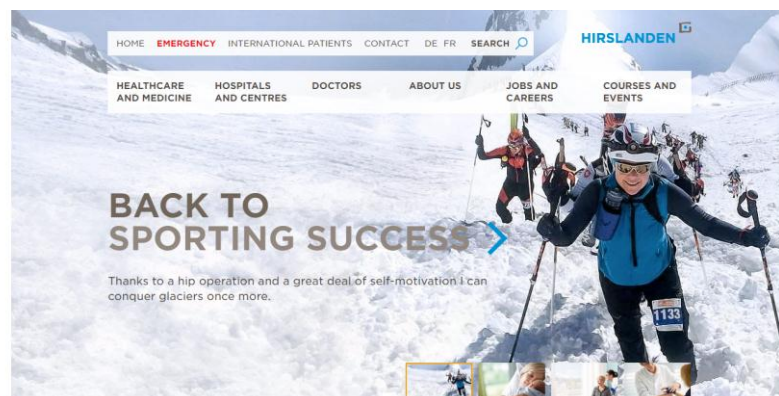


Figure 7 Hirslanden Hospital home page

This website clearly focuses on international since they have a different version of their website for international patients (accessed by clicking on “International Patients”). This has its advantages since it’s possible to evade putting unnecessary content for local patients and vice-versa.

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Their doctor search is kind of limited since they only allow the search based on the name, specialty and/or a clinic location. Impossible to filter doctors by working hours or days. Quite inconvenient if the patients are on a tight schedule. They would need to contact a clinic for that.

They've got detailed information about their clinics and an easy to use contact form.

One of the disadvantages is that they don't provide online appointment making, neither registration. One of the reason for that might be that they are quite a big clinic company so it could be a little bit more complex to schedule everything online.

In summary, it provides the following features on their website:

- Multi-language site: English, German and French
- Contact form
- Information about the clinic
- List of all specialties
- User rights
- Some useful calculators such as BMI calculator
- Search doctor by different criterions: name, specialty and/or clinic they work at.
- Special page for international patients
- Emergency handling

Valencian social security official website

Finally, we'll also analyze the official valencian website for hospitals online: [Conselleria de Sanitat Universal i Salut Pública](#).



Figure 8 San Gva logo



Figure 9 San Gva home page

This website clearly focuses only or mostly on local patients since they only have Spanish and Valencian language version of the website. International patients might have problem using it or finding some useful information.

It's impossible to search for all different doctors that one hospital has. Normally, Spanish citizens are assigned family doctors and they normally can't be changed. Other specialty doctors' information is not available for public online.

The website has an extensive amount of informational content such as: helps, special programs, legal patient rights, medical card info, drug information, news and a big etc. This is very useful for patients since they'll be able to easily find most of the information they are interested in at any time.

The website doesn't provide registration but, since it's a government website, they have information of all the Spanish people's medical cards (SIPs). Therefore, in order to make appointments, cancel them or other related functions, only a SIP number is required.

Cita per internet



Cita Prèvia - Identificació del sol·licitant

A DADES DE LA PERSONA SOL·LICITANT

Introduïska el seu número de targeta SIP i la seua data de naixement:

Número SIP * Dia * Mes * Any *



Nº SIP

Figure 10 SIP verification

The disadvantage is that a patient can't change the doctors they were assigned online. That could maybe be done at the hospital in person.

Another disadvantage is that it has too much content and, some less experienced users, could get confused and/or take longer to find what they wanted to find.

In summary, it provides the following features on their website:

- Only local languages (Spanish and Valencian)
- Contact form
- Patient rights
- A lot of different content such as financial helps, programs and advises on health problems.
- Online appointments making/cancelation/consultation.
- Patient medical file consultation

Summary of clinic’s websites

After analyzing those 3 successful websites we can find what exactly customers want when they visit a medical website.

Table 1 Website features

Website features	Internet website			
	Hirslanden	Bumrungrad	San Martin	GVA
Registration form	No	No	No	Partial
The presence of private profile	No	No	No	Partial
Ability to make appointments online	No	Yes	Yes	Yes
Search for doctors and specializations	Yes	Yes	No	No
Multi-lingual website	Yes	Yes	No	No
Availability of full information about the clinic	Yes	Yes	Yes	Yes
Range of services provided	Yes	Yes	Yes	No
Presence of online helper	No	No	No	No
Social media websites use	No	Yes	Yes	Yes
Useful health tips/posts	Yes	Yes	Partlv	Yes
Contact form	Yes	Yes	Yes	Yes
Prices	No	Yes	Partlv	No

This comparative analysis allowed identifying the main consumer properties, which the patients appreciate.

None of the websites provide any sort of registration for its users. It’s not a problem if all they have is patients that come once and that’s it. But, for those patients that have to come every certain time (such as psychology visits or dietologists) it might be better to store their contact information in their account and make appointment making/cancelling easier and faster to achieve.

All of them provided search for doctors working in their websites. All users are interested in knowing what doctor is going to attend them.

Considering the competitive analysis of these 4 applications, we made a list of all the required functionalities that we would like to provide our users.

2.2 Required functionality

After analyzing several websites, we would like to specify what kind of functionality we want to offer in our website.

In order to do that, we have to talk about what kind of users will be using our website and what each one of them will be able to do there.

2.2.1 Website users

Here we will specify what kind of users will be using the website. We can say that we will have 4 types of users:

- **Guests:** those are the users that are not registered and access our website. We can say that they are our potential clients so we have to let them see all the information they might be interested in about services provided by a clinic
 - Display information about clinic including services, specializations, company description
 - Display doctors' profiles with their specializations and working schedule
 - Search for a doctor based on some criterions like working day or gender
 - Contact form with a clinic
 - Register/login form
 - Access social media of the clinic
 - Make guest appointments
- **Patients:** this user group is the one that created an account in our website and had logged in. They have all the functionality provided to Guest user group (except register/login form and make guest appointments) in addition to the following ones:
 - Make online appointment form with one of the doctors searched previously by some criterions
 - View all the upcoming appointments
 - View the results of the past visits
 - Login and logout from account
 - Cancel any of the upcoming appointments
 - See and change their own profile
 - Export iCal of the appointments
- **Doctors:** this user group are the ones logged in with a credentials provided to them by a company. They have Guest functionality (except Register/login form and make guest appointments) and the following:
 - Display upcoming appointments in a calendar format
 - Give result to a visit
 - See the medical file of the patients (all the appointments they made with this doctor up until now).
 - Add his/her holiday day
 - See today's appointments.
- **Receptionist:** This group will be logged in with credentials given by a company. They have all the functionality provided to Guest user group (except register/login form and make guest appointments) in addition to the following ones:
 - Display today's appointments
 - Check if a patient came to appointment or not
 - Display and change any patient's profiles
 - Put holidays and non-working days and notify patients if there is some problem.
 - Make an appointment for another patient



- Show medical files of any registered patient
- Add a holiday day of the clinic or a doctor
- Create a new doctor account
- Create a new patient account
- Cancel or edit any of the upcoming appointments
- Send a message to some patient
- Show clinic's holidays and delete them if needed

2.3 Requirements

Taking into account the comparative analysis stated in the previous section we could start specifying the requirements that our website should achieve.

As a basis, an article on all the different requirements for software development was taken into account during this process [2].

We divide the requirements in 2 types: functional and nonfunctional requirements.

2.3.1 Functional requirements

- **FR01:** The user should be able to register and manage his appointments online at any time.
- **FR02:** Database has to store all the information efficiently without any information loss.
- **FR03:** The user shall be able to search for the doctors by specialty, name, working time and/or gender.
- **FR04:** The user can change his profile info at any time
- **FR05:** Doctors can manage all appointments made with him on his account.

2.3.2 Nonfunctional requirement

- Portability requirements:
 - **PR01:** A website has to be compatible with different popular web browsers (Google Chrome, Mozilla Firefox, Opera, Safari and Internet Explorer 8+)
- Reliability requirements:
 - **RR01:** The probability of failure less than 0.01%
 - **RR02:** Uptime of at least 99%
 - **RR03:** Less than 30 minutes needed to recover from system failure.
- Usability requirements:
 - **UR01:** Interface elements (e.g. menus) should be easy to understand
 - **UR02:** The user should be able to learn to use a system in less than 30 minutes.
 - **UR03:** Time required for registration less than 5 minutes.
 - **UR04:** Error messages should explain how to recover from the error
 - **UR05:** Actions which cannot be undone should ask for confirmation
 - **UR06:** Responsive design should be implemented
- Space requirements:

- **SR01:** User needs only enough disk space and RAM for web browser
- Performance requirements:
 - **PR01:** All of the operations carried out in the system must respond within 5 seconds
 - **PR02:** The system has to support 100 concurrent users
- Implementation requirements:
 - **IR01:** All the plugins and components should be free of charge.
 - **IR02:** All the plugins should work correctly and satisfy the performance and reliability requirements.
- Standards requirements:
 - **SR01:** The system should be as close as possible to ISO/IEC 9126 [3] quality standard.
- Ethic requirements:
 - **ER01:** Users should be informed of their rights and obligations when they come to a visit.
 - **ER02:** All the risks of services should be told to the patients
- Interoperability requirements:
 - **IR01:** The system should properly interoperate with the database (MySQL)
- Security requirements:
 - **SR01:** The password should be at least 8 characters, 1 Upper case, 1 lower case and 1 number.
 - **SR02:** Website should use different techniques in order to have secure transfer of data to database
- Privacy requirements:
 - **PR01:** All the user's data can't be sold or distributed to other entities without their previous approval.
- Organizational requirements
 - **OR01:** Company will have a developed business plan
 - **OR02:** Company will have to have all the necessary personnel needed for its functioning.
 - **OR03:** There have to be meeting each week to analyze how business is going. Everything has to be documented.
- Scalability requirements:
 - **SR01:** In case of needing more bandwidth or disk space, the system should be prepared to those situations.
 - **SR02:** When increasing the resources of the website, there can't be any penalty to response time or having more errors than usual.

2.3.3 Requirement testing

Each one of the requirements need to have a way to evaluating if they have been successfully done or not. In this section, we will put the different tests that will be conducted to see if the previous requirements have been implemented successfully.



Reliability testing

Reliability testing is used to find out the errors, bugs or failures before the deployments of the final product.

Unluckily, software reliability cannot be directly measured as of now. Other factors should be measured instead such as development process, faults and failures found.

We made 'x' number of tests (usually 7) and saw how many of them failed in some sort. When a requirement succeeded, we proceeded with the development.

Usability testing

Usability is tested by testers to see how easy it is to use the system. It is a black box testing (internal structure/ design/ implementation of the item being tested is not known to the tester) [4] which will also reveal how comfortable with our system they are. It will test how easy the website is to use and how easy is to learn to use.

The tests that we will perform are:

Take some testers and give them some tasks to do such as make an appointment, create an account or see the appointments made by them. It could be also done for doctors but with different things to do. While they do it, we time them and see how much time they needed to do the action. If they accomplished it in less than the amount specified in a requirement, than the test was successful.

At the end of the testing, each tester will give his/her feedback as to what things they found really nice and what things they found badly developed, hard to spot or just things to improve on in general.

Space testing

Size testing is used to see how much memory, both RAM and/or hard drive, is needed for a correct functioning of a website.

We require that users do not need to install any additional software or download anything other than a browser with which they will access our website.

This requirement is quite easy to compute. We will see if we can use a website with just a browser installed on a PC.

Portability testing

We will see how the website functions on different devices. We used it on different browsers (Chrome, Firefox, Opera, Safari) and saw website's performance on all of them.

Performance testing

Performance testing tests how fast a system responds in different environments. It also measures the system workload.

If finance allows it, a clinic could hire a lab to do quantitative tests such as measuring the response time in MIPS (millions of instructions per second).

Since we are limited in budget, we will test each functionality several times and compute the average time for each one of them. The average time should be less than 5 seconds.

And for concurrent users, we will just connect several users to a website at the same time and see how it performs. If all will be fine, the requirements will be satisfied.

Security testing:

Security testing checks whenever a software/website is secure or not by checking if it is vulnerable to attacks, if anyone can access a database or if anyone can login without authorization.

Several test cases exist to check some of the security of the website that we performed before deployment phase:

- Access bookmarked page without logging into the system
- Check password strengths
- Restricted pages can't be accessed by restricted users

Also, different WordPress plugins exist to prevent malicious code, max logging attempts control, control hack attempts (that could be used to check system vulnerabilities), scan for several known backdoors, etc. One of the most popular ones is WordFence [5]. Therefore, we used it for security reasons.

Scalability testing

Scalability testing tests the ability of a system to continue to function when more size or bandwidth is required.

We will achieve it by using a remote web hosting that will enable us to control the amount of bandwidth we will have and the storage space provided to us (More on that in section 3).

Ethic testing

When users will make appointments, they will be asked to read their rights and obligations and accept them. This will be asked every time they make an appointment.

The risk of services will be notified by the doctors in a visit.

2.4 Project constraints

We must specify what are the limits of the project. The three most significant project constraints are schedule, cost, and scope.

Schedule



- The maximum time of development of the product should be of 2 months in the worst case

Cost

- The project can't go over the budget given by the company: 3.000€

Scope

- The users will be able to register and make appointments online at any time of the day. Only registered users can make appointments online.
- Any users can access all the doctors' profiles

2.5 Process diagrams

Before starting the development stage of our application, it is imperative to have an idea on what are the steps for each function of the website and the interaction of the system with database and website users. To achieve it, different process diagrams were created using BPMN 2.0 specification [6]. These will provide us the steps of development of each function that will make the development phase more organized and smooth.

Guest user registration

A registration can be done either by a guest user when a user accesses our website or can be done by the receptionist.

When registering an account, in order to simplify the registration process, we ask only the most necessary information out of the user. The only things that are asked are: email, full name, password and patient's identification card number. This number will be the username that will be used to login into the website. All the other optional information can be filled in when the patient comes to a consultation in person or by doing it himself after logging in into his account.

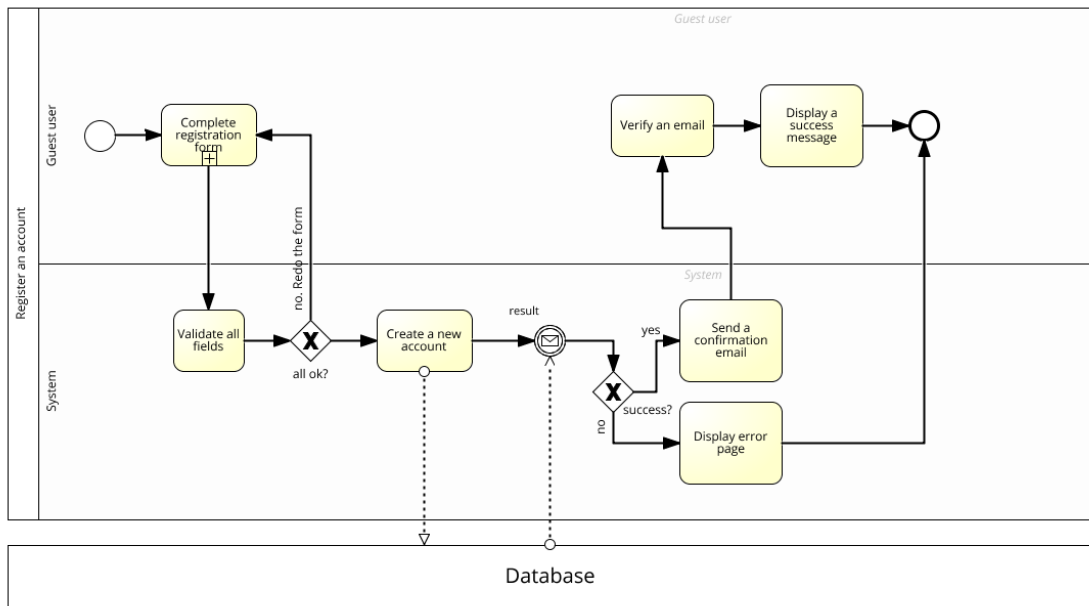


Figure 11 UC1 - Registration process for a guest user

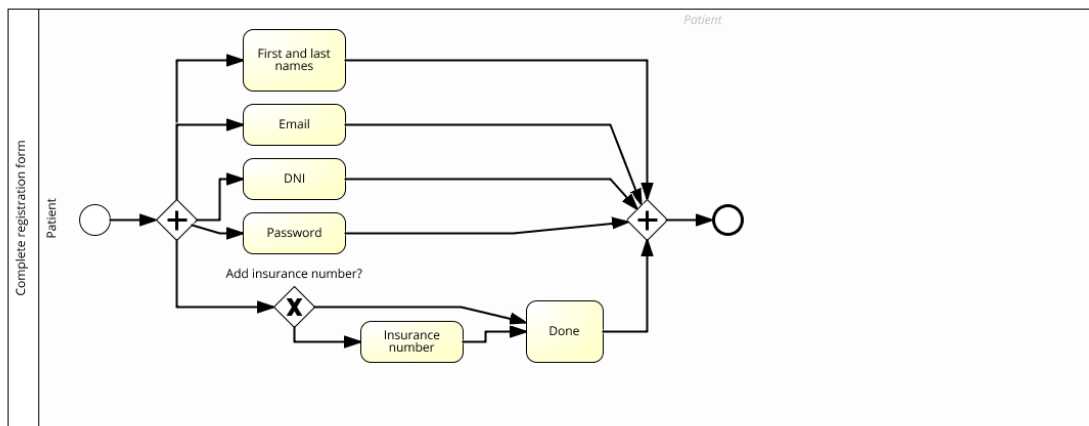


Figure 12 Complete registration form sub process

Add a holiday

A receptionist is the one in charge of adding the holidays of a clinic and/or of doctors. The process is very straightforward: a receptionist will have to select for whom a holiday will be added. In case it is for a particular doctor, the receptionist will have to select a doctor using an autofill field search by typing a name of a doctor. After selecting the range of dates of the holiday and submitting the form, the holiday will be successfully added to a DB. In case there was some appointment made in this range of dates, the receptionist will have a possibility of sending a message to all the patients that had a visit these days.

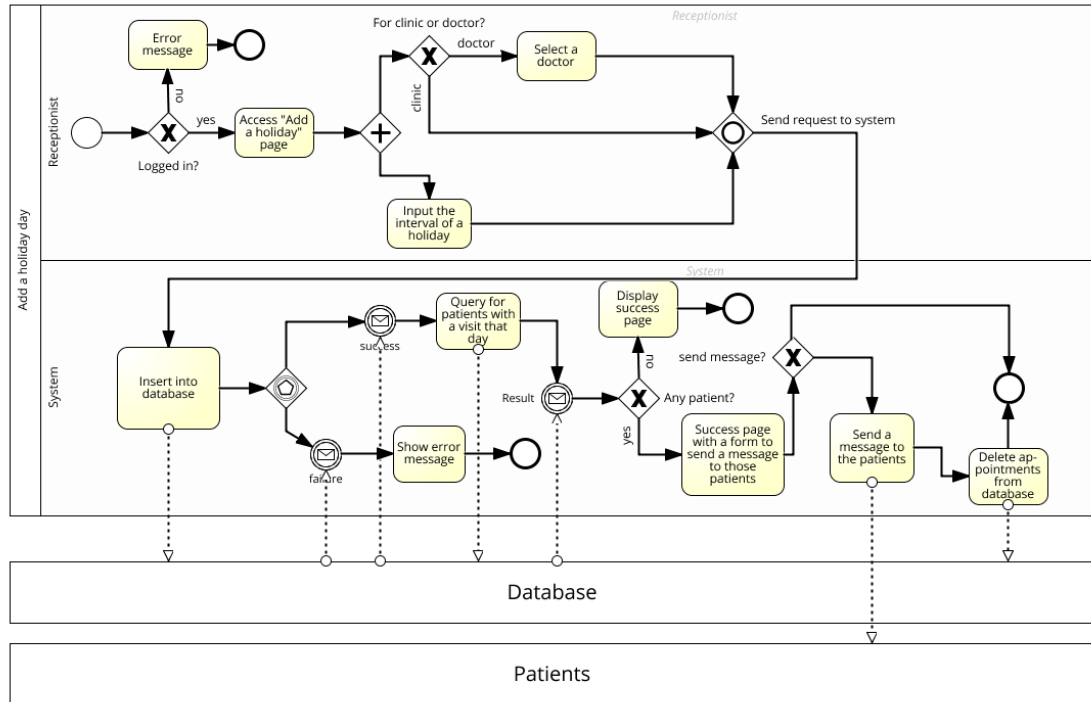


Figure 13 UC2 - Add a holiday day process

Add the result to the visit

Doctors are able to submit the results/observations about the visit that was already attended. Since some of the information about a particular visit should be not disclosed to the patient, we have 2 different types of results: public ones that patients will be able to access and the private ones that only doctors are able to visualize.

In order to submit the result, the doctor should be logged in, select if what he is adding is a private or public result, select the visit to which to add the result using an autofill form either using patient's name, DNI and/or a datetime of the visit. After that, patient will be able to write the result and submit it to the database.

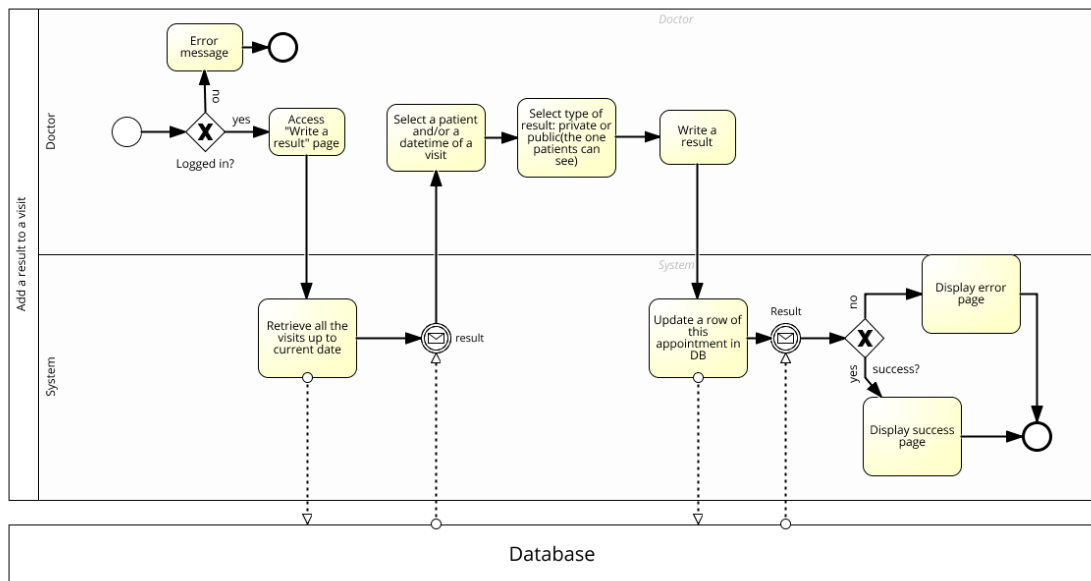


Figure 14 UC3 - Add a result to a visit

Cancel appointment

In order to cancel the appointment, the patient should be logged into his account and, first of all, list all his appointments and, near the appointment that a patient wants to cancel, click on a button Cancel appointment. There will be a confirmation before doing the cancellation in case a patient accidentally clicked on the button.

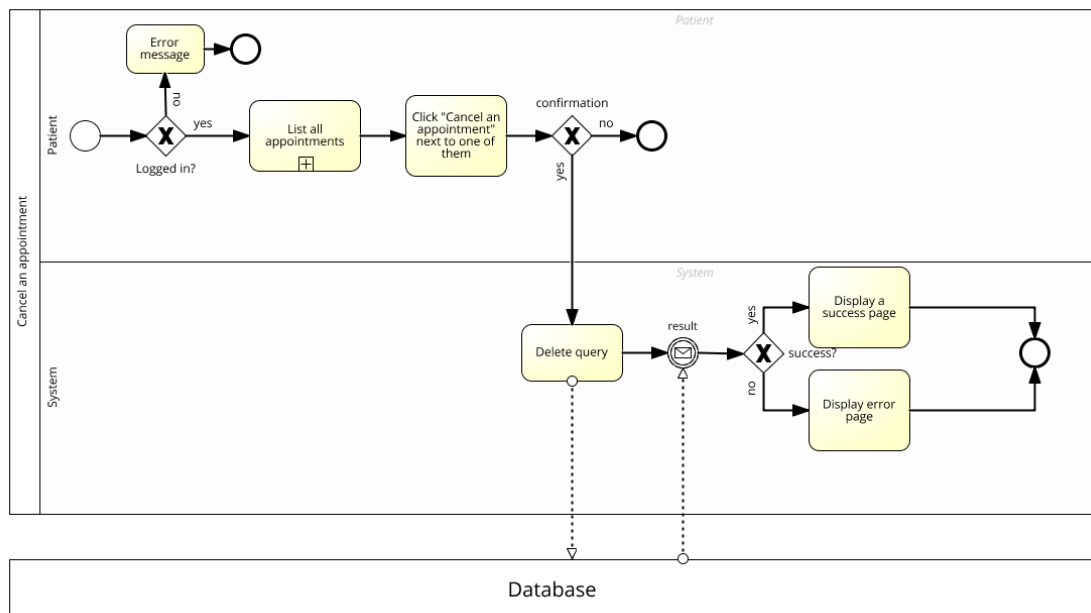


Figure 15 UC4 - Cancel appointment

Export iCal of the appointment

The procedure is almost identical to the Cancel appointment process except that, in this case, the patient will have to click on the Export iCal button.

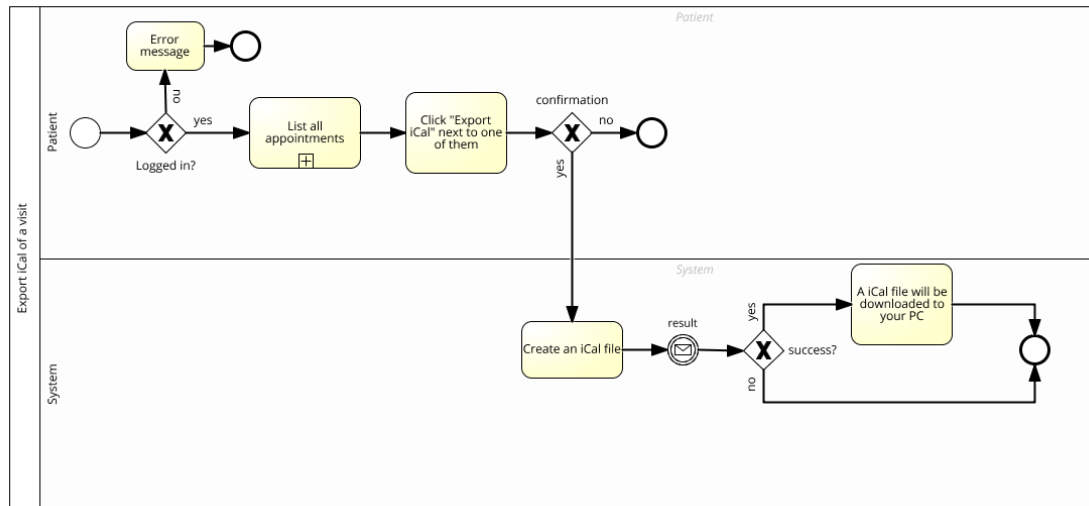


Figure 16 UC5 - Export iCal of the appointment

See the result of the visit

In order to see the result of the visit, the patient should access the “See a result” page while being logged in in his account. In order to display the result, the patient will have to select the visit of interest using the autofill form by inputting doctor’s name and/or datetime of the visit. After selecting the appointment, the result will be displayed in a new page.

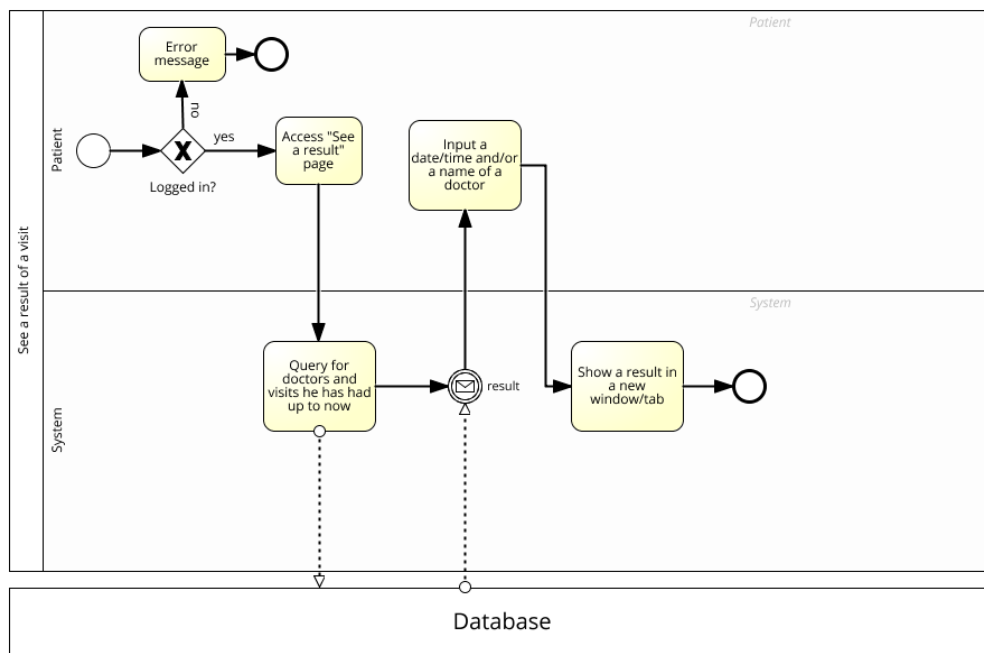


Figure 17 UC6 - See a result of a visit

Make the appointment (Patient)

In order to make the appointment the patient should be logged in and access Make an appointment page. First of all, the patient will have to choose doctor’s specialization which will display the list of all doctors of this specialization. Afterwards, after selecting the doctor, the patient will be shown the calendar with available dates in which the appointment can be made. After selecting the date, all the available timeslots will be shown. A patient will fill what bothers him (optionally), select the timeslot of the appointment, if this appointment is for him or another person (he might make the appointment for his relative. In this case a name of the patient will have to be specified) and will specify if it’s the follow up or a first appointment. This will make it easier for the doctor to manage his patients. After form submission, appointment will be made and can be seen in “My appointments” page.

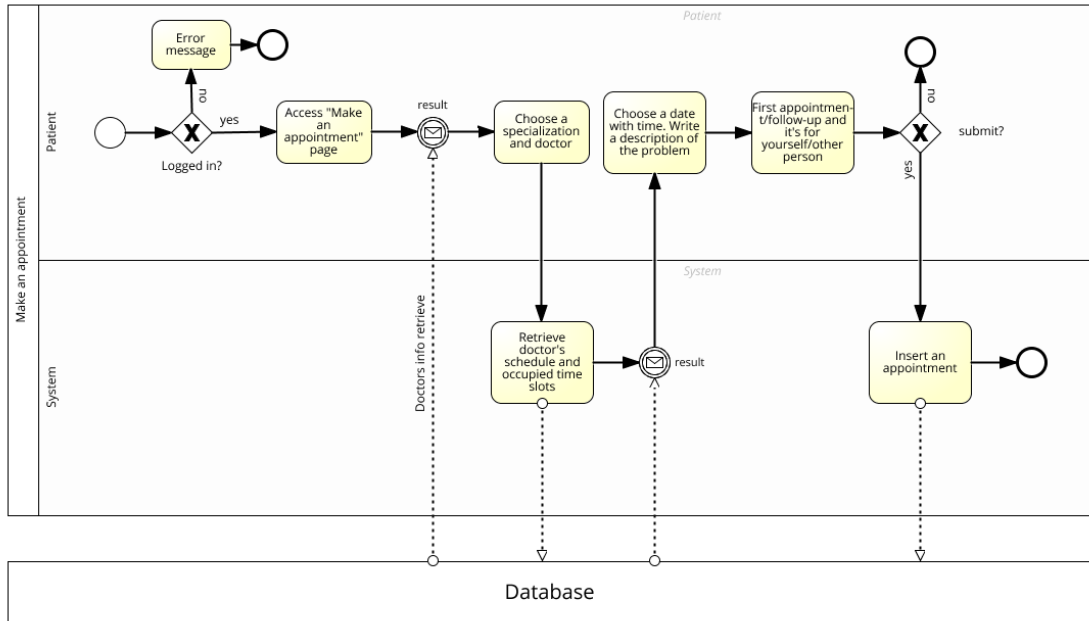


Figure 18 UC7 - Make the appointment (Patient)

Login

In order to login, the patient will have to access “Login/Register” page. After filling up the username (patient’s DNI) and password, patient will have to click on Login button. If all the data provided is correct, patient will be logged in and will have access to all the functionality of that account.

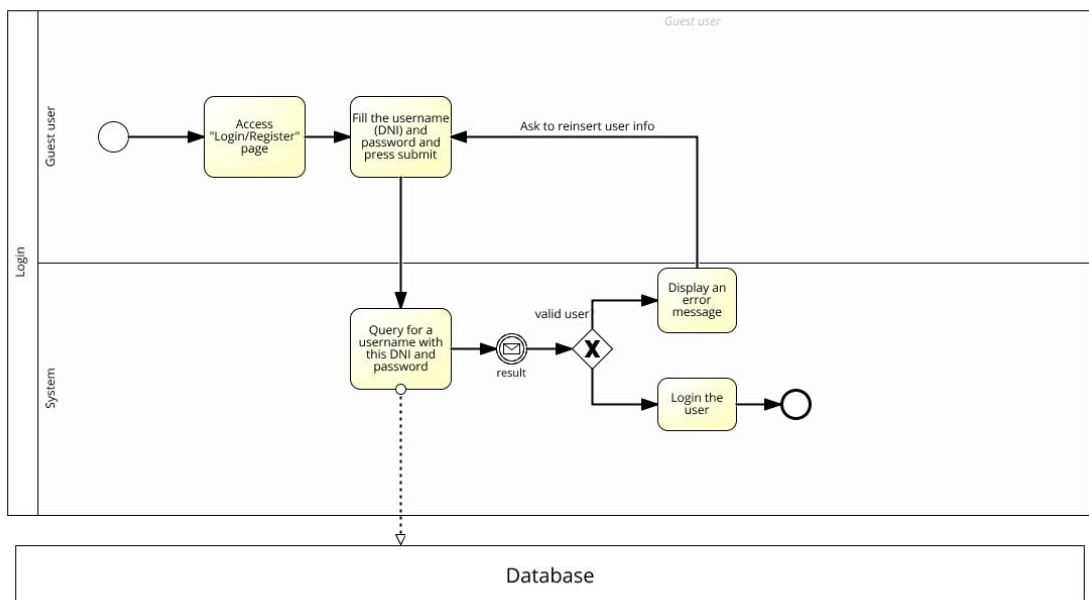


Figure 19 UC8 – Login

List all appointments of the patient

In order to display the upcoming patient's appointments, patient will have to access "My appointments" page while being logged into their account. All the appointments will be displayed on page with export iCal and cancel appointment buttons.

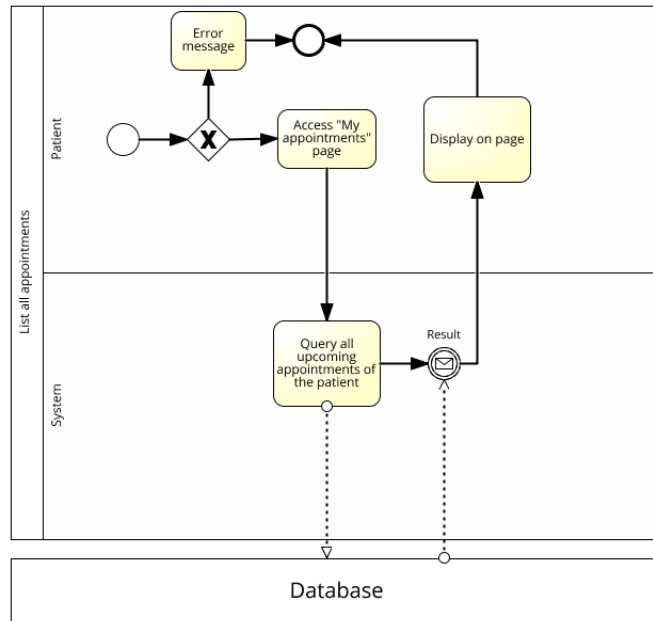


Figure 20 UC9 - List all appointments of the patient

Make a guest appointment

Some of the users don't know a lot about how to use a computer/browser so they have problems registering on websites. Also, there are users who just don't want to be bothered by registering at all. For these kind of users, we allow to make up to 5 guest appointments at the same time. The procedure is basically the same one as for the registered users, except users are not asked to specify for whom this appointment is. To identify how many appointments the guest user has made, we use his IP address as an attribute. If 5 have already been made, we don't let the patient make any more guest appointments until he/she goes to some of these visits or register an account.

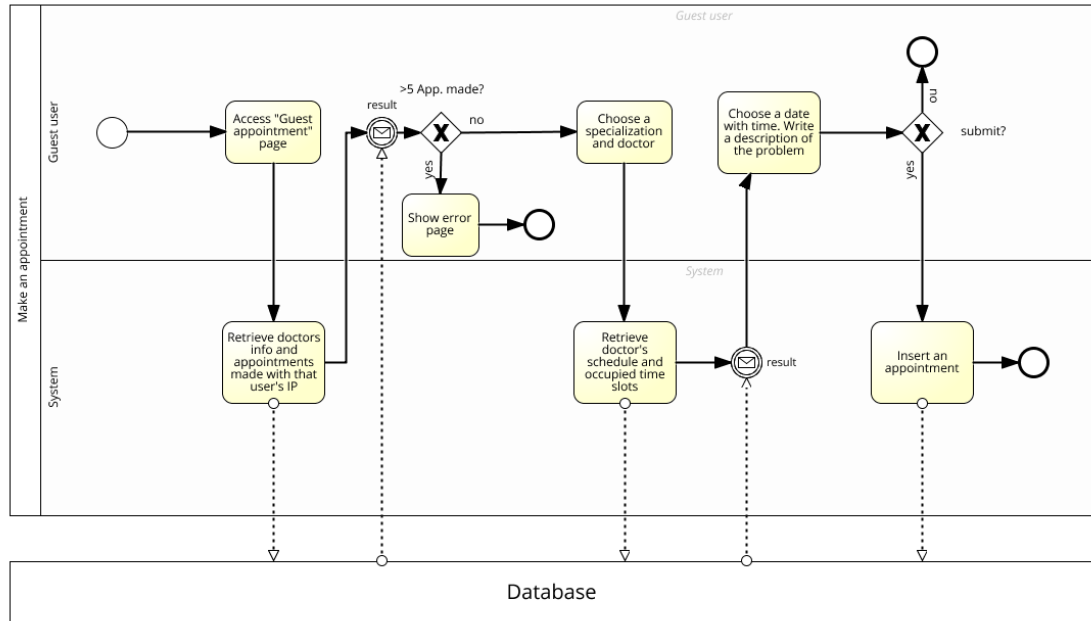


Figure 21 UC10 - Make a guest appointment

Write a message to patient

In order to send message to some patient, the receptionist will have to be logged in with her/his account and access "Write message" page. After which, patient will have to be selected by using autofill field inputting patient's DNI and/or full name. After selecting one of the patients, text area will be displayed for the receptionist to write a message in. After form submission, message will be successfully sent to that patient.

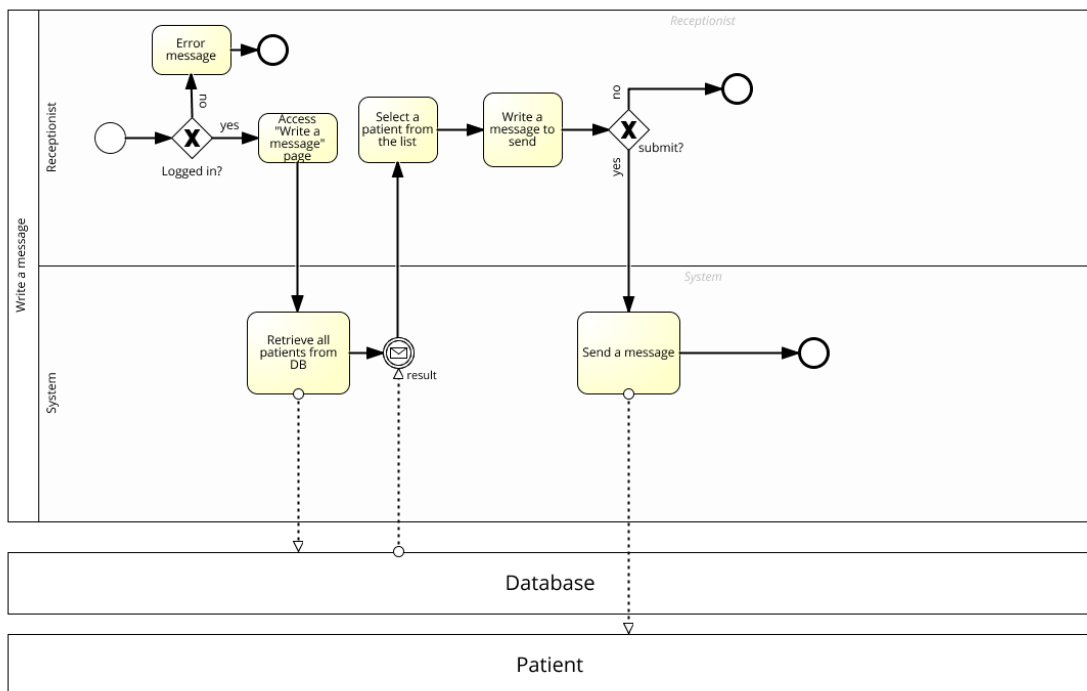


Figure 22 UC11 - Write a message to patient

Show patient's medical record

In order to show patient's medical record, receptionist has to be logged in and access "Medical records" page. After which, the patient will have to be selected by using autofill field inputting patient's DNI and/or full name. After selecting one of the patients, patient's basic info will be displayed on page with a table with all the past and future appointments made by him.

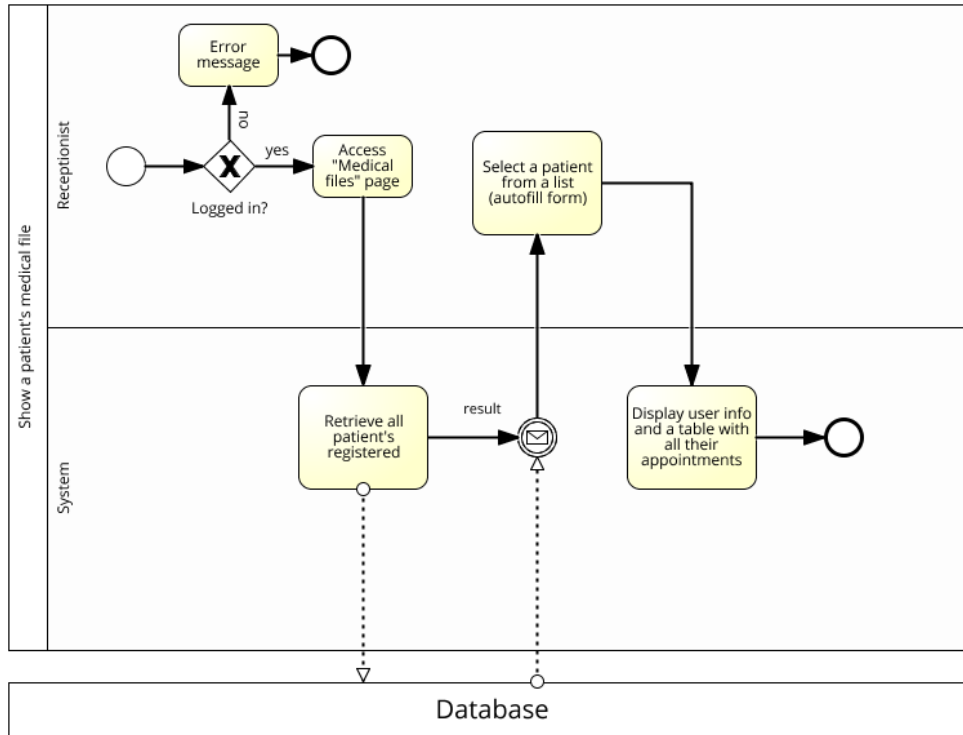


Figure 23 UC12 - Show patient's medical file

List all doctor's appointments

In order to display the upcoming appointments or today's appointments of the doctor, he/she will have to access "List appointments" page while being logged into his/her account. By default, today's appointments will be displayed on the same page using table, which can be sorted by different criterions.

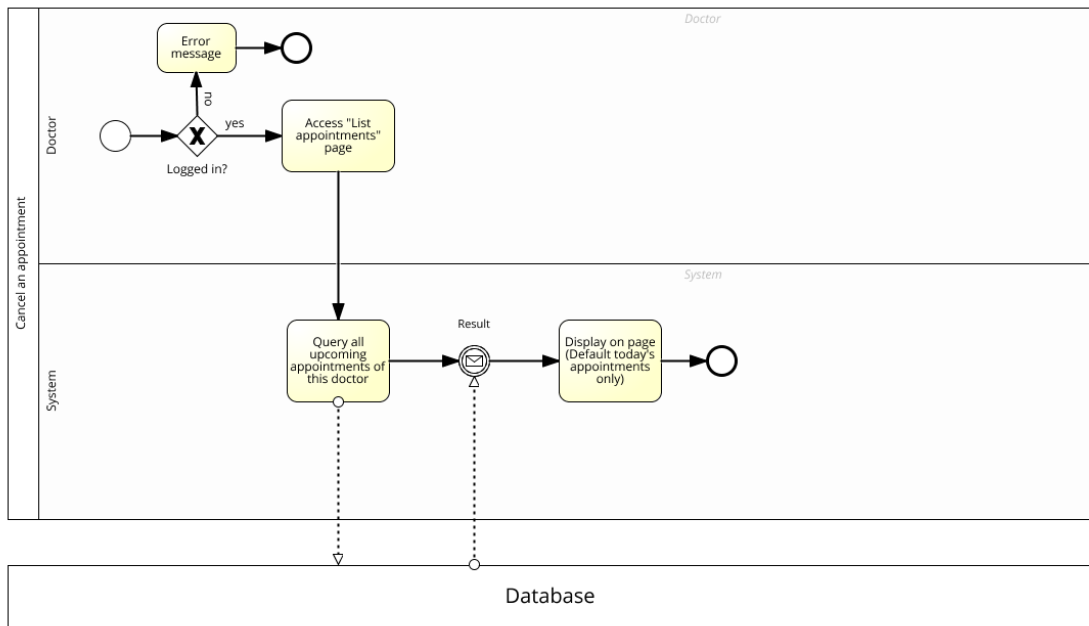


Figure 24 UC13 - List all doctor's appointments

Search for doctors

Website users are able to search for doctors that work in the clinic based on different criterions. All the criterions are not required to fill in. A user has to access "Search for doctors" page and fill the fields that he finds necessary (therefore the inclusive gateway in a diagram above). If none fields are filled, all the doctors will be shown. After submitting the search form, the resulting list of doctors will be shown.

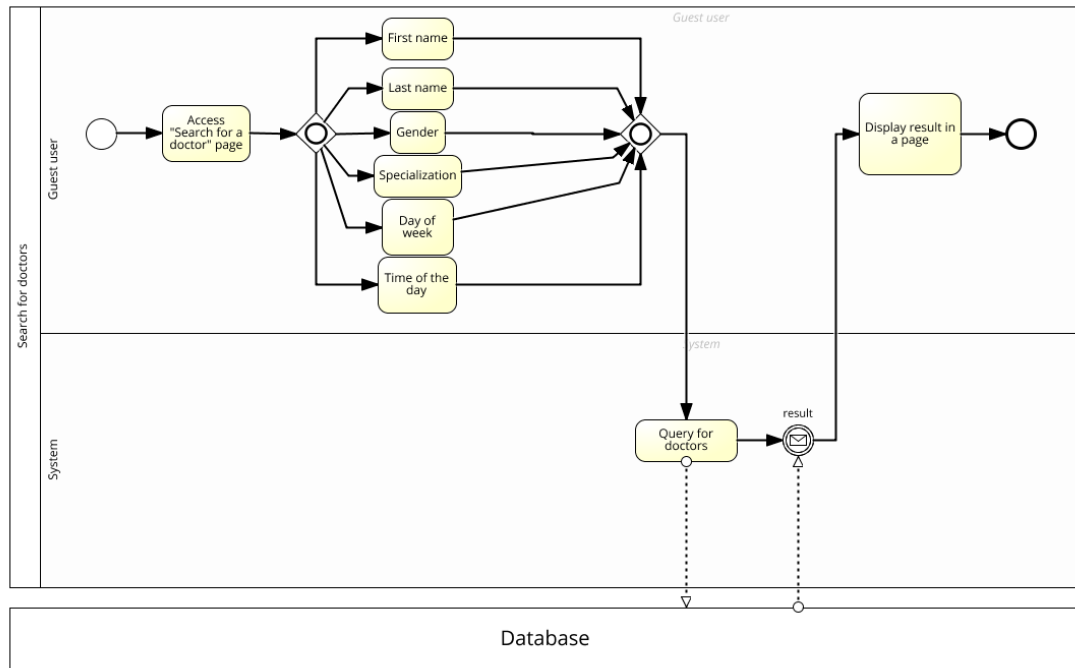


Figure 25 UC14 - Search for doctors

Change profile info

The user has to be logged in as any of website’s roles (patient, doctor or receptionist) and access “Change profile” page. The current profile information will be displayed on page and a user will be able to change those to the new ones he/she wants. After clicking submit, system will verify all the new data given. If DNI and/or the Email are not of the correct format, alert the user of that and don’t proceed with the form submission. In addition, if the new DNI and/or Email already exist on any other account, also notify the user and don’t let the form submission proceed. If a verification succeeded, user’s information update will be done correctly.

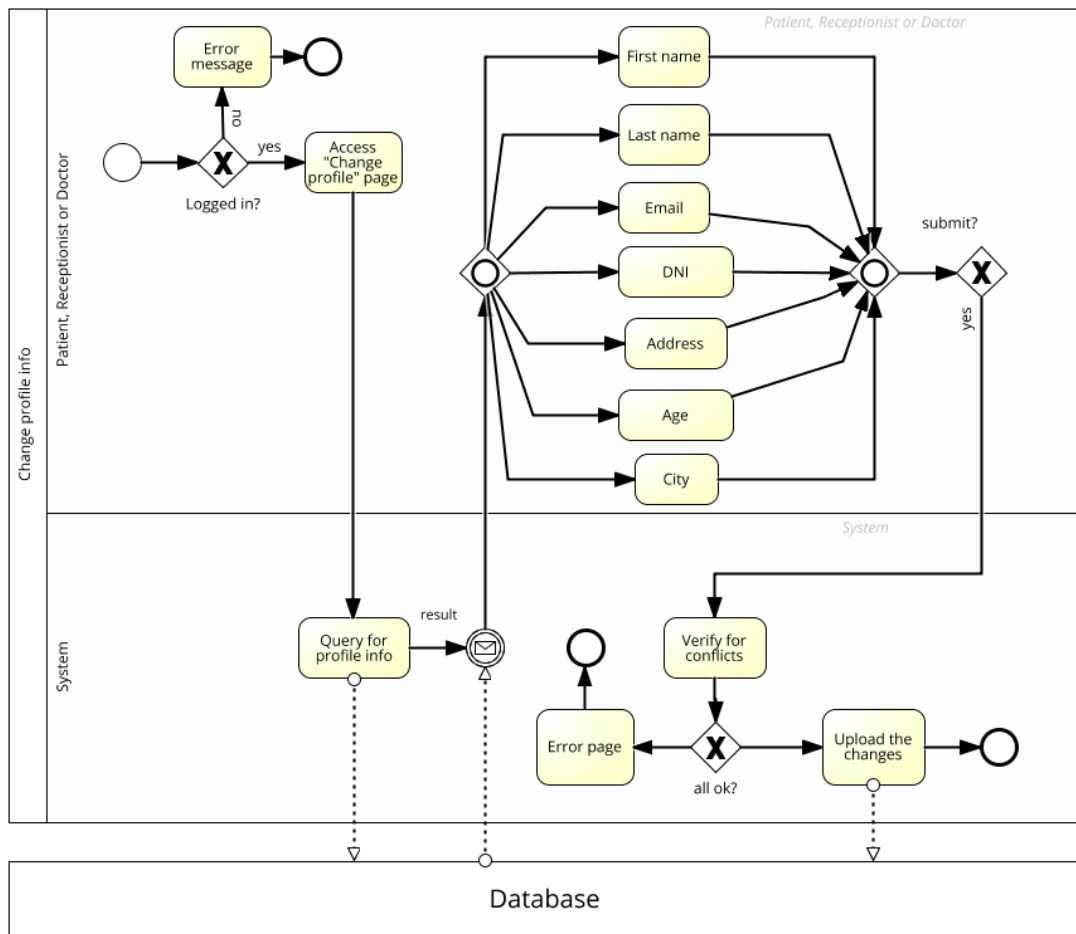


Figure 26 UC15 - Change profile info

Add a holiday day (Doctor)

It's the same as the one done by Receptionist role. The only difference is that doctor can add a holiday only for himself/herself. Doctors can't add a holiday for the whole clinic.

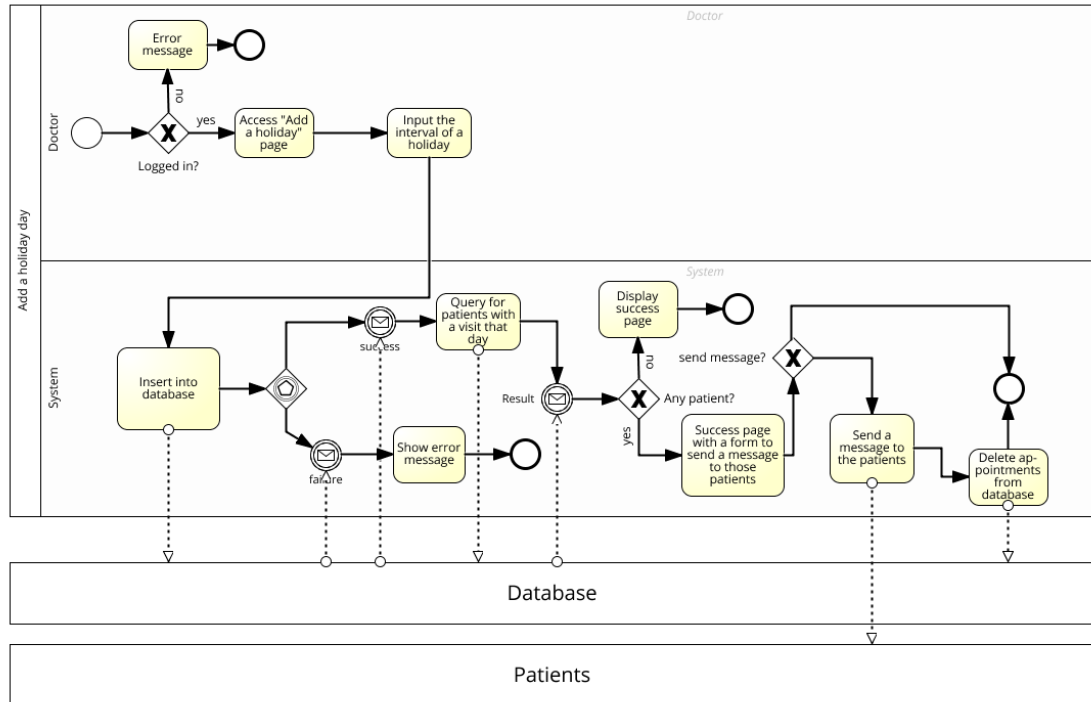


Figure 27 UC16 - Add a holiday (Receptionist)

Mark visit/s as assisted or completed

The user has to be logged in as Receptionist and access “Manage visits” page. Afterwards, doctor has to be selected using autofill input field using their name. After selecting one, all the today’s appointments will be displayed on page. If needed, other day’s appointments can be displayed by selecting “Other day” radio button and a day on the same page. Right to each one of the appointments there will be 2 checkboxes: one for assisted and another one for completed. Receptionist should check/uncheck those he/she finds appropriate and press the “Submit” button when he/she finishes. All the needed rows in DB will be updated.

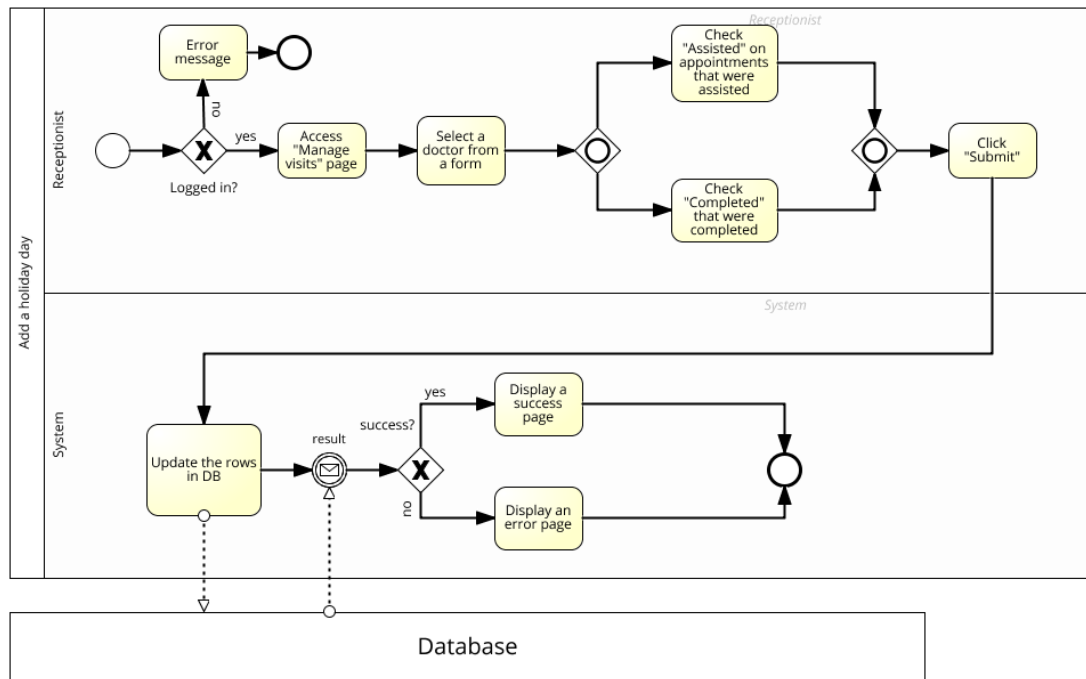


Figure 28 UC17 - Mark visit/s as assisted or completed

Edit the appointment

The user has to be logged in as a Receptionist and access “Manage visits” page. Afterwards, doctor has to be selected using autofill input field using their name. After selecting one, all the today’s appointments will be displayed on page. If the appointment that is wanted to be edited is from another day then select another day. That will show all the appointments during that day. Beneath each one of the appointments there is an “Edit” button. Receptionist should click on one of them related to the appointment that he/she wants to change. That will redirect to another page where a he/she will have to select a new date, time and optionally update the description of the problem. At the end, he/she should press “Update” button for the changes to be reflected in a database.

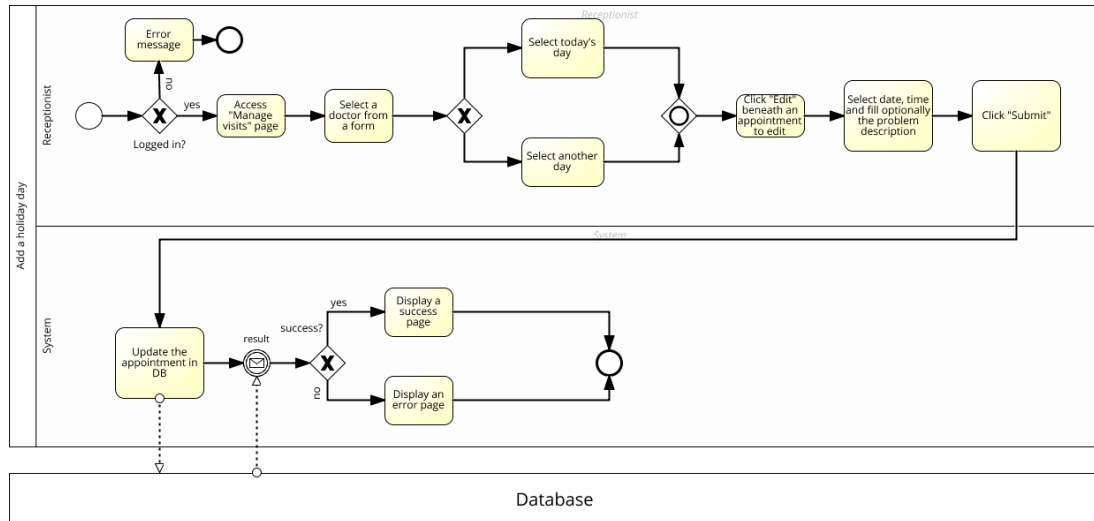


Figure 29 UC18 - Edit the appointment

Cancel appointment (Receptionist)

The user has to be logged in as a Receptionist and access “Manage visits” page. Afterwards, doctor has to be selected using autofill input field using doctor’s name. After selecting one, all the today’s appointments will be displayed on page. If the appointment that is wanted to be cancelled is from another day then select another day. Beneath each one of the appointments there is a “Cancel” button. Receptionist should click on one of them related to the appointment that he/she wants to delete. That will erase the row from a database.

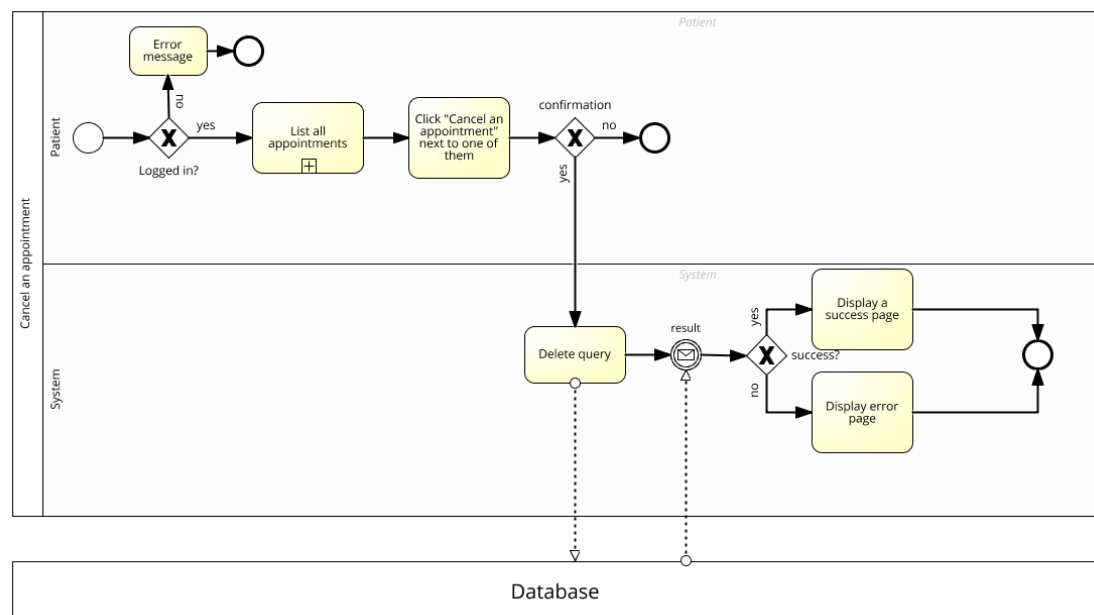


Figure 30 UC19 - Cancel appointment (Receptionist)

Create a doctor

The user has to be logged in as a Receptionist or Admin role and access “Create a doctor” page. Afterwards, all the required details have to be filled in about a doctor (first and last names, email, specialization, schedule). Schedule has to be filled for at least one day (a doctor can’t have no schedule). When finished, a “Register” button will have to be pressed. If everything is fine, a success page will be displayed and a new user will be added to a database.

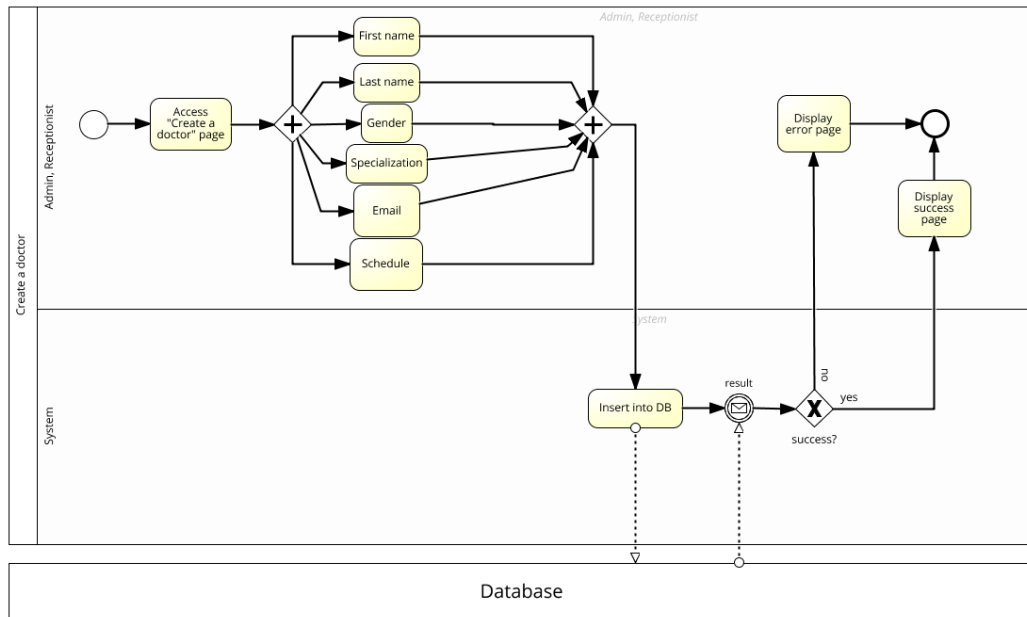


Figure 31 UC20 - Create a doctor

Create a patient (Receptionist)

The user has to be logged in as a Receptionist role and access “Create a patient” page. Afterwards, all the required details have to be filled in about the patient (first and last names, email, DNI) and some optional fields (Address, city, age). When finished, a “Register” button will have to be pressed. If everything is fine, a success page will be displayed and a new user will be added to a database.

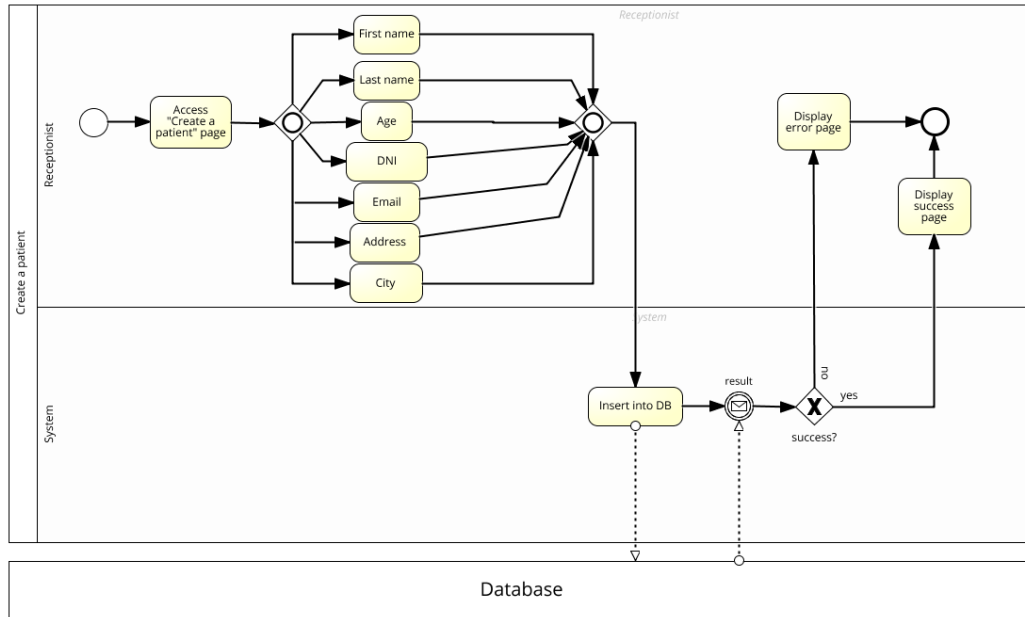


Figure 32 UC21 - Create a patient (Receptionist)

Show and delete holidays

The user has to be logged in as a Receptionist role and access “Holidays” page. As a result, all the clinic’s holidays from today’s day will be retrieved and shown in a sortable table. Every holiday can be deleted by clicking “Delete” near each one of them. If clicked, a page will be refreshed and a row related to this holiday will be deleted from database.

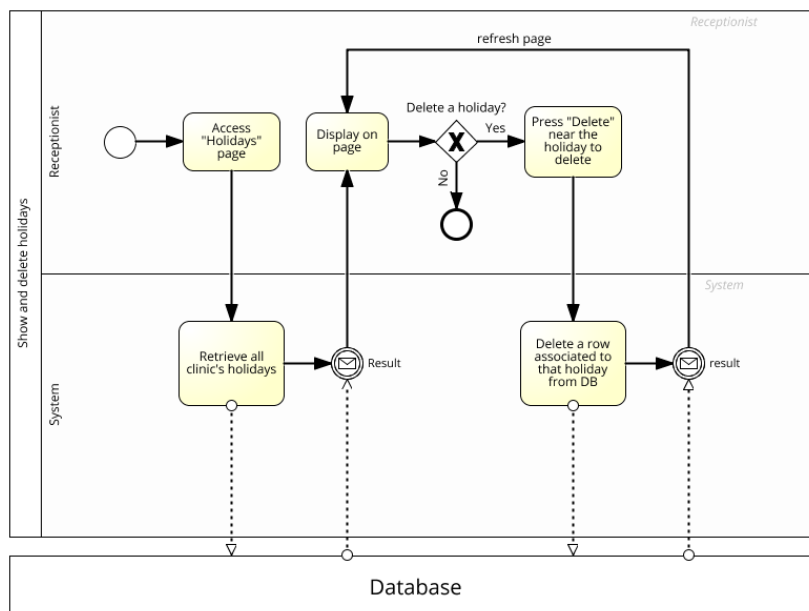


Figure 33 UC22 - Show and delete holidays

2.6 Use case diagrams

Table 2 UC1 - Register an account

Use case 1	Register an account	UC-1
Actors	Patient	
Description	Registers an account with a Patient role which will enable all the different functionalities of the patients	
Precondition	Access a registration form of a website	
Basic Flow	<ol style="list-style-type: none">1. Fill all the required information (name, email, DNI, password) and optionally insurance number2. Click on "Submit" button3. Confirm an email by clicking on a link send to his inbox	
Alternate Flow	If any of the required fields were not filled in, show an error message without letting him complete his registration.	
Postcondition	A user will be registered in a website and will be able to Access his account	

Table 3 UC2 - Add a holiday day

Use case 2	Add a holiday day	UC-2
Actors	Receptionist	
Description	Allows to add a holiday day for a clinic or for a particular doctor. The holiday days are taken into account when patients make an appointment.	
Precondition	Logged in as a Receptionist role on the website and accessed “Add a holiday day” page.	
Basic Flow	<ol style="list-style-type: none"> 1. Choose if it’s a holiday of a clinic or a particular doctor. In second case, select a doctor from a list. 2. Select the range of dates of a holiday. 3. Click on “Submit” button. 4. If there are any appointments made in that range of dates, have a possibility of sending a message to them. 	
Alternate Flow	If no doctor is selected or no dates are selected, give an error message.	
Postcondition	A new holiday will be added to database. All the appointments on that day will be deleted and, if yes, all the patients will be notified of it.	

Table 4 UC3 - Add a result of a visit

Use case 3	Add a result of a visit	UC-3
Actors	Doctor	
Description	Allows to add a private or public result of a previously made visit. Public results will be available to see for a patient.	
Precondition	Logged in as a Doctor role on the website and accessed “Write a result” page.	
Basic Flow	<ol style="list-style-type: none"> 1. Select a patient and/or a datetime of a visit 2. Select the range of dates of a holiday. 3. Select type of result: private or public (the one patients can see) 4. Write a result and click “Submit” button 	
Alternate Flow	If some required fields are not filled (patient or datetime of a visit), show an error message.	
Postcondition	A public or private result will be added/updated on database.	

Table 5 UC4 - Cancel an appointment

Use case 4	Cancel an appointment (Patient)	UC-4
Actors	Patient	
Description	Allows to cancel a previously made appointment by this patient.	
Precondition	Logged in as a Patient role on the website and accessed "My appointments" page.	
Basic Flow	<ol style="list-style-type: none"> 1. Click "Cancel an appointment" next to one of them 2. Confirm with clicking yes or no 	
Alternate Flow	If there was an error deleting an appointment from a database, show it.	
Postcondition	An appointment information will be deleted from database.	

Table 6 UC5 - Export iCal of a visit

Use case 5	Export iCal of a visit	UC-5
Actors	Patient	
Description	Allows to export a iCal file of a previously made appointment by this patient. This file can be used to add an event to an iOS calendar, Google Calendar and other popular calendar services,	
Precondition	Logged in as a Patient role on the website and accessed "My appointments" page.	
Basic Flow	<ol style="list-style-type: none"> 1. Click "Export iCal" next to one of them 2. A file should be downloaded to a patient's PC 	
Alternate Flow	None	
Postcondition	An appointment information will be exported to an iCal file.	



Table 7 UC6 - See a result of a visit

Use case 6	See a result of a visit	UC-6
Actors	Patient	
Description	Allows to display a result of some visit to which a doctor wrote previously.	
Precondition	Logged in as a Patient role on the website and accessed “See a result” page.	
Basic Flow	<ol style="list-style-type: none"> 1. Input a date/time and/or a name of a doctor 2. Click “Show” button 	
Alternate Flow	If one of the fields is not filled, show an error when clicking “Show” button	
Postcondition	The result/results will be shown on a page.	

Table 8 UC7 - Make an appointment

Use case 7	Make an appointment	UC-7
Actors	Patient	
Description	Allows to make an appointment by a logged in patient.	
Precondition	Logged in as a Patient role on the website and accessed “Make an appointment” page.	
Basic Flow	<ol style="list-style-type: none"> 1. Choose a specialization and doctor 2. Choose a date with time. Write a description of the problem 3. Choose if it’s a first appointment/follow-up and if it’s for yourself or another person 4. Click “Submit” button 	
Alternate Flow	If one of the required fields is not filled, show an error when clicking “Submit” button.	
Postcondition	An appointment will be added to a database. Now it can be visualized in “My appointments” page	

Table 9 UC8 - Login

Use case 8	Login	UC-8
Actors	Guests	
Description	Allows to login into a website	
Precondition	Access a “Login/Register” page in a website.	
Basic Flow	<ol style="list-style-type: none"> 1. Fill the username and password. 2. Click “Login” button 	
Alternate Flow	<p>If one of the required fields is not filled, show an error when clicking “Login” button.</p> <p>If the login and/or password are not correct, display an error message.</p>	
Postcondition	A user will be logged into website. He will be able to use the functionalities of that particular role.	

Table 10 UC9 - List all appointments

Use case 9	List all appointments	UC-9
Actors	Patient	
Description	Allows display all the appointments made by a logged in Patient.	
Precondition	Have to be logged in as a Patient role.	
Basic Flow	<ol style="list-style-type: none"> 1. Access “My appointments” page 	
Alternate Flow	None	
Postcondition	All the upcoming appointments will be displayed of that particular Patient.	



Table 11 UC10 - Make guest appointment

Use case 10	Make guest appointment	UC-10
Actors	Guests	
Description	Allows to make an appointment by a non logged in user.	
Precondition	Access “Guest appointment” page.	
Basic Flow	<ol style="list-style-type: none"> 1. Choose a specialization and doctor 2. Choose a date with time. Write a description of the problem 3. Choose if it’s a first appointment/follow-up 4. Write your full name 5. Click “Submit” button 	
Alternate Flow	<p>If one of the required fields is not filled, show an error when clicking “Submit” button.</p> <p>If a user has already created 5 appointments from the same IP address, show an error page and don’t let him make an appointment.</p>	
Postcondition	An appointment will be added to a database.	

Table 12 UC11 - Write a message to a patient

Use case 11	Write a message to a patient	UC-11
Actors	Receptionist	
Description	Allows to send messages to registered patients	
Precondition	Be logged in as a Receptionist and access “Write a message” page.	
Basic Flow	<ol style="list-style-type: none"> 1. Select a patient from the list 2. Write a message to send 3. Click “Submit” button 	
Alternate Flow	If one of the required fields is not filled, show an error when clicking “Submit” button.	
Postcondition	A message will be sent to a patient	

Table 13 UC12 - Show patient's medical file

Use case 12	Show patient's medical file	UC-12
Actors	Receptionist	
Description	Allows to show patient's information and display all the appointments made to this day	
Precondition	Be logged in as a Receptionist and access "Medical files" page.	
Basic Flow	1. Select a patient from the list (autofill form) by writing a name or/and a DNI	
Alternate Flow	None	
Postcondition	Patient's info will be displayed on page	

Table 14 UC13 - List all appointments of a doctor

Use case 13	List all appointments of a doctor	UC-13
Actors	Doctor	
Description	Allows display all the appointments made by a logged in Doctor.	
Precondition	Be logged in as a Doctor	
Basic Flow	1. Access "My appointments" page 2. If needed, select another date for which to display the appointments	
Alternate Flow	None	
Postcondition	By default, only today's appointments will be displayed	



Table 15 UC14 - Search for doctors

Use case 14	Search for doctors	UC-14
Actors	Guests, Patients, Receptionist	
Description	Enables users to search for doctors that work in a clinic based on some criterions (name, specialization, working hours, etc).	
Precondition	Access a "Search for doctors" page in a website.	
Basic Flow	<ol style="list-style-type: none"> 1. Fill the fields that are interested to a user. All of them are optional. 2. Click "Search" button 	
Alternate Flow	None	
Postcondition	A page with the resulting doctors will be displayed to a user. He will be able to see their information on screen	

Table 16 UC15 - Change profile info

Use case 15	Change profile info	UC-15
Actors	Receptionist, Doctor, Patient	
Description	Allows to change the profile information of the registered users	
Precondition	Be logged in and access "Change profile" page.	
Basic Flow	<ol style="list-style-type: none"> 1. Change the fields that need changing 2. Click "Submit" button 	
Alternate Flow	<p>If email or DNI are not of a correct format, alert a user and don't let the submit continue.</p> <p>If another user has the new email or DNI, alert the user and don't let the submit continue.</p>	
Postcondition	The profile information will be updated in a database	

Table 17 UC16 - Add a holiday (Doctor)

Use case 16	Add a holiday (Doctor)	UC-16
Actors	Doctor	
Description	Allows to add a holiday day for a clinic or for a doctor. The holiday days are considered when patients make an appointment.	
Precondition	Logged in as a Doctor role on the website and accessed “Add a holiday day” page.	
Basic Flow	<ol style="list-style-type: none"> 1. Select the range of dates of a holiday. 2. Click on “Submit” button. 3. If there are any appointments made in that range of dates, have a possibility of sending a message to those patients. 	
Alternate Flow	If no dates are selected, give an error message.	
Postcondition	A new holiday will be added to database. All the appointments on that day will be deleted and, if yes, all the patients will be notified of it.	

Table 18 UC17 - Mark a visit as assisted or completed

Use case 17	Mark a visit as assisted or completed	UC-17
Actors	Receptionist	
Description	Allows to set which appointments were completed and/or assisted by a patient.	
Precondition	Logged in as a Receptionist role on the website.	
Basic Flow	<ol style="list-style-type: none"> 1. Access “Manage visits” page 2. Select a doctor using an autofill form 3. Mark if a visit was assisted and/or completed 4. Press “Submit” button 	
Alternate Flow	None	
Postcondition	The row/s will be updated so that all the changes are reflected on a database. The fields that will be modified are the assisted and invisit from appointment table	



Table 19 UC18 - Edit an appointment

Use case 18	Edit an appointment	UC-18
Actors	Receptionist	
Description	Allows to edit an appointment of some patient	
Precondition	Logged in as a Receptionist role on the website.	
Basic Flow	<ol style="list-style-type: none"> 1. Access “Manage visits” page 2. Select a doctor using an autofill form 3. Find an appointment to be changed 4. Press “Edit” button beneath the appointment to change 5. Select the new date, time and update the description of the problem 6. Press “Update” button 	
Alternate Flow	If a date was not selected, alert the user about it and don’t let the application to proceed.	
Postcondition	This visit will have their date, time and description of the problem updated.	

Table 20 UC19 - Cancel an appointment (Receptionist)

Use case 19	Cancel an appointment (Receptionist)	UC-19
Actors	Receptionist	
Description	Allows to cancel an appointment of some patient	
Precondition	Logged in as a Receptionist role on the website.	
Basic Flow	<ol style="list-style-type: none"> 1. Access “Manage visits” page 2. Select a doctor using an autofill form 3. Find an appointment to be cancelled 4. Press “Cancel” button beneath the appointment to cancel 	
Alternate Flow	None	
Postcondition	This visit will be deleted from DB.	

Use case 20	Create a doctor	UC-20
Actors	Receptionist, Admin	
Description	Allows to create a new doctor user	
Precondition	Logged in as a Receptionist or Admin role on the website.	
Basic Flow	<ol style="list-style-type: none"> 1. Access “Create a doctor” page 2. Fill the required fields 3. Press “Register” button 	
Alternate Flow	If email is already taken, a schedule has not been filled or the schedule format is wrong, alert the user of it and don’t let the submission continue.	
Postcondition	A new doctor user will be added to DB.	

Use case 21	Create a patient(Receptionist)	UC-21
Actors	Receptionist	
Description	Allows to create a new Patient user	
Precondition	Logged in as a Receptionist role on the website.	
Basic Flow	<ol style="list-style-type: none"> 1. Access “Create a patient” page 2. Fill the required fields 3. Press “Register” button 	
Alternate Flow	If email or DNI is already taken, alert the user of it and don’t let the submission continue.	
Postcondition	A new patient user will be added to DB.	



Use case 22	Show and delete holidays	UC-22
Actors	Receptionist	
Description	Allows to display all clinic's holidays and delete them if needed.	
Precondition	Logged in as a Receptionist role on the website.	
Basic Flow	<ol style="list-style-type: none"> 1. Access "Holidays" page 2. Press "Delete" near each one of the holidays that need deletion. 	
Alternate Flow	None.	
Postcondition	Holidays that needed to be deleted will be removed from database.	

2.7 Technological analysis

During the construction of a medical clinic website there can be used a variety of techniques and technologies - from the construction of each of the items manually to the application of already fully finished standard templates.

2.7.1 Good website characteristics

Before choosing what framework, we'll use, we must state what features we want to maximize to attract more customers.

The following characteristics are considered important in website development [7]:

- **Appearance**
 - Effective use of color
 - Text that is easily read
 - Meaningful graphics
 - Simplicity
 - Quality photography
- **Content**
 - Short and organized text, clear labels
 - Quality writing
- **Functionality:** Every component of your site should work quickly and correctly
- **Usability**
 - Easy to use
 - Fast-loading pages
 - Consistent layout
 - Logical navigation
 - Cross-platform/browser compatibility
 - Screen Resolution
- **Search Engine Optimized (SEO)**

- **Secure**

Therefore, we want our website to be as close to these as possible

In terms of appearance, our website uses a straightforward design using 3 primary colors: blue, white and green. The images used (in slider and doctors' photos) are related to a clinic in question. The font size is big enough to be easily read (13 – 15 px).

Only the necessary content will be present on the website. Clinic's description, working hours, doctors' profiles and working schedule, specializations.

All the different functionalities of website have been tested for correctness before deploying it. In the late development stages, all of website's functions were correctly done without any errors.

Usability was also tested in the development stage. Cross platform testing was performed with tablet (iPad 4th generation), Android phone, wide screen laptop and high-resolution desktop PC. Website was successfully resized to user's needs. Loading time was also evaluated and were not high at all taking into account we used a free web hosting. All the important website's functionality is easily located in its main menu panel making it easy for website's users to use all the necessary functionality they require.

WordPress provides several SEO plugins [8] to make it easier for both users to find a clinic in different searching engines and for the clinic to make itself easier to spot by potential customers (patients).

There are a lot of already made plugins that makes it easier for WordPress websites to maintain themselves secure and virus clean [9]. On top of that, different techniques to not let hackers access the database data were used (they can be seen in the Database access and security section).

2.7.2 Traditional website development

Manual development (traditional website development) involves taking a framework such as HTML, PHP and ASP.NET and start building the website from scratch.

This method provides different advantages such as:

- **Customizability:** you can create anything you want and you have practically no restrictions in the design of a website.
- **Less code:** only the necessary code
- **The best SEO friendliness**

Among the disadvantages are:

- the learning curve is pretty high, much more HTML, CSS, etc. knowledge needed in order to develop a quality website
- More resources needed: more developers and/or time



2.7.3 Content management system method

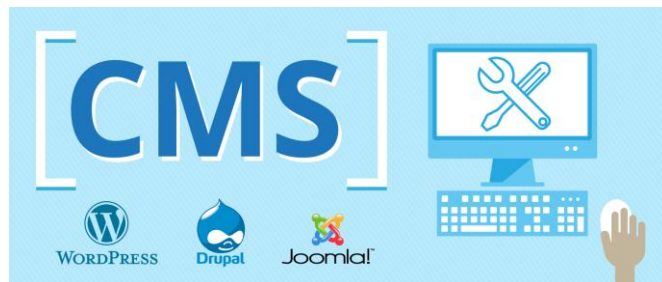


Figure 34 Popular CMS systems [10]

CMS [11] (a.k.a. Content Management System) - is a software that facilitates creating, editing, organizing, and publishing content. It allows to create and publish content on the Internet. Websites can be created easily from a user-friendly GUI provided.

Using the CMS- systems for the development of the site provides a number of benefits to

Developers and end users:

- **Cost:** one of the most important ones. With CMS, it's much easier to develop a website therefore you need resources to create a quality website. Normally when you would have needed a team of developers, one web developer can develop a website single-handedly.
- **Greater Accessibility:** normally, in order to make any change to a website, a developer has to go to his computer and make changes there. With CMS, you can access admin area from any computer connected to internet and make any changes from there.
- **Ease of integrating new functionality:** if you want to implement something new, normally you would have to code it by yourself and test it several times before deploying. CMS, however, have different plugins and components already created that can be installed in 1 click and integrated to the website.
- **Cross-platform support:** no need to create a different website for mobile users/tablet. Some CMS provide integrated cross-platform support (WordPress).
- **SEO Friendliness:** not as good as in traditional development but most of CMS provide a quality code that works well with searching engines.
- **Template-based design:** a lot of templates already available on the internet that you can start developing from. Saves a lot of time
- **Maintainability:** very easy to maintain a website up to date. Most CMS even provide and auto-update feature for most components used on website.
- **Fast Learning Curve:** some CMS are easier to use than others but all of them are not very hard to use.

On top of that, most of CMS provide a lot of built-in features:

- Modules
- RSS support, banners and Meta tags.
- Web statistics such as number of visits per day
- Document management system.

- Blogs, chat, forums, f.a.q.
- Customizable feedback forms
- Photos, polls
- Product catalog, online store
- Search the site
- Newsletter subscription

MedClinic is limited in budget that they can invest in website development. The best framework that is cost efficient with several functionalities is hands down CMS. Therefore, it is the one that will be used in the development of MedClinic website.

The most popular CMS is hands down WordPress with 25% of total websites powered by WordPress and over 58% of all websites using CMS use WordPress. It has everything a CMS promises and has the largest community.

Therefore, we will use WordPress [12] as our CMS of choice.



Figure 35 WordPress logo [13]

The structure of a website when using WordPress CMS can be easily understood by observing a following image:



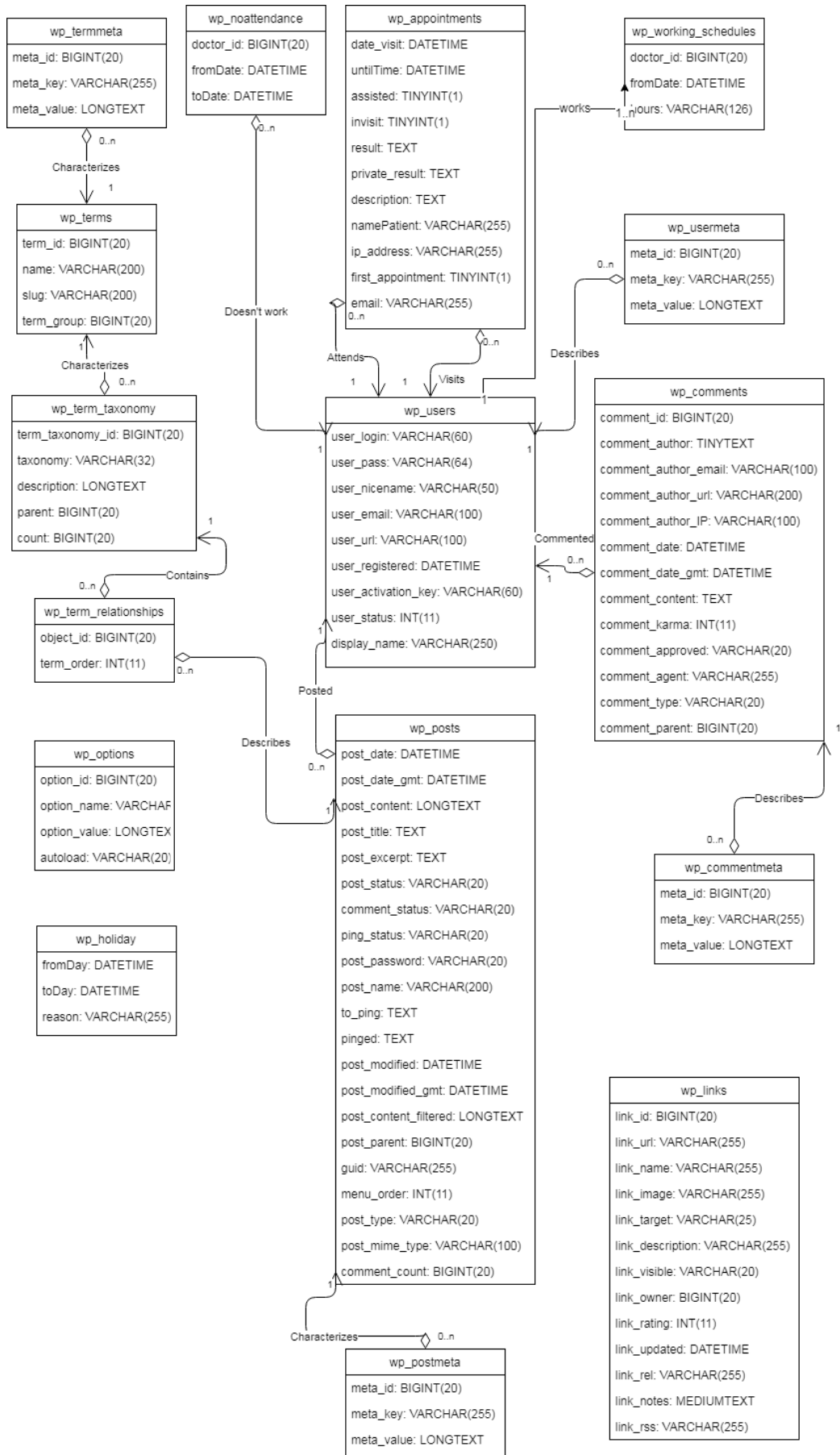
Figure 36 Theme hierarchy of WordPress websites [14]

2.8 Database structure

WordPress CMS uses MySQL as a DBMS (database management system). MySQL is the most popular Open Source SQL database management system. MySQL is an efficient, secure and stable system for data storing.

One of the first steps in the database design is the conceptual design that we are going to represent using a UML [15] class diagram. All the relations with their attributes and associations types should be specified before the actual website development starts. WordPress won't allow to add data to the database that doesn't have any tables created or if the columns are not correct. An UML diagram was created using draw.io [16] online tool (Fig. 31).

From the UML class diagram, we get the relational scheme ER model [17] that defines a data/structure of a database using MySQL Workbench [18] (Fig. 32).



Online Medical Appointment Scheduling System

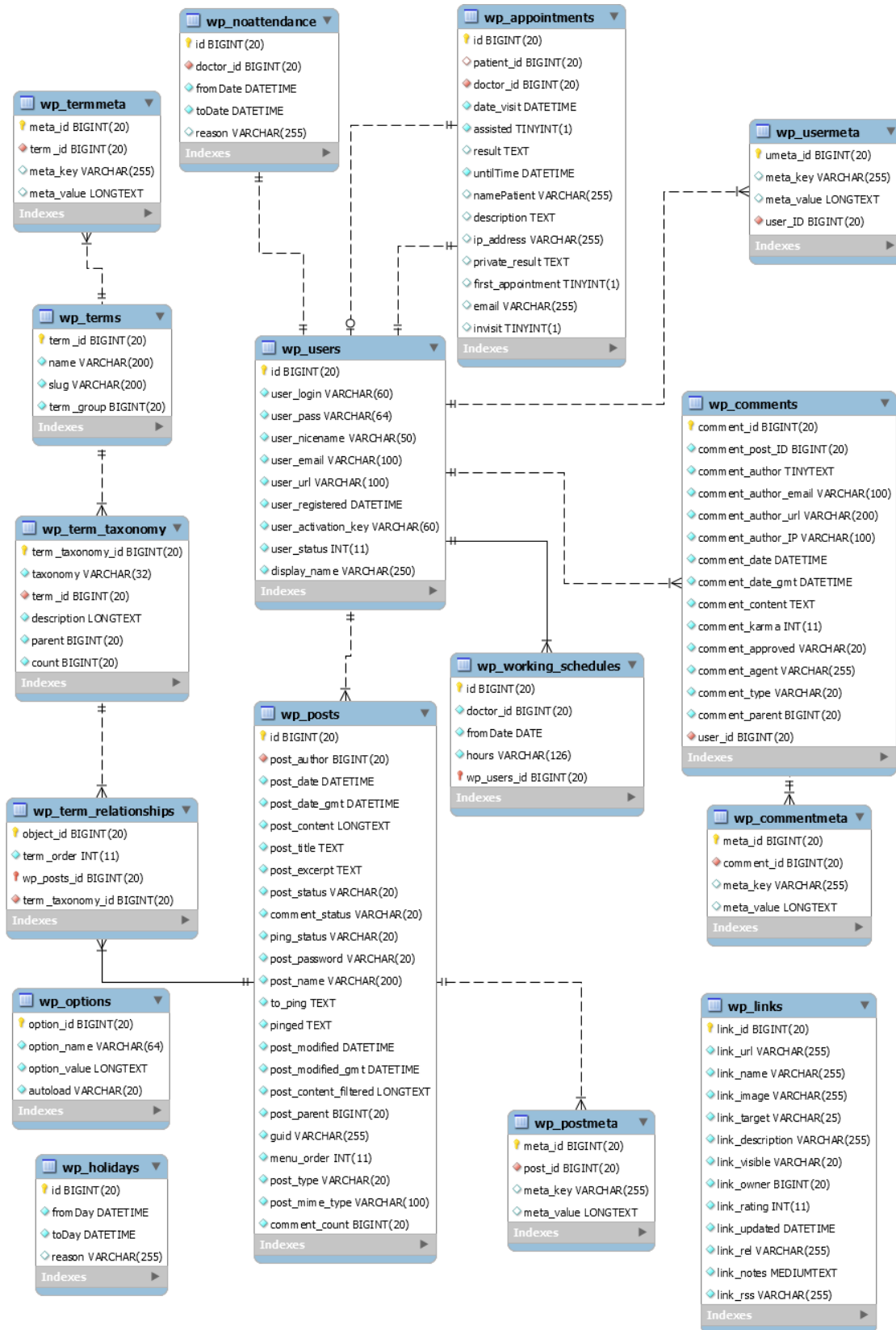


Figure 38 Websites DB diagram

The following tables are the ones used by WordPress CMS and the appointment system:

- **wp_comment:** this table is used to store all the comments made by users in the posts of wordpress. Comments can be disabled if needed.
- **wp_commentmeta:** comment metadata is stored here. Metadata can be any information possible about some particular comment such as an attribute that says the most used word in a comment, some image, etc.
- **Wp_options:** wordpress configuration attributes are stored here. An example could be a timezone of a website or a website title.
- **Wp_users:** all the registered users are stored here. Only the a few required fields are stored about each of the users.
- **Wp_usermeta:** user metadata is stored here. All the information other than the required fields are here.
- **Wp_links:** This table contains information about custom links added to your site
- **Wp_terms:** Categories and tags for posts, pages or links are stored in here. A slug is a unique identifier.
- **Wp_term_relationship:** this table links these terms (categories and tags) to objects (posts, pages or links).
- **Wp_term_taxonomy:** describes the terms in details. You can imagine it as meta data of the terms for simplicity
- **Wp_posts:** this table stores the posts of a website.
- **Wp_postmeta:** post metadata is stored in here. Custom fields, main image, etc.

The following tables are used by the appointment management system developed for this project:

- **Wp_appointments:** all the information about any appointment made is stored in this table.
- **Wp_holidays:** the holiday days of the whole clinic are stored here. Optionally, a reason of a holiday can be specified.
- **wp_noattendance:** the holidays of some particular doctor are stored here.
- **wp_working_schedules:** this table has the working schedules of each doctor.



Table 21 Appointments DB table

Name of the attribute	Description	Type	Obligatory field
id	ID number of the table	BIGINT(20), AI	PK, Not Null, Unsigned
patient_id	FK for patient	BIGINT(20)	FK, Unsigned
doctor_id	FK for doctor	BIGINT(20)	FK, Unsigned, Not Null
date_visit	Date and time of a visit	DATETIME	Not Null
assisted	Represents if a patient assisted to a visit or not	TINYINT(1)	Not Null, Unsigned
result	Result of a visit	TEXT	None
untilTime	When a visit ends	DATETIME	Not Null
namePatient	Name of a guest user	VARCHAR(255)	None
description	Description of a problem of a patient	TEXT	None
ip_address	IP address of a guest user	VARCHAR(255)	None
private_result	Private result of a visit	TEXT	None
first_appointment	First appointment or not	TINYINT(1)	Unsigned
email	Email of a guest user	VARCHAR(255)	None
invisit	If a patient finished a visit or not	TINYINT(1)	Unsigned

This is one of the most important tables for our application. All the appointments are stored in this table. We must distinguish 2 types of appointments, though:

- **Guest appointments:** Guest users that, for several reasons, don't want to or can't create an account can make a guest appointment without the need of an account. In this kind of appointment, since a user is not registered and doesn't have an ID, patient_id FK is set to null. We must ask them for some basic contact info: their name and an email that will be stored in namePatient and email attribute fields respectively. In order to control the spam of guest appointments, we decided to use an ip_address from where the appointment was made from and also the email address given when creating an appointment. If there are already 5 upcoming appointments made from the ip_address that accessed the guest appointment making menu, the system won't allow them to proceed making an appointment because of the limit. Same for the email but that check is done right before the submitting of the appointment.
- **Registered appointments:** In this case, the patient_id will contain an ID of the patient that will make the appointment. The name and email will not be asked since they are

already contained in a wp_users table. The limit is of 50 upcoming appointments at the same time.

The result attribute will contain the result of a visit that will be submitted by a doctor. The private_result attribute contains a result that is only seen by a doctor that could be used to store some information that patient don't need to see.

The date_visit and untilTime attributes are used to store the date and time of a visit and when it ends. It's interesting to store when the visit is supposed to end because, in case the clinic will add some services that take variable amount of time to complete, the changes to the system will be minimal.

Finally, the assisted and invisit attributes are used to see if some users don't come to the appointments they make for administrative purposes.

Table 22 Clinic holidays DB table

Name of the attribute	Description	Type	Obligatory field
id	ID number of the table	BIGINT(20), AI	PK, Not Null, Unsigned
fromDay	Date and time when a holiday starts	DATETIME	Not Null
toDay	Date and time when a holiday ends	DATETIME	Not Null
reason	Reason of a holiday	VARCHAR(255)	None

In this table, we store the holiday days of the whole clinic. Optionally, a reason of the holiday can be specified.

Table 23 Doctors' not working days DB table

Name of the attribute	Description	Type	Obligatory field
id	ID number of the table	BIGINT(20), AI	PK, Not Null, Unsigned
fromDate	Date and time when a holiday starts	DATETIME	Not Null
toDate	Date and time when a holiday ends	DATETIME	Not Null
reason	Reason of a holiday	VARCHAR(255)	None
doctor_id	FK for doctor	BIGINT(20)	FK, Not Null, Unsigned

In this table, we store the holidays and/or non-working days of each of the doctors.



Table 24 Doctor's working schedules table in DB

Name of the attribute	Description	Type	Obligatory field
id	ID number of the table	BIGINT(20), AI	PK, Not Null, Unsigned
doctor_id	FK for doctor	BIGINT(20)	FK, Not Null, Unsigned
fromDate	Date and time when a working schedule starts	DATETIME	Not Null
hours	Text representation of the working schedule	VARCHAR(126)	Not Null

In this table, we store all the working schedules of the doctors. A doctor can have several working schedules stored from future dates. These working schedules will be used on the make appointment forms in order to show the patients which days are not available for appointment making and which time slots are free.

The attribute 'hours' has the schedule of all 5 working days of a week. For example, 10:00-15:00, 0, 0, 09:30-12:00+14:00-16:00,0. Each day is separated by a comma. If there is a break (lunch, etc) in one of the days, we will add '+' symbol to represent a break between 2 different hour schedules in the same day.

The last thing worth mentioning is the way the users are managed in our system.

The way WordPress manages their users is, it stores the critical information about one user in a wp_users table (login, password, email, display name). Other information is uploaded into wp_usermeta table that can be retrieved using an id of each user.

While developing the website it was considered the creation of a table just for doctors since we will have to store quite a lot of information about them. But then, we could also make use of the way the users are managed by WordPress. The biggest advantage would be, clearly, that we can use a lot of already existent libraries, plugins, widgets, functions, etc. provided by WordPress itself to make some of the most frequent functionalities much easier to achieve. For example, WordPress has special functions that could check if there is an already registered user with some particular email/login or function that can easily create a new user. Instead of making ourselves the different SQL queries for this kind of things, we can just do it with one line of code.

Therefore, we manage our users using the WordPress way. On top of that, we use a plugin called Advanced Access Manager [19] to easily manage user roles, their permissions and restrict some content depending on user roles (for example, patients can't add a holiday day).

2.9 Life cycle of project

To have a smooth development of website we have to beforehand research on what steps we have to achieve for a smooth development of a website.

After researching the different techniques, we found out the one so called SDLC [20] (Systems development life cycle) that is exactly what we want since it is centered on software/website development.

SLDC consists of the following main phases:

- Analysis
- Design
- Development
- Integration and testing
- Deployment
- Maintenance

There exist different ways how these phases can be done during the development. The main two models that are used nowadays in software development are waterfall model and agile development model.

Before proceeding we have to find which one is better for our case.

2.9.1 Waterfall model

Also called the traditional model since it's the oldest one and that has been used for a long time until recent time. Waterfall is a linear approach to SLDC phases. All the steps are realized step by step and in order and, once one is done, we don't go back.



Figure 39 Waterfall development model [21]

Some of the main characteristics of waterfall model are these:

- Customer presence is only required during the requirement at the analysis phase and while delivering the finished product.
- Easy to understand model since it is done linearly.
- All the requirements/things to do are known from the start
- Emphasis on analysis phase. Documentation is very important

Some of the drawbacks known to this model are:

- Sometimes customer doesn't know from the start all the things he wants to have in website. Therefore, it's possible that new requirements might be introduced in later stages that are very costly to implement [22]
- Requires knowing what technologies that will be used from the start. Can be costly to integrate new ones in later stages.

Therefore, this model can be used in most projects where the customer knows exactly what he wants and developers also know exactly what has to be used in order to achieve it.

2.9.2 Agile development

Agile methodology [23], in turn, is an iterative, incremental, evolutionary, team-based approach to software development. The rapid delivery is crucial in this method, made in parts. Instead of linear phases agile method uses a concept of “sprint” that is a “time boxed” phase. Each sprint contains its duration and a list of requirements that must be done during that period.

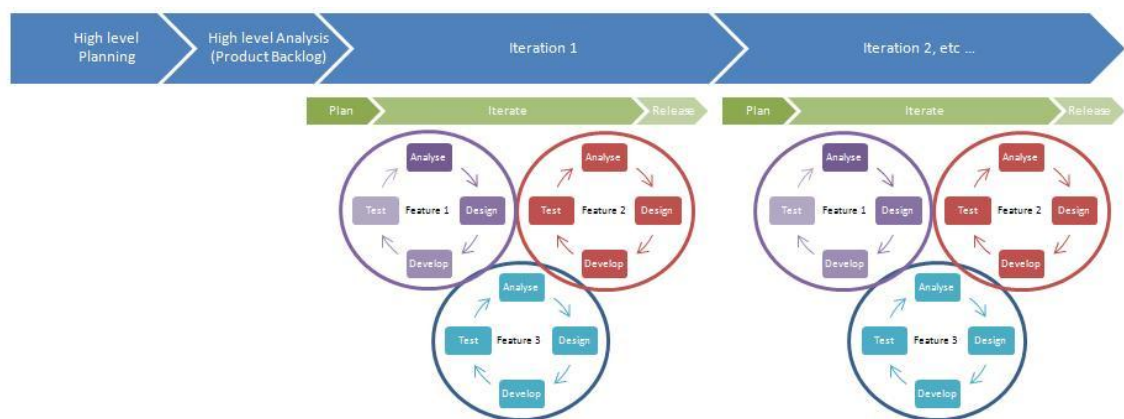


Figure 40 Agile development method [24]

Agile main characteristics are:

- Iterative: sprints envelop in them the same phases that are done each time a new sprint starts.
- Focused on testing: anything that has to be done during a sprint have to work perfectly as was asked from customer.
- At the start of each sprint, developers and customer meet to discuss about what has been done until now and to set the objectives for the following sprint. Therefore, customer's' presence is more continuous than in traditional approach.
- Easy to introduce new requirements minimizing changes in later phases of software development.
- Since the development is broken into small stages, a higher quality of code is produced
- Code is the focus of this method. Code is what sells therefore it is made of the best quality possible.

Therefore, a project where there are many customers (different sets of requirements) and when customers want to see a progress of a development each sprint and not only at the end would more likely want to use this kind of method.

2.9.3 Method chosen

In the development of the web clinic website, it is very probable that a customer would like to add some new requirement as time progresses. On top of that, a customer wants to take a more active part in the development of it therefore agile development methodology is preferred and is the one that will be used.

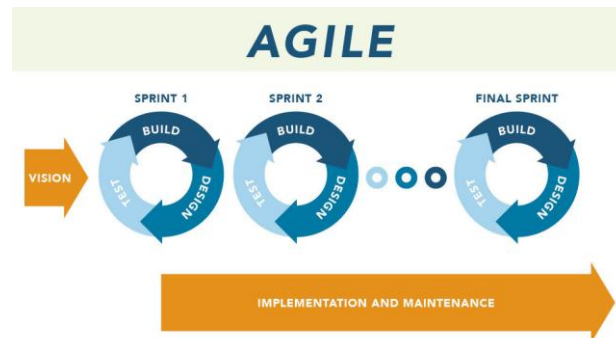


Figure 41 Agile development sprints [25]

2.9.4 Agile Project plan

Here we will explain the distinct phases followed during the development of the website.

Pre-project

First of all, our project will have an Initial Pre-project phase where we will have to address some important questions before actually starting the project itself.

Some of the questions to be answered are:

- What is the problem to be solved?
 - The problem is to develop a website with an appointment making system which will provide a way of creating appointments online for patients of the existing medical clinic.
- For whom do we solve this problem?
 - For both medical clinic for whom we develop a website and their patients and staff (receptionist/s and doctors) who will use the system.
- How success will be measured?
 - Agile development will be used which is a test driven methodology. Different tests will be conducted during the development of each of the functionalities.
- Approximated total cost

Basically, this phase will serve to set the Vision, Business plan, Mission of the project in the long run.

Iteration zero

Also called as project initiation, this is where we will set the initial goals, requirements and technologies to be used.

The teams will be formed in this phase. There will be arrangement on how often team will meet up, the place where it will be done.

The initial Sprint planning will be done in this phase. The team will have to communicate closely with the client to set the high-level requirements of the entire project and the requirements specific to the first sprint.

The developers of the product will have to set the infrastructure to be used during the first sprint. Those include:

- **Environment:** developer machines, servers and database technologies, etc.
- **Test driver development:** what tools will be used for testing, methods for testing.

For testing we will be using Chrome integrated debugger for JavaScript debugging and the debugging tools provided by WordPress to debug the PHP code and DB interactions.

Iterative sprints

Starting from first agile iteration, we will have to do several things each time a new iteration/sprint starts.

Sprint planning:

- Meet with the client before the start of the Sprint.
- Familiarize with the user stories and discuss them with the client.
- Decide on which use stories/functionalities will have to be developed during the next Sprint. Several things are considered such as the cost (time) and importance of this feature.

Testing:

- The tests will have to be written to have an idea of when a function is correctly developed.

Development:

- The developer starts coding this user story/functionality.

When the code is finished, it is passed through the test units previously made. In case a bug is found, the sprint plan will have to be changed accordingly to solve this bug as soon as possible. All these changes will be discussed during the next meeting with the client.

One feature is complete when the development is complete, test units run successfully without any bugs and all the things documented for a client.

At the end of each sprint, the developers discuss how this sprint went, what were the errors and how to improve during the next sprints. In our case, since we only have one developer, he will be the one to think what can be done in the next sprints to improve the efficiency.

All the user stories that were recompiled during the whole development process are the following ones:

Table 25 User stories

User Story ID	As a <type of user>	I want to <perform some task>	so that I can <achieve some goal>
1	Patient	View all the upcoming appointments	check when I have to attend a clinic
2	Patient	Be able to export some of my appointments as an iCal file	Add it to a calendar application of my choosing
3	Patient	Search for all the doctors based on some criterions	Choose the most appropriate doctor for me
4	Patient, Receptionist or doctors	Visualize my profile information	Be sure all the information is correct
5	Patient, Receptionist or doctors	Change profile information	Have my information up to date
6	Patient	Make appointment online	I won't have to call or come in person
7	Patient	See the results of past visits	See what I have to do to cure my illness
8	Doctor	See today's appointments	See what patients will be coming today to my office
9	Doctor	See upcoming appointments	Consult how many patients will come some future day
10	Doctor	Give a result of a visit to patient	A patient can see what has to be done for his illness
11	Doctor	Have a private field for each visit with a patient	have private information about this particular visit
12	Doctor	Add a holiday day	make the patients not make any appointments that day
13	Patient	Be notified if an appointment is cancelled	know that I won't have to come to a clinic that day
14	Patient	Cancel an appointment	reschedule a visit to another day
15	Receptionist	Create an account for a patient	give them access to websites functionalities
16	Receptionist	Change some user's profile	keep their contact information up to date
17	Receptionist	See some patient's medical file	visualize his illness progression
18	Receptionist	Add a holiday day of a clinic or doctor	patients can not make appointments that day
19	Receptionist	Notify patients if their visit has to be cancelled	they don't have to come to the clinic that day



Online Medical Appointment Scheduling System

User Story ID	As a <type of user>	I want to <perform some task>	so that I can <achieve some goal>
20	Receptionist	Able to write a message to patients	be in contact with them if needed
21	Guests	Being able to register	access functionalities of registered patients
22	Guests and Patients	Contact the clinic	ask any question about some issues they might have
23	Guests and Patients	See clinic's working hours	know when I can come to talk with receptionist
24	Receptionist	Create doctor accounts	add new doctors to the website
25	Receptionist	Display clinic's holidays	consult and being able to delete some of them if needed.

In our project, we could complete the whole development process in 7 Sprints of 1 week each. The Sprint plan is the one represented by the following table and figure:

Table 26 Agile planning

Task Name	Start	End	Days
Sprint 1	3.5	10.5	7
Search for doctors	3.5	5.5	2
Customize home page	5.5	7.5	2
Registration and Roles setup	8.5	10.5	2
Sprint 2	11.5	18.5	7
Login and password recovery	11.5	12.5	1
Contact form	12.5	13.5	1
Make appointment	13.5	18.5	5
Sprint 3	20.5	27.5	7
Guest appointment	20.5	25.5	5
User profiles	25.5	26.5	1
Change profiles	26.5	27.5	1
Sprint 4	1.6	8.6	7
List appointments(Patients)	1.6	4.6	3
List appointments(Doctors)	5.6	6.6	1
Add holidays	6.6	8.6	2
Sprint 5	9.6	16.6	7
Add visit result	9.6	11.6	2
Display visit result	12.6	14.6	2
Cancel appointments	14.6	16.6	2
Sprint 6	17.6	24.6	7
Export iCal	17.6	18.6	1
Write message to patient	19.6	20.6	1
Register new patient (Recep.)	20.6	22.6	2
Change patient's profile (Recep.)	22.6	24.6	2
Sprint 7	25.6	30.6	7
Add info about clinic	25.6	28.6	3
Show patient's medical file	28.6	30.6	2
Display holidays and delete them	30.6	1.7	1
Create doctor	1.7	2.7	1



Each sprint has a duration of 7 days. Before every sprint begins, a developer meets with the client to see what are the functionalities that have more priority and that they want to see functioning as soon as possible. Each one of these functions/tasks have priority and cost of developing them (expressed in time). Those that have high cost are the complex functions which will require more effort to develop. At a meeting with a client, they will choose those tasks that will be developed during the next sprint (during next week). The following graph is a visual time representation of Table 26.

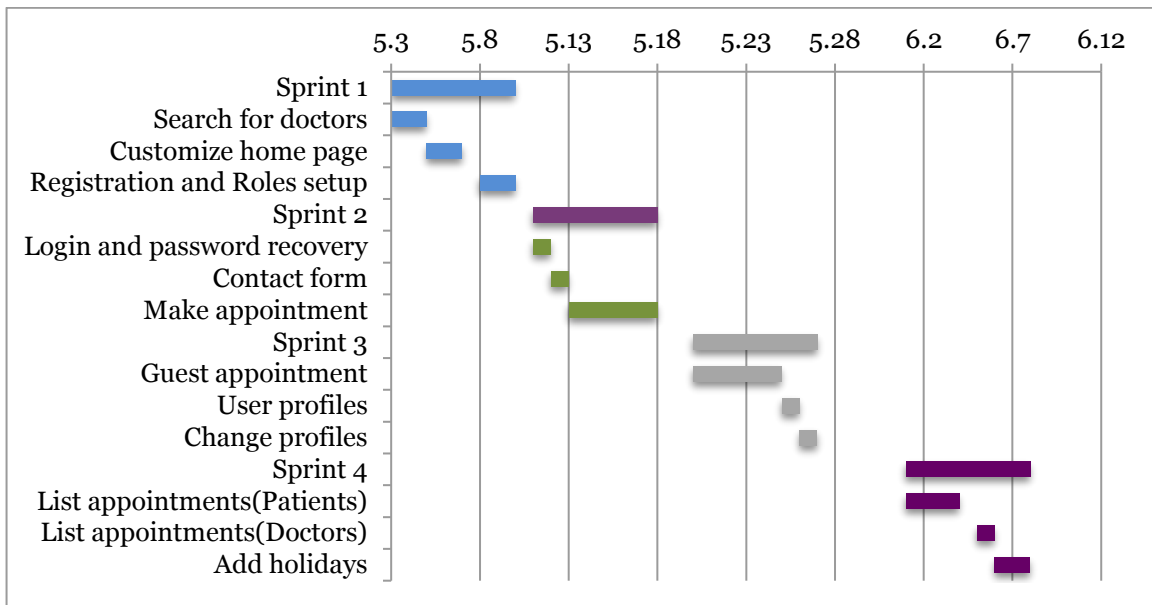


Figure 42 Sprints 1 to 4

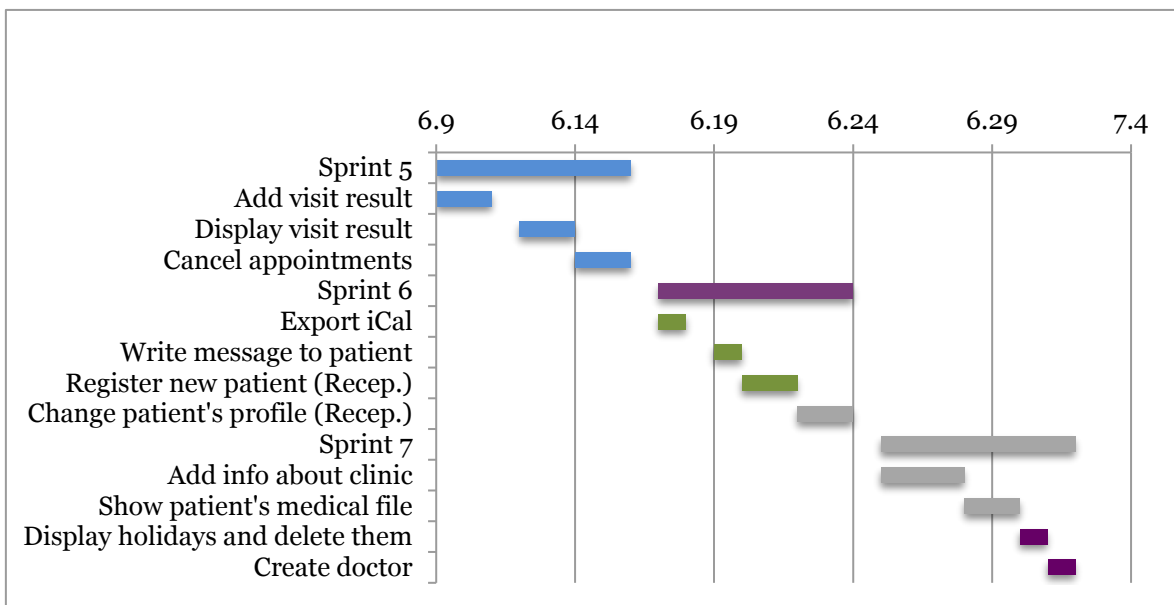


Figure 43 Sprints 5 to 7

2.10 User Interface

In this section, we will put the screenshots of the website to show the Graphical Interface

2.10.1 Homepage

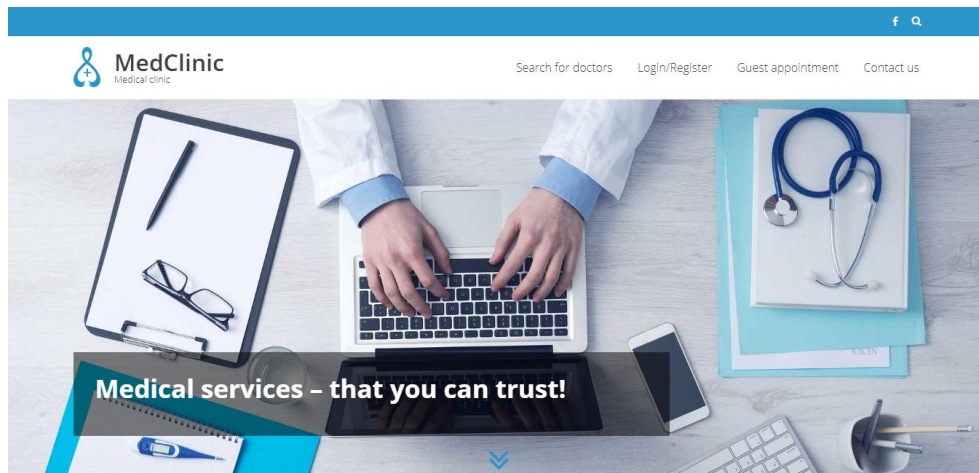


Figure 44 Homepage slider and menu

Here we can observe the Main menu of the website with its Logo. This is a Main Menu that Guest users (not logged in users) see when they access a webpage. On top right, we can see the toolbar with Social Media websites that a clinic has a page on. At the moment, we have a Facebook, Twitter, YouTube, Google+ and LinkedIn but others could be added if needed.

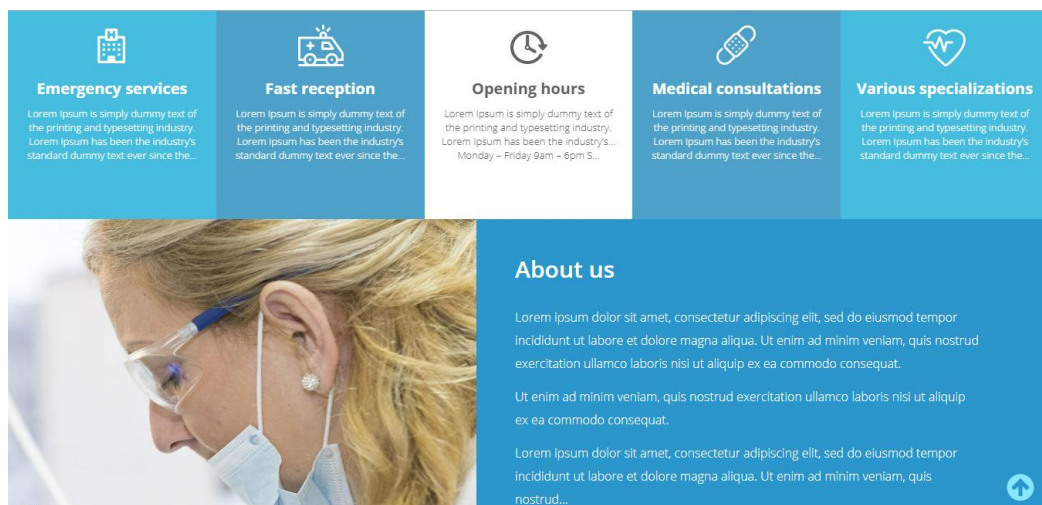


Figure 45 About Us section and featured information about clinic

All the posts are completely customizable in the administrator panel

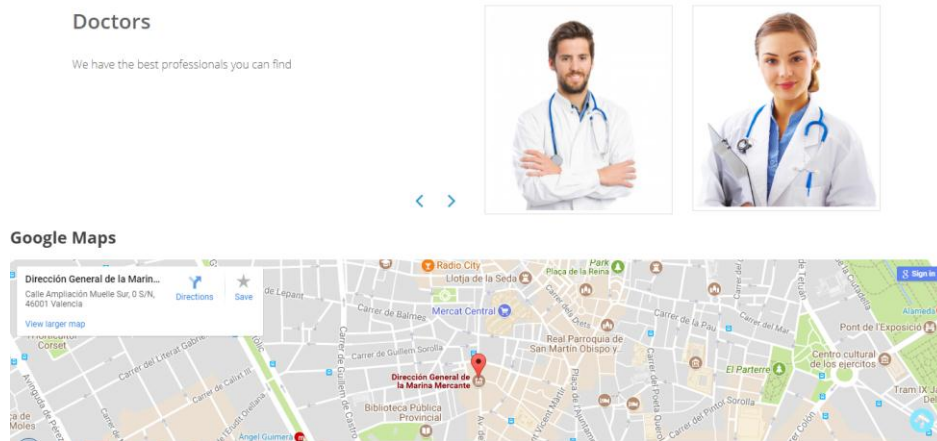


Figure 46 Doctors slider and Google Maps widget

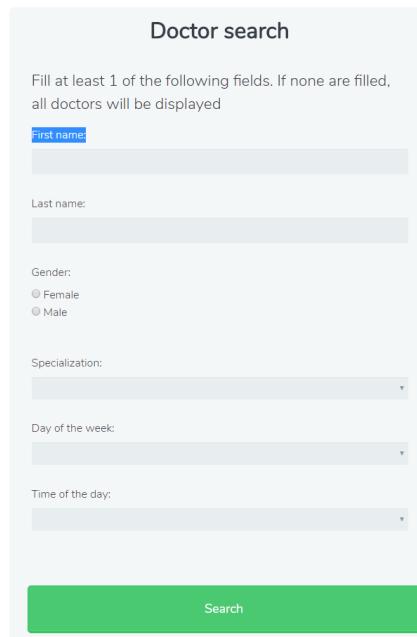
Here we can see that we have a slider of the doctors in the clinic that scrolls automatically by itself.

In the end of the page we can see the Google Maps widget integrated in a theme. We only needed to copy the iframe code of the location of the clinic from Google Maps website and post it into the Google Maps widget. Important to mention that this is a fictional clinic and it is not actually located in this street.

With this the Homepage demonstration has ended. The homepage is easily customizable using the theme's personalized Homepage page customization tool.

There is also an option of adding news section if a clinic would also like to add it in the future.

2.10.2 Search for doctors



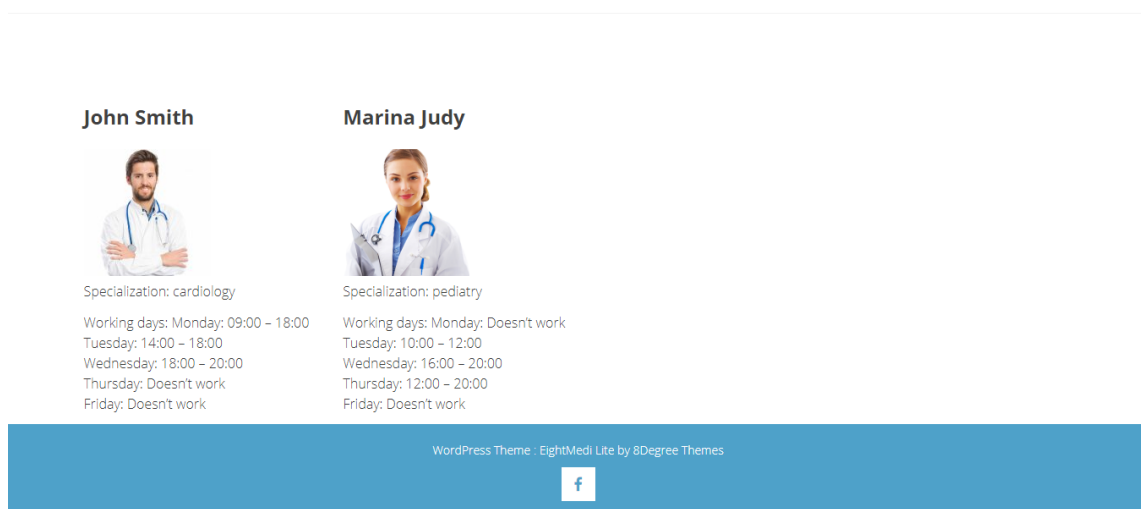
The screenshot shows a 'Doctor search' form with the following fields and options:

- First name:** A text input field.
- Last name:** A text input field.
- Gender:** Radio buttons for 'Female' and 'Male'.
- Specialization:** A dropdown menu.
- Day of the week:** A dropdown menu.
- Time of the day:** A dropdown menu.
- Search:** A green button at the bottom.

Instructions above the form: 'Fill at least 1 of the following fields. If none are filled, all doctors will be displayed'.

Figure 47 Search for doctors

Here is the screenshot of the Doctor search form with all the different criterions that can be used to search for a perfect doctor match. If a patient already knows the name of the doctor they are searching for, they could just add his first and/or last names. Otherwise, a patient could search a doctor by his/her gender (some might prefer female doctors other males and vice-versa), specialization of a doctor, which day of the week he/she must work at and/or what time of the day. All these are optional to fill in. In case none are filled, all clinic's doctors will be displayed.



The screenshot shows two search results side-by-side:

- John Smith:** Specialization: cardiology. Working days: Monday: 09:00 – 18:00, Tuesday: 14:00 – 18:00, Wednesday: 18:00 – 20:00, Thursday: Doesn't work, Friday: Doesn't work.
- Marina Judy:** Specialization: pediatry. Working days: Monday: Doesn't work, Tuesday: 10:00 – 12:00, Wednesday: 16:00 – 20:00, Thursday: 12:00 – 20:00, Friday: Doesn't work.

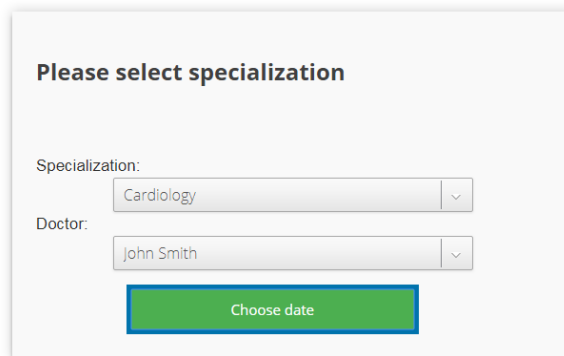
At the bottom of the page, there is a footer with the text 'WordPress Theme - EightMedi Lite by 8Degree Themes' and a Facebook icon.

Figure 48 Example of result of a search



2.10.3 Make appointment form

Appointment making form consists of several stages. First of all, a patient will have to choose the specialization for which he is going to make appointment for. After choosing a specialization, there will appear a box with all the doctors that are specialized in this field.



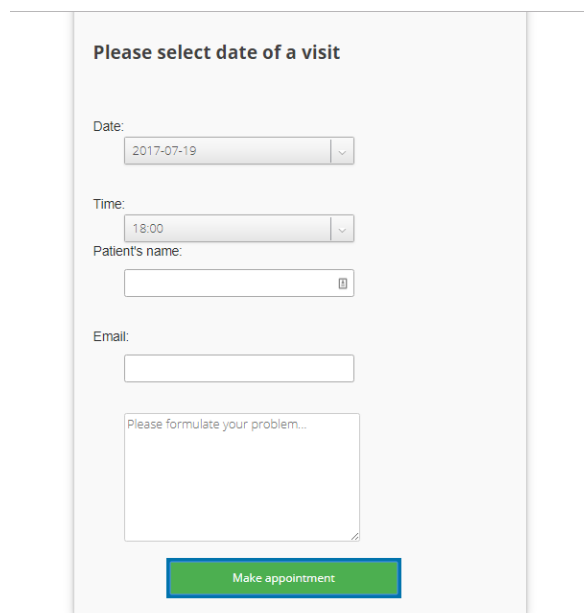
Please select specialization

Specialization:

Doctor:

Figure 49 Specialization and doctor selection

After submitting a form, we will proceed to choosing date and time of an appointment. The date will be selected using a calendar plugin by jQuery library [26]. Depending on who makes an appointment (registered user or guest user), different fields will be asked. In case of guest users, on top of date, time of a visit and description of a problem, a name of a patient will be asked and his email. These will be used for contact purposes only. If the user will input an email which some of the registered users has, they will be asked to put another email or login into his account.



Please select date of a visit

Date:

Time:

Patient's name:

Email:

Please formulate your problem...

Figure 50 Guest user form

In case of registered users, on top of date time and description of a problem, they will be asked if the appointment is for them or for other person (family member for example). In case it's for someone else, a name of that patient will be asked.

Please select date of a visit

Appointment for:
Yourself

Select date:
2017-07-19

Time:
18:00

Please formulate your problem...

Make appointment

Figure 51 Patient user form

Submitting successfully this form will result in adding a new row into appointment table of website's database. Registered users will be able to consult their appointments in "My appointments" page.

2.10.4 Register and login forms

A guest user is able to register on a website at any time. By accessing the Register page, he will be redirected to the following register form:

DNI *

First Name

Last Name

Social security number
Please put you security number if you have one.

Contact Info

E-mail *

Password *
Minimum length of 9 characters


Repeat Password *

Register

Figure 52 Register form

DNI or Email can be used as a username to login into a website. After submitting the form, a validation email will be sent to their email. It will contain a link which has to be accessed in order to validate the account and start using website's services.

In order to login, a user will have to access a Login page and fill their username and password.



Username or Email

Password

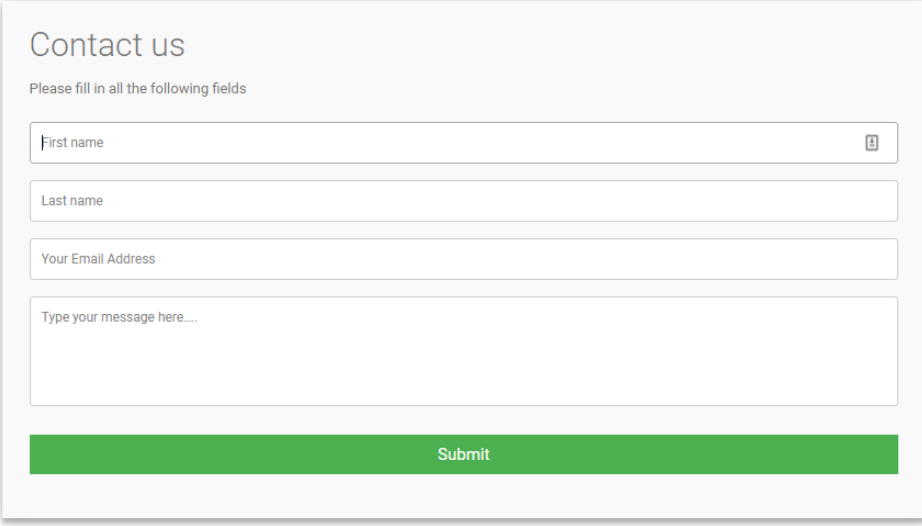
Remember Me

Figure 53 Login form

After pressing Log in button, if everything was correct, the patient will be logged in and could start using services for registered patients.

2.10.5 Contact us form

Website users can contact the clinic at any time. They have to access the Contact us page and they will be redirected to the following contact form:



Contact us

Please fill in all the following fields

First name

Last name

Your Email Address

Type your message here....

Figure 54 Contact form

After filling all those fields (registered and logged in patients will have the name and email fields filled for them) and submitting the form, a message will be sent to the clinic's email with all the necessary info.

2.10.6 Manage visits for receptionists

Receptionist can edit, cancel or mark appointment's status (attended and/or completed) by accessing Manage visits page. They will then have to select if they want to see today's visits of some particular doctor or some other day. In case of other day, a date will have to be selected from a calendar that will appear.

After selecting a doctor from an autofill field (contains all the doctors' names) the list of appointments will appear of that day.

MedClinic
Medical clinic

Today's appointments Other day

Doctor's name:

Time: 18:15 Attended Completed
With patient: Guest: gggg
[Edit](#) [Cancel](#)

Time: 18:30 Attended Completed
With patient: Guest: gggg
[Edit](#) [Cancel](#)

Figure 55 Manage visits page

In this example, we have showed today's appointments of a doctor called John Smith. At that moment, 2 appointments were made with him by a guest user. A receptionist can Edit the appointment by clicking "Edit" button beneath the appointment he/she wants to edit.

Please select a new date of a visit

Date:

Time:

edited

Figure 56 Edit appointment

In order to edit the appointment, a receptionist will select a new date and time. If needed, a description can be changed too. By submitting, a row related to that appointment will be updated with new data.

A receptionist can also cancel an appointment by clicking a “Cancel” button beneath the appointment he/she will cancel. When clicking, the row related to that visit will be deleted from the database.

Finally, to change appointment’s status, the receptionist will check the related statuses next to the appointments she is interested to change and click “Submit” button.

2.10.7 List doctor’s appointments

Doctors are able to display their appointments of the day or other days by accessing “List appointments” page. Then, after selecting the day of appointments (today’s or other day), a table will be displayed with them.

Today's appointments Other day

Show entries Search:

Time	Patient name	DNI
18:30	Olga Cara	20987215e

Showing 1 to 1 of 1 entries Previous Next

Figure 57 List appointments

This is an example of the table in case there is one appointment for that day. A plugin for jQuery called [DataTables](#) was used to display the appointments. If clicked on the time, a more detailed information about that appointment will be displayed in a new window:

Appointment information

Date: 2017-08-29 18:30:00
Patient name: Olga Cara
DNI: 20987215e
Description: No problem description was submitted

Public result

Private result

Figure 58 Detailed appointment information

If a doctor wishes, he will be able to change the results of a visit in this form. He will have to fill a public result and/or a private result and click Update results button to update the results attribute of that appointment in a database.

If a doctor clicks on a patient's name (only if it was a registered user), it will display this patient's medical file with this doctor in particular.

2.10.8 List patient's appointments

Patients are able to display their upcoming appointments by accessing "List appointments" page. In that page, a list of all upcoming appointments of that patient will be displayed:



Figure 59 Upcoming appointments list

For each upcoming appointment a patient had made, he/she will be able to export an iCal file to add to their electronic calendars (also possible to export more than one calendar events with Export all events button) and also, he/she will be able to cancel an appointment.

2.10.9 Holiday management

Holidays can be added either by receptionist (either clinic holiday or a holiday for one specific doctor) or by a doctor (only for himself). In order to do that, they have to access a page "Add a holiday" that will display the form to add a holiday:

Holiday for:

Doctor
 Whole clinic

Date:

From:

Time:

To:

Time:

Input the reason of the holiday

Figure 60 Add a holiday (Receptionist)

Holidays can be deleted by receptionist by accessing Holidays page. It will display a table with all clinic's holidays that could be deleted by clicking on Delete holiday (last column of each row).

Show entries Search:

From	To	Reason	
2017-09-01	2017-09-03	Clinic's reform	Delete holiday

Showing 1 to 1 of 1 entries Previous Next

Figure 61 Holidays display

2.10.10 Create a doctor

Receptionists can create doctor users by accessing Create a doctor page:

Doctor register form

1 Doctor's basic info

First name:

Last name:

Specialization:

Email:

Gender:
 Female
 Male

2 Working hours

Monday:

Tuesday:

Wednesday:

Thursday:

Friday:

Figure 62 Doctor creation form

All the fields are required to fill in except the working hours: only one of the days is required to fill in. After submitting the form, if validation was successful, a new doctor will be created and a message will be sent to his/her email with login information.

2.10.11 Create a patient (Receptionist)

Receptionists can create doctor users by accessing Create a patient page:

Register form

1 Patient's basic info

First name:

Last name:

DNI:

Email:

2 Patient's info

Insurance number(optional):

City(optional):

Address(optional):

Age:
 Under 18
 18 or older

Figure 63 Create a patient (Receptionist)

Patient's basic info is required to fill in. Patient's info is optional to fill in (those can be updated later by receptionist or a patient himself). After submitting the form, if validation was successful, a new patient will be created and a message will be sent to his/her email with login information.

2.10.12 See visit results

Patients, in order to see results to visits they have made before, have to access Visit results page. There, a table with all past visits will be displayed and, clicking on See result, will display a result:

Show entries Search:

Visit date	Doctor's name	Result
2017-07-31 17:30:00	John Smith	See result

Showing 1 to 1 of 1 entries Previous Next

Figure 64 See visit result

3 Implementation and deployment

3.1 Implementation of functionalities

3.1.1 Design of the website

We started out using one of the already made templates and then started customizing the content to our needs. The template that was used was specially created for websites related with medicinal field. Its name is [Eightmedi Lite](#) from [8Degree Themes](#).

When selecting a theme to use, there were different criterions taken into account:

- **Free to use:** we want to save as much money as possible during the development of the project. Therefore, the theme to be used has to be free to use.
- **Created specifically for medical field websites:** it will be a big plus if a theme's features are all centered on medical companies since some of the needed features might be already developed or a design might be more appealing for medical websites.
- **Several useful plugins/widgets:** all the useful plugins already integrated into the theme would be greatly appreciated such as Social media plugins and Google Maps integration.
- Attractive design
- **Cross platform friendly:** since the boom is the use of portable devices such as Tablets and mobile phones, cross platform websites are always welcome for the ease of use for the users.
- Responsive

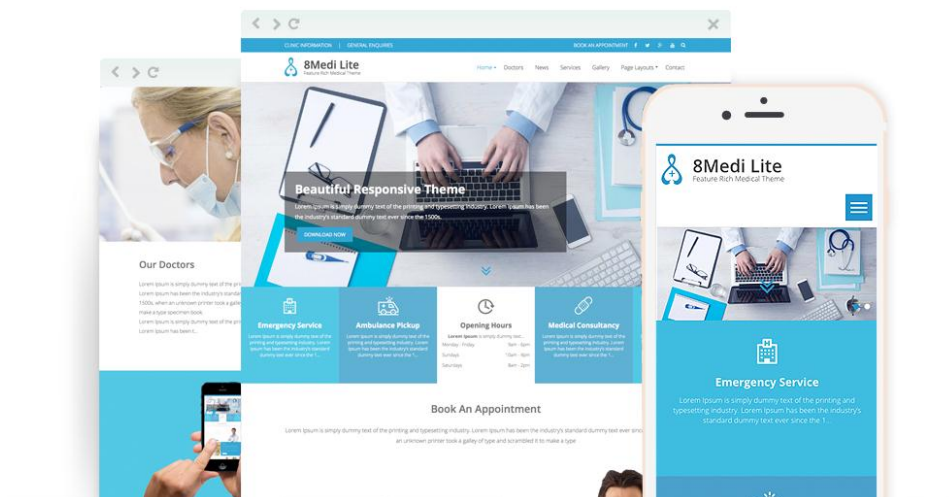


Figure 65 Eightmedi Lite theme

We chose the Eightmedi Lite theme provided all these features and on top of these they also provided:

- **Free theme support:** most of the free themes don't provide theme support for their free version of the product. This one, in turn, does provide it. It's a big plus in case there is some problem with the theme in the near future.
- Fully customizable homepage

3.1.2 Application analysis

As mentioned before, we are using a WordPress CMS. Therefore, all the software and systems that we will be using are based on what WordPress is using.

WordPress requires MySQL [17] for storing and retrieving all the data needed for a proper functioning of a website. All the posts, pages, settings, global variables and other features that WordPress has are stored in a MySQL database.

MySQL is an open source relational database management system. It is one of the most used DBMS in a web development, part of the LAMP [27] software bundle which is one of the main bundles used to create different web applications nowadays.

WordPress makes use of PHP [28] to store and retrieve data from the MySQL database. The data is stored or retrieved using SQL queries [17] which stands for Structured Query Language which most DBMS use (is a part of MySQL acronym).

To make a management of the DB, there are some web applications existent to make it easier. The most popular that most web hosts have integrated is phpMyAdmin [29] which allows users to manage their database using a web based GUI. This way it's possible to manipulate all the tables of the WordPress website easily while the phpMyAdmin application manages all the needed SQL queries for that.

3.1.3 Database access and security

Now that we know all the different technologies used to be able to develop and run a website, we can start explaining how exactly they interact between themselves in order to make it possible.

The following diagram basically explains the distinct parts and interactions needed in order to make our website work:

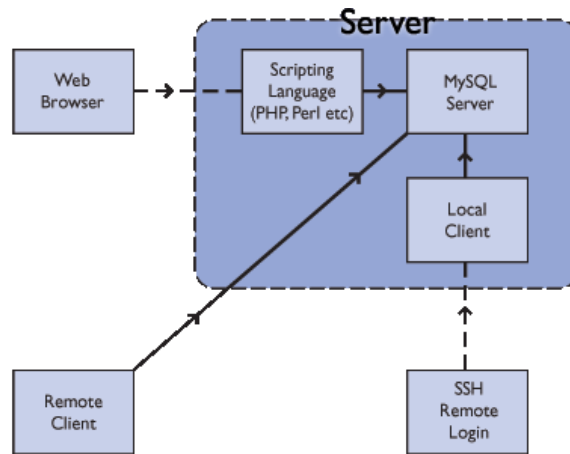


Figure 66 Database Access diagram

A server is basically a remote host or it can be installed locally.

A local client is a client installed on the same machine as the server and it accesses directly and sends SQL queries to a MySQL Server. Some examples are Command Line and phpMyAdmin.

A remote client, as can be deduced, are clients located outside the machine where a server is installed and it can access a MySQL server directly and run some SQL statements.

There is a possibility to remotely connect to one of the Local Clients (SSH Remote Login) from outside.

The access to the database is realized using PHP language with the help of WordPress functions.

One of the main problem that should be prevented are all the different kind of malicious attacks that could be performed on our website's database.

There are 3 of the most important ones:

- **DDOS:** multiple devices (previously infected by some virus such as Trojan) access the website at the same time. This can easily lead to website's denial of service.
- **SQL injection:** when malicious SQL statements (such as to dump the whole database tables) are inserted into some input field (for example when registering an account) which will be later executed when inserting into a database.
- **Unwanted input data:** our website has a lot of different forms the data that is inputted in them will be uploaded to database. Hackers can use this to hack into our database and have Access to all the user's data.

DDOS is a very hard attack to protect the website from. Whole new companies are founded specifically to offer this service to website owners. In our case, since our website is not very big and won't have any very vital information about customers (such as credit cards or other payment methods) we won't need high level of protection.



By searching on website, we found a free DDOS protection from [Cloudflare](#). By simply registering and adding our website we will have basic DDOS protection. Whenever we need more protection we could consider paying a subscription.

SQL injection is possible only if we use methods or libraries that access a database AND allow multiple statements execution in one call. In order to be immune to this kind of attack, all the inputted data must be verified and sanitized which is the process of cleaning or filtering the input data. Luckily, WordPress provides different methods in order to make this easier. [30]

To prevent the unwanted input data, we just must verify all the input data before uploading it into the database.

3.2 Deployment

3.2.1 Needed resources

In the first place, we should consider all the necessary things to run effectively the website. There are three types of resources that we will need:

- Hardware:** all the physical devices needed
- Software:** all the programs needed in our hardware
- Staff:** people that we should have

The website will be hosted on a remote web host. There are many free or cheap options to do it. It is not economical to set our own host in our computer since the costs will be much higher (more hardware needed, more energy consumption...). It is much cheaper to contract a remote host for our purpose. On top of that, our website would be very scalable and we would achieve it very cheaply. By just paying a little bit more for a remote hosting, we would be able to have more bandwidth, more storage and other useful perks.

There are a lot of free options in case a website doesn't have many concurrent visitors and many registered users in general. Looking at the most popular free web hosting [000webhost](#), the free option consists of the next characteristics:

- 2 GB disk space
- 20000 bandwidth
- No SSL certificates
- No support
- Only free domains

If free options are not enough, paid options start from as cheap as 2€/month ([iPage](#)) which is very affordable with unlimited storage, unlimited name domains and other excellent features.

Therefore, when we start out we can use the free web hosting until we see that we have more users. Then we can buy subscription for a very affordable price.

3.2.2 Hardware

First of all, we will state the hardware needed for developing of a website. The website will be developed firstly on localhost since it is much easier. After testing everything on our computer, we can integrate it on the web hosting for user's access. Therefore, this is what will be needed for the development of the website:

- Router and internet connection.
- PC: we don't need a powerful computer to develop a website. One of the most requiring programs will be Photoshop that will need 2GB RAM minimum or 8GB recommended. In terms of secondary memory, we won't need much since we will host our website on a remote server (300GB will be more than enough). Intel i3 CPU will be enough, too.

All this hardware is provided by the developer, therefore not included in budget calculations.

Other hardware needed is the one for receptionist/s and doctors. Each one of them will need a good enough PC that will be able to open a browser and access a website. Therefore, a clinic will have to buy a PC device for each of the doctor's offices and one for receptionists. These computers will be shared by different doctors that will be using the same office. If we will hire two receptionists, one for morning and evening shifts, they will share the same PC.

3.2.3 Software

All the software needed for website development:

- My SQL Community Server
- Apache web server 2.4+
- PHP 5.5+
- Remote web host
- FileZilla for easy FTP transfer between localhost and web host.
- Adobe Dreamweaver
- Modern internet browser (Not IE)

3.2.4 Employees

The company has CEO, a receptionist and several doctors who will provide all the services related to the clinic. For website, we will need to hire a system administrator for website development and future maintenance. An external system administrator is preferable since it will be much cheaper than hiring a partial or full-time system administrator and, on top of that, a website is not that big as to require a full-time administrator.



3.3 Cost analysis

In this part, we will analyze the costs of designing a website, the cost of maintenance and the estimated savings achieved by implementing this appointment scheduler system.

3.3.1 Website design and development phase

The website design and development was done by one person. All the programs, libraries, APIs, website theme and CMS were all free. A developer worked for 2 months, 5hours/day. Paying 10€ per hour, a developer will receive 50€ per day's work which, multiplied by 20 days a month for 2 months, approximately comes to 2000€.

Free web hosting was used while developing a website and making tests specified previously.

A developer met with his client every week and he needed to travel 40 km once a week. Considering that that trip costs 8€, we can assume that approximately $8€ \times 9 \text{ weeks} = 72€$ was spent on transportation.

A clinic will have to buy hardware necessary for website's use. It depends on how many PC units will be needed.

Therefore, a cost of approximately 2100€ needed for development of a website and its initial deployment.

3.3.2 Maintenance phase

At the moment, the only maintenance cost implied by creating a website is, every certain time (once a month or two months) a developer will come and go through the whole website checking if no bugs/errors/inconsistencies were found during that time. Taking into account that it could take around 2 hours if nothing was found, 40€ will have to be paid each month (20€/hour). If a clinic will be big enough so that a bigger number of users would use an appointment scheduling system, they could consider hiring a full-time developer.

In case of any unexpected events such as website failure or any important bugs, a developer will have to come which implies additional cost.

Other costs might appear with time. At the moment, a website uses a free remote web hosting. In case more storage/bandwidth would be needed, a clinic might consider paying a small amount to receive more hosting power. As we showed previously, it is very cheap. In average, it's around 5-8€ per month.

Therefore, a cost of approximately 40-50€ per month might be expected to maintain the website running.

3.3.3 Estimated savings

Thanks to a creation of a website, we need only 1 receptionist instead of 2 thanks to lesser amount of work they must do daily. That implies a saving of one whole salary, 1500€ approximately, every month.

Other savings are related to saving consumable items that was needed for appointment scheduling. That is paper, pens and others. These are not that much but still add up in the end.

4 Conclusion

Here in this section we will describe all the results and considerations of developing the website, the difficulties and further possible improvement that can be done to a product.

Results

During the development of the project, whose purpose was the creation of a medical clinic site allowing interactive collaboration of different user groups of the website (patients, doctors, receptionists and administrator), the following tasks were done to achieve that objective:

- Analyze the competitive environment, technological analysis and development methodologies to use so that we are able to develop a website with the most needed features, with the best technologies in the most efficient way.
- We wanted to give the early version of the website to the client as early as possible so that

A technical analysis and the competitive environment of the enterprise was performed, which has identified the need to establish a medical clinic site that would reduce the cost of clinic's staff and increase staff's working efficiency by developing the online appointment scheduling application. The competitive environment analysis allowed us to see the most important features a website should offer in an online medical clinic.

The process of developing the clinic site consisted of several stages, including the formation of the basic concept of the site, creation of user groups and assignment of appropriate access rights, the use of extensions to design pages with specific requirements and the use of useful widgets, plugins and libraries provided by a CMS of choice, WordPress.

Overall, we consider that all the requirements/objectives were fulfilled accordingly. We can say that the development team has learned several techniques during the development of this website making possible to further improve it and maintain it with necessary efficiency.

Difficulties

Apply changes between local host and remote host

One of the difficulties we stumbled with was the transfer of files and changes between the local host and the remote host the website is located on. Some of the changes, especially the ones related to the admin area and user groups rights were quite difficult to transfer.

Choosing the optimal remote host

A lot of research had to be done to find the optimal host where the website would be located. Not all the hosts have the same quality of service and the same features so these had to be considered.

Setting up correctly local host

We needed to install the Apache, MySQL and PHP web development software bundle to start developing a website and correctly set all of these components.

A XAMPP helped us considerably but we still stumbled with problems, especially related with MySQL server limiting the size of the databases .sql files while importing/exporting them. To solve that, we had to tweak the configuration files in order to remove the size limit of database files.

Finding and installing all the different plugins and widgets

WordPress gives us a wide range of plugins and widgets that could be used by our website. The hard part was that each one of them had different configuration steps and some of them needed the installation of other plugins first which could make it quite complex.

Further possible improvements

As further improvements, we could add a lot some or all of these features in the future:

- Online consultations: until now users must come to clinic to be examined. If users show interest in online consultations that don't require physical examinations, we could add this feature.
- Online payments: until now all the payments are made when a user comes to clinic. If we integrate online consultations or users will show more interest in paying online instead than in cash at clinic, we could integrate this feature. Joomla allows this kind of feature.
- User feedback: we could ask users for their feedback on the website and what they would like to see on it.



Bibliography

- Appointment-Plus, "Manual Vs. Automated Appointment Scheduling," [Online]. Available: https://www.appointment-plus.com/images/pdf/manual_vs_automated_appointment_scheduling.pdf. [Accessed 5 June 2017].
- "Software Requirements," Autumn 2003. [Online]. Available: <http://www.inf.ed.ac.uk/teaching/courses/ip/CS2Ah0405-SoftwareRequirements.pdf>. [Accessed 03 July 2017].
- Arisa, "<http://www.arisa.se/compendium/node6.html>," [Online]. [Accessed 05 July 2017].
- S. T. Fundamentals, "Black Box Testing," Software Testing Fundamentals, [Online]. Available: <http://softwaretestingfundamentals.com/black-box-testing/>. [Accessed 26 July 2017].
- Wordfence, "WordFence Security," WordPress, [Online]. Available: <https://wordpress.org/plugins/wordfence/>. [Accessed 2017 July 26].
- B. Silver, BPMN Method and Style, 2nd ed., Cody-Cassidy Press, 2011.
- Spritz, "Spritz Web Solutions," Spritz, [Online]. Available: <https://www.spritzweb.com/resources/good-website-characteristics.html>. [Accessed 15 June 2017].
- E. Staff, "WordPress Beginner," WPBeginner, [Online]. Available: <http://www.wpbeginner.com/showcase/9-best-wordpress-seo-plugins-and-tools-that-you-should-use/>. [Accessed 26 July 2017].
- I. Institute, "Infosec Institute," 6 February 2015. [Online]. Available: <http://resources.infosecinstitute.com/7-best-wordpress-security-plugins/#gref>. [Accessed 26 July 2017].
- Thenextweb, "Thenextweb," [Online]. Available: https://thenextweb.com/dd/2014/02/20/can-learn-evolution-content-management-systems/#.tnw_2EHdgNu2. [Accessed 15 June 2017].
- B. Boiko, Content Management Bible, 2 ed., Wiley, 2004.
- D. A. Williams, Wordpress for Beginners 2017: A Visual Step-by-Step Guide to Mastering Wordpress, CreateSpace Independent Publishing Platform, 2016.

- Wordpress, "WordPress logo," [Online]. Available:
13] <https://wordpress.org/about/logos/>. [Accessed 2 July 2017].
- WordPress, "WordPress template hierarchy," [Online]. Available:
14] <https://developer.wordpress.org/themes/basics/template-hierarchy/>. [Accessed 15 June 2017].
- M. Fowler, UML Distilled: A Brief Guide to the Standard Object Modeling Language,
15] 3 ed., Addison-Wesley Professional, 2003.
- Draw.io, "Draw.io," [Online]. Available: <https://www.draw.io/>. [Accessed 6 July
16] 2017].
- N. & Elmasri, Fundamentals of Database Systems, 6 ed., Pearson, 2011.
17]
- MySQL, "MySQL Workbeck," ORACLE, [Online]. Available:
18] <https://www.mysql.com/products/workbench/>. [Accessed 19 August 2017].
- V. Martyniuk, "Advanced Access Manager plugin," [Online]. Available:
19] <https://wordpress.org/plugins/advanced-access-manager/>. [Accessed 1 June 2017].
- Wikipedia, "Systems development life cycle," [Online]. Available:
20] https://en.wikipedia.org/wiki/Systems_development_life_cycle. [Accessed 25 June 2017].
- G. L. Systems, "Green Line Systems," [Online]. Available:
21] <http://www.greenlinesystems.com/agile-software-development/>. [Accessed 15 June 2017].
- "Spritz Web," [Online]. Available: [https://www.spritzweb.com/resources/good-
22\] website-characteristics.html](https://www.spritzweb.com/resources/good-website-characteristics.html).
- A. Stellman, Learning Agile: Understanding Scrum, XP, Lean, and Kanban, 1 ed.,
23] O'Reilly Media, 2013.
- K. Waters, "101 Ways," 4 May 2011. [Online]. Available:
24] <http://www.101ways.com/agile-development-cycle/>. [Accessed 15 June 2017].
- M. Consulting, "Key features of waterfall and agile development," Mands Consulting,
25] [Online]. Available: [https://www.mandsconsulting.com/key-features-of-waterfall-and-
agile-development-methods/](https://www.mandsconsulting.com/key-features-of-waterfall-and-agile-development-methods/). [Accessed 6 June 2017].
- J. Duckett, JavaScript and JQuery: Interactive Front-End Web Development, 1 ed.,
26] Wiley, 2014, p. 640.
- Wikipedia, "LAMP (Software Bundle)," [Online]. Available:
27] [https://en.wikipedia.org/wiki/LAMP_\(software_bundle\)](https://en.wikipedia.org/wiki/LAMP_(software_bundle)). [Accessed 5 July 2017].
- L. Ullman, PHP and MySQL for Dynamic Web Sites: Visual QuickPro Guide, 4 ed.,



28] Peachpit Press, 2011.

phpMyAdmin, "phpMyAdmin Docs," [Online]. Available:
29] <https://www.phpmyadmin.net/docs/>. [Accessed 5 July 2017].

WordPress, "WordPress data sanitation," [Online]. Available:
30] <https://developer.wordpress.org/themes/theme-security/data-sanitization-escaping/>.
[Accessed 15 June 2017].

R. J. T. Dyer, Learning MySQL and MariaDB: Heading in the Right Direction with
31] MySQL and MariaDB, 1 ed., O'Reilly Media, 2015.

B. Forta, SQL in 10 Minutes, Sams Teach Yourself, 4 ed., Sams Publishing, 2012.
32]

Wikipedia, "Enhanced entity–relationship model," [Online]. Available:
33] https://en.wikipedia.org/wiki/Enhanced_entity%E2%80%93relationship_model. [Accessed
6 July 2017].