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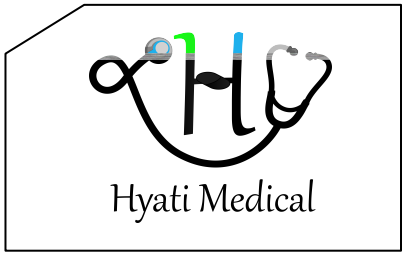
Hyati Medical



Presented by :
DIOP Mohamed
CHEBICHEB Kheir Eddine

On the theme :

Towards an Integrated Health Management System in Algeria with Collaborative Communication: Development of an e-Health Platform for Cooperation between Health Professionals, Patients, and Medical Imaging Laboratories

Defended publicly on June 11, 2024 in Tiaret in front the jury composed of:

Mr OUARED Abdelkader	MCA	Tiaret University	President
Mr TALBI Omar	MCA	Tiaret University	Supervisor
Mr MERATI Medjeded	MCA	Tiaret University	Examiner
Mr BELADJINE Khaldia	MCA	Tiaret University	Incubator representative
Mr SEKIOU Anwar	Organization		Representative of the economic partner

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Dedications

Dedication

I take this special occasion to thank my parents, my family in Senegal as well as in Mali and all my close friends for their support.
I thank my dear mother for her support during my higher studies and for all these blessings for my success, may Allah SWT reward her.
I sincerely thank my uncle **Arona Diop** for his availability and his support as a tutor, father and person in charge of me, I will never stop thanking him.
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Finally, I would like to thank all those people who have been able to help me directly or indirectly in my success, may this modest work be the fulfillment of your many wishes, the fruit of your countless sacrifices. May God, the Almighty, grant you health, happiness and longevity.

– ***Mohamed Diop***

Dedication

I take this special occasion to thank my parents, family, and close friends for their support. I express my heartfelt gratitude to my dear mother for her unwavering support during my studies and for her countless blessings for my success; may Allah SWT reward her.

I thank My brothers for their support during my studies and all these blessings for my success, may Allah SWT reward her.

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Finally, I would like to thank all those who have helped me directly or indirectly in my journey. May this modest work be a fulfillment of your many wishes and a fruit of your countless sacrifices. May God, the Almighty, grant you health, happiness, and longevity.

– ***Chebicheb Kheireddine***

Abstract

Abstract

Effective and efficient collaboration between the patient and their medical environment, as well as inter-professional cooperation, are essential to ensure quality care. Information and Communication Technologies (ICT) emerge as a solution aimed at facilitating this process. In Algeria, the digitization of healthcare services is receiving considerable attention from authorities, as evidenced by recent decrees on the subject. Although this process has already been initiated, there are still challenges to be addressed in terms of communication, centralization of healthcare services, patient empowerment, medical data management, care coordination, and adaptation to new technologies, particularly Artificial Intelligence (AI).

To address these challenges, a set of two platforms—a mobile application for patients and a web application for healthcare professionals—has been developed, facilitating their collaboration in the care process. Using an agile methodology such as SCRUM, this project empowers patients by providing medical information features like a chat bot, management of their Electronic Health Record (EHR), and teleconsultation. Additionally, it offers better cooperation among healthcare professionals through features such as telemedicine, decision support assistants, and full access to EHR.

Keywords: e-Health, patient empowerment, integrated platform, electronic medical records, health management, collaborative communication, Algeria, health information system, AI in healthcare.

ملخص

التعاون الفعال والكفاءة بين المريض وبيئته الطبية، بالإضافة إلى التعاون بين الاختصاصيين، أمر ضروري لضمان الرعاية الصحية ذات الجودة. تظهر تكنولوجيا المعلومات والاتصالات (ICT) كحل يهدف إلى تسهيل هذه العملية. في الجزائر، يتلقى تحويل خدمات الرعاية الصحية إلى الرقمية اهتمامًا كبيرًا من السلطات، كما يتضح من المراسيم الأخيرة حول الموضوع. على الرغم من أن هذه العملية قد بدأت بالفعل، لا تزال هناك تحديات تتعلق بالاتصال، وتوحيد خدمات الرعاية الصحية، وتمكين المرضى، وإدارة البيانات الطبية، وتنسيق الرعاية، والتكيف مع التكنولوجيات الجديدة، وخاصة الذكاء الصناعي (AI) .

لمواجهة هذه التحديات، تم تطوير مجموعة من منصتين ـ تطبيق محمول للمرضى وتطبيق ويب للمحترفين الصحيين ـ لتسهيل تعاونهم في عملية الرعاية. باستخدام منهجية مرنة مثل SCRUM ، يمكن لهذا المشروع تمكين المرضى من خلال توفير ميزات المعلومات الطبية مثل الدردشة الروبوتية، وإدارة سجلاتهم الصحية الإلكترونية (EHR) ، والاستشارات عن بعد. بالإضافة إلى ذلك، يقدم تعاونًا أفضل بين المحترفين الصحيين من خلال ميزات مثل الطب عن بعد، ومساعدي الدعم في اتخاذ القرار، والوصول الكامل إلى السجلات الصحية الإلكترونية (EHR) .

كلمات مفتاحية : الصحة الإلكترونية، تمكين المريض، منصة متكاملة، سجلات طبية إلكترونية، إدارة الصحة، تواصل تعاوني، الجزائر، نظام معلومات صحية، الذكاء الصناعي.

Résumé

Une collaboration efficace et efficiente entre le patient et son environnement médical, ainsi que la coopération interprofessionnelle, sont essentielles pour garantir des soins de qualité. Les technologies de l'information et de la communication (TIC) apparaissent comme une solution visant à faciliter ce processus. En Algérie, la numérisation des services de santé reçoit une attention considérable de la part des autorités, comme en témoignent les récents décrets sur le sujet. Bien que ce processus ait déjà été amorcé, il reste encore des défis à relever en termes de communication, de centralisation des services de santé, d'autonomisation des patients, de gestion des données médicales, de coordination des soins et d'adaptation aux nouvelles technologies, notamment l'intelligence artificielle (IA).

Pour relever ces défis, un ensemble de deux plateformes - une application mobile pour les patients et une application web pour les professionnels de la santé - a été développé, facilitant leur collaboration dans le processus de soins. En utilisant une méthodologie agile telle que SCRUM, ce projet permet d'autonomiser les patients en leur fournissant des fonctionnalités d'informations médicales comme un chatbot, la gestion de leur dossier électronique médical (DEM), et la téléconsultation. De plus, il offre une meilleure coopération entre les professionnels de la santé grâce à des fonctionnalités telles que la télémédecine, des assistants à la prise de décision, et un accès complet aux dossiers électroniques médicaux (DEM).

Mots-clés : e-santé, empowerment du patient, plateforme intégrée, dossiers médicaux électroniques, gestion de la santé, communication collaborative, Algérie, Système d'Information Sanitaire, l'IA dans les soins de santé.

Contents

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List of Acronyms

AI	Artificial Intelligence
API	Application Programming Interface
BERT	Bidirectional Encoder Representations from Transformers
BioBERT	Bidirectional Encoder Representations from Transformers for Biomedical Text Mining
BMC	Business Model Canvas
CBCT	Cone Beam Computed Tomography
CDSS	Clinical Decision Support System
CIS	Clinic Information System
DICOM	Digital Imaging and Communications in Medicine
EHR	Electronic Health Record
EMR	Electronic Medical Record
FG-AI4H	Focus Group on "Artificial Intelligence for Health"
FHIR	Fast Healthcare Interoperability Resources
GPT	Generative Pre-trained Transformer
HIS	Health Information System
HL7	Health Level Seven
HoIS	Hospital Information System
HTTP	HyperText Transfer Protocol
HTTPS	Secure HyperText Transfer Protocol
ICT	Information and Communication Technologies
IDE	Integrated Development Environment
IP	Internet Protocol
ITU	International Telecommunication Union
JSON	JavaScript Object Notation

LIS	Laboratory Information System
MVC	Model View Controller
NLP	Natural Language Processing
NER	Named Entity Recognition
NHIS	National Health Information System
NoSQL	Not Only SQL
OHIR	Online Health Information Resources
OLED	Organic light-emitting diode
PACS	Picture Archiving and Communication System
PIS	Pharmacy Information System
PMR	Patient's Medical Record
QA	Question Answering
RE	Relation Extraction
RIS	Radiology Information System
SOAP	Simple Object Access Protocol
STS	Socio-Technical System
TCP	Transmission Control Protocol
UCD	Use Case Diagram
UX	User Experience
UI	User Interface
UML	Unified Modeling Language
WCAG	Web Content Accessibility Guidelines
WHO	World Health Organization
W3C	World Wide Web Consortium
XML	Extensible Markup Language

General Introduction

General Introduction

Study Context

Efficient and effective collaboration between the patient and their medical environment as well as inter-professional cooperation are essential to ensure quality care. The reduction of information and knowledge asymmetry between patients and health professionals has contributed to the development of what is called "health democracy"[8] a term that appeared in the 1990s in a French law aimed at strengthening the participation of citizens, patients, and their representatives in health-related decision-making processes. The status of the patient is evolving towards a so-called "contemporary" patient, meaning a patient who can be an "actor," "informed," "expert," "partner," or "autonomous" depending on the context[8, 9]. With the advent of ICT and its full development in the early 2000s, particularly through the Internet, many digital platforms were born to facilitate these interactions[10].

Problem Statement

In Algeria, the digitization of healthcare services is receiving considerable attention from authorities, as evidenced by recent decrees on the subject [11]. Although this process has already been initiated, there remain challenges in terms of communication, centralization of healthcare services, patient empowerment, medical data management, care coordination, and adaptation to new technologies, particularly AI.

Objectives

In this context, the main objective of this project is to develop an innovative platform, integrated into the Algerian National Health Information System (NHIS), which enhances these aspects by enabling a rich, smooth, and secure interaction between patients and healthcare professionals. It is accompanied by these more specific objectives :

- **Manage Electronic Medical Records (EMRs):** Create a centralized and secure system for managing medical records accessible by both patients and healthcare professionals.
- **Integration with medical devices :** Facilitate the integration of medical devices through interfacing technologies (HL7, DICOM).
- **Integration with AI:** Integrate new AI technologies particularly Natural Language Processing (NLP) to provide a tool for checking medication interactions with recommendations and a chat bot assistant dedicated to patient information.

- **Ensure Telemedicine:** Adoption of the 5 acts of Telemedicine (teleconsultation, tele-expertise, medical teleassistance, medical telemonitoring, regulation).
- **National Health Identification System:** Digital medical card to identify patients and prevent certain emergency situations.

Methodology

To achieve this objective, we will use Scrum methodology, a widely recognized agile approach known for its flexibility and efficiency. Scrum was designed to increase speed of development, align individual and organization's mottos, define a culture focusing on performance, support shareholder value creation, to have good communication of performance at all levels, and improve individual development and quality of life [12].

Thus, its numerous advantages justify our choice of this approach, as it promotes better communication within the team and especially allows for early detection and resolution of problems during the development stage.

Structure of the Thesis

This thesis is structured into 6 chapters as follows:

- **Chapter 1 "E-Health and the Patient":** In this chapter, we will present a general overview of e-health, its impact on current healthcare systems, and its effect on patient engagement in their own care process.
- **Chapter 2 "Literature Review":** This chapter includes a concise state-of-the-art review related to our study context. We will highlight key platforms in this area, their strengths and limitations, to classify them according to how well they meet our objectives.
- **Chapter 3 "Requirements Specification":** As the name suggests, we will specify all the requirements (functional, non-functional, and technical) needed to achieve our objectives, describing the functionalities, the main actors of our system, and use case diagrams showing their intrinsic interactions.
- **Chapter 4 "Analysis and Design":** In this chapter, we will conduct an architectural and detailed analysis of the final system, presenting its architecture, class and component diagrams, sequence and activity diagrams for some key functionalities, and the deployment diagram.
- **Chapter 5 "Realization":** In this chapter, we will indicate and justify the technical and technological choices for system implementation and present the main resulting interfaces.
- **Chapter 6 "Conclusion":** Finally, this chapter includes a summary of the work we have done, the limitations and obstacles we faced, presenting the perspectives and a general conclusion.

Chapter 1
E-Health and the Patient

Chapter 1

E-Health and the Patient

Introduction

This chapter explores the impact of e-health on patients; we will examine how e-health improves access to care, the quality of medical services, and patient engagement in managing their health. This chapter will also define key terms such as e-health, telemedicine, Health Information System (HIS) and types of PMR to provide a clear framework for subsequent discussions.

1.1 E-Health

At the end of the 1990s, the term e-health appeared for the first time in an article named "What is e-health" as being "an emerging field in the intersection of medical informatics, public health and business, referring to health services and information delivered or enhanced through the Internet and related technologies" [13]. In the same article, researcher Gunther Eysenbach characterizes it as "The 10 e's in e-health" namely:

- **"Efficiency":** Increasing the efficiency of care to reduce costs, notably by reducing redundant medical procedures through enhanced communication among stakeholders in the care process.
- **"Enhancing quality":** Enhancing the quality of care, which results from increased efficiency by "directing patient streams to the best quality providers"[13].
- **"Evidence based":** In the medical field, which is highly critical in terms of patient life, the effectiveness and efficiency of interventions should be proven rather than assumed, especially through scientific approaches.
- **"Empowerment":** Empowering patients and consumers to reduce information and knowledge asymmetry between them and healthcare providers [8] by "giving them access to medical knowledge bases and personal electronic records via the internet" [13].
- **"Encouragement":** "Encouragement of a new relationship between the patient and health professional, towards a true partnership, where decisions are made in a shared manner" [13].
- **"Education":** "Education of physicians through online sources (continuing medical education) and consumers (health education, tailored preventive information for consumers)" [13]

- **"Enabling":** "Enabling information exchange and communication in a standardized way between health care establishments" [13] notably through standard conventions such as Health Level Seven (HL7) and Digital Imaging and Communications in Medicine (DICOM).
- **"Extending":** "E-health enables consumers to easily obtain health services online from global providers" [13], this would indeed allow the expansion of medical action across a wide geographical area.
- **"Ethics":** Ethics is common to all sectors of activity, and the medical sector is no exception. Interaction between healthcare providers and patients must be conducted with the utmost respect for ethical standards such as "online professional practice, informed consent, privacy and equity issues" [13].
- **"Equity":** Equity is a multidimensional concept that applies to several areas, notably health and access to healthcare. "Health equity means that everyone has a fair and just opportunity to be as healthy as possible. Achieving this requires removing obstacles to health—such as poverty and discrimination and their consequences, which include powerlessness and lack of access to good jobs with fair pay; quality education, housing, and health care; and safe environments" [14]. The concept encompasses societal, environmental, financial, ethnic, and cultural dimensions, as well as aspects related to gender and age.

Since then, several studies have been conducted in the field of e-health [15]. Furthermore, on Google Scholar, the article "What is e-health?" by Gunther Eysenbach [16] has been cited approximately "4678" times since its first publication.

E-health encompasses a wide range of areas where ICTs are used to support healthcare. This includes HIS that enable the collection, storage, processing, and distribution of relevant health information for individuals, communities, or populations, a domain focusing on remote care: telehealth, and also an emerging field in recent years: artificial intelligence in healthcare and robotic [2, 4, 1].

The figure 1.1 illustrates different components within e-health.

1.1.1 Telehealth

With the increase in the elderly population, lifestyle changes leading to a rise in chronic diseases, and the need to improve the quality of care while considering limited financial resources [17, 18], a new challenge arose in the medical field: home healthcare by using ICTs was the appropriate response [19]. Although the terms telehealth and telemedicine are used interchangeably [20, 21], their definitions differ. Telehealth is defined as the "delivery of healthcare services when patients and providers are separated by distance" [22]. According to the World Health Organization (WHO), it is the use of "ICT for the exchange of information for the diagnosis and treatment of diseases and injuries, research and evaluation, and for the continuing education of health professionals" [22]. Thus, telehealth involves remote care services (telemedicine) and encompasses all means for training and informing various healthcare stakeholders.

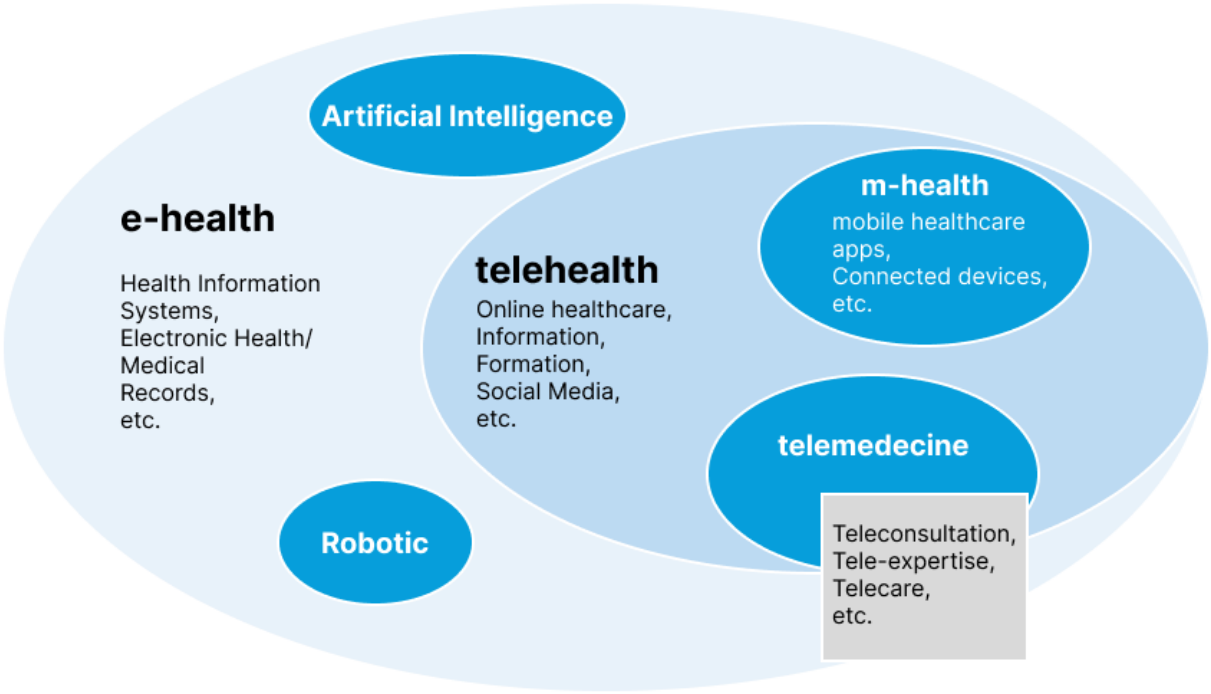


Figure 1.1: Diagram illustrating the different components of e-health. Adapted from [1, 2]

1.1.1.1 Telemedecine

As mentioned above, many definitions add to the confusion surrounding telemedicine. Indeed, most definitions consider telemedicine and telehealth as exactly synonymous[23]. However, telemedicine is a subset of telehealth that focuses solely on the provision of medical services remotely. The prefix "tele" conveys this image [24] and is applied to all sub-domains, including :

- **teleconsultation** : which allows patients to consult healthcare professionals remotely through real-time communication technologies.
- **telemonitoring** : allowing for monitoring the medical condition of a patient.
- **teleassistance** : enabling healthcare professionals to provide remote assistance to patients or other healthcare professionals.
- **teleexpertise** : which allows a healthcare professional to seek the opinion of other healthcare professionals.
- **regulation** : management of emergencies and coordination of interventions in response to them.

To this list is added **telesurgery**, an emerging sub-domain using robotic technologies and wireless networks to conduct surgical operations remotely [25, 26].

1.1.1.2 M-health

"M-health," or mobile health, is a field within e-health, sometimes complementary to telemedicine, which utilizes mobile technologies (smartphones, tablets, etc.) in the realm of healthcare [27]. The acceptance of mobile users through the democratization of mobile technologies has allowed this field to experience considerable success [28, 29]. Indeed, according to "What's the Big Data," there are nearly 6.9 billion smartphone users as of

early 2024, representing 85% of the global population [30]. Furthermore, with the advent of 5G and the latest wireless connection technologies offering high-speed transmission and low latency [31], the use of wearable devices is becoming increasingly prevalent as they can "provide real-time feedback regarding a person's health conditions" [32].

Used in teleconsultation, telemonitoring, teleassistance, and even teleexpertise, m-health contributes to resolving telemedicine's challenge regarding the connection between patients, healthcare professionals, and the professionals themselves [18].

1.1.2 Medical Record

The earliest traces of medical records date back to antiquity, defined as a set of information that allows knowing "who the patient is and who provided health care," "what, when, why and how services were provided," and "the outcome of care and treatment" [33, 34]. Nowadays, in the digital age, the patient's medical record has inevitably transitioned from paper to digital, a shift that has proven to be very beneficial in managing the patient's medical record [35].

1.1.2.1 Electronic Health Record / Electronic Medical Record

Although the terms Electronic Health Record (EHR) and Electronic Medical Record (EMR) are used interchangeably (in the article [35]), they differ in their scope of use. Both are legal medical records created in the healthcare setting that "reduce medical errors by utilizing computerized prescription entry, predicting drug interactions and displaying a warning for the health-care provider, assisting clinicians in reconciling patient medications, and most important, maintaining a detailed and legible medical record" [36]. The EMR is more specifically used in clinics and ambulatory settings, whereas the EHR is more comprehensive and used throughout the entire care process [37]. The EHR consists of multiple EMRs.

1.1.2.2 Advantages of EHR/EMR Management Systems

EHR/EMR Management Systems help to provide a consolidated view of medical records by enabling the integration of various Health Information Systems (HISs) such as Hospital Information Systems (HoISs). As a result, EHR Management Systems plays an important role in providing better healthcare services [38].

1.1.3 Health Information System

For effective care, we need good management, and the flow of information at every point influences optimal management [39]. To achieve this, the inevitable solution was the adoption of system enabling this flow: Health Information System (HIS) [40]. HIS is defined as "a set of components and procedures organized with the objective of generating information which will improve health care management decisions at all levels of the health system" [39]. HIS is composed of several subsystems that manage specific institutions within the healthcare domain alongside the patient's EHR.

1.1.3.1 Hospital Information System (HoIS)

With the definition provided of the HIS above, the HoIS (not exempt from this definition rule) is defined as a Socio-Technical System (STS)[1] of the hospital comprising all processes of treatment of health information as well as the actors included in this process [41].

As mentioned in an article [42], the HoIS is composed of two or more of these subsystems:

- **Picture Archiving and Communication System (PACS):** it "includes several subsystems and components: image acquisition devices, a data management system, data storage de-vices, a transmission network, image display stations, and devices to produce hard-copy images."[43]
- **Radiology Information System (RIS):** for managing radiology services (billing, appointments, etc.).
- **Clinic Information System (CIS):** for managing critical clinical information in the care process.
- **Pharmacy Information System (PIS):** manages pharmacy services by providing features for checking drug interactions, allergies, etc., to assist in decision-making and prevent any errors in medication prescription.
- **Laboratory Information System (LIS):** is "a software-based laboratory and information management system that offers a set of key features that support a modern laboratory's operations" [42].
- **Clinical Decision Support System (CDSS):** "is intended to improve healthcare delivery by enhancing medical decisions with targeted clinical knowledge, patient information, and other health information" [3]. The figure 1.2 illustrates the diagram of key interactions in knowledge-based and non-knowledge based CDSS.

[1]STS in organizational development is an approach to complex organizational work design that recognizes the interaction between people and technology in workplaces

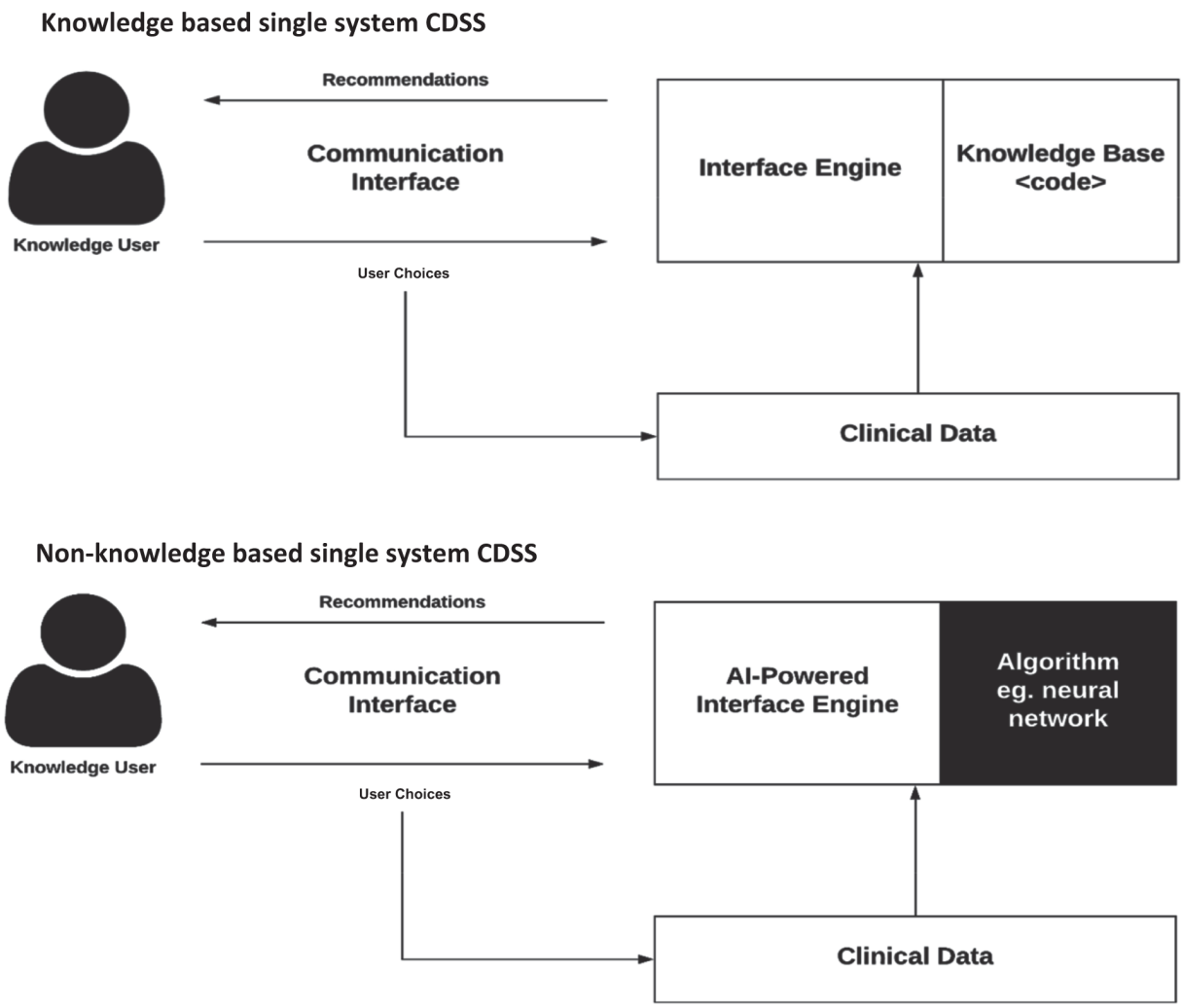


Figure 1.2: Diagram of key interactions in knowledge-based and non-knowledge based CDSS. From [3]

1.1.3.2 Online Health Information Resources (OHIR)

The creation, sharing, and consumption of information have become easier through interactive and collaborative web applications [44], especially if they are credible [45]. OHIR are systems using the Internet to convey health information among various health domain users. This facilitates information dissemination and education. In a study on online health information-seeking behavior based on 483 questionnaires [46], it was found that nearly "Seventy-five percent of the health information consumers believed the obtained online health information had either a minor or major impact on them (or their families and friends) in their health treatment decision making, overall health maintaining approach, and the way the health information consumers thought about health-related issues" [47].

They present themselves as a database and logic server for services in the health domain: BMI calculator, drug interaction checker, health news, etc., accessible through access interfaces such as web and mobile applications, APIs, etc. Figure 1.3 illustrates the structure of OHIR.

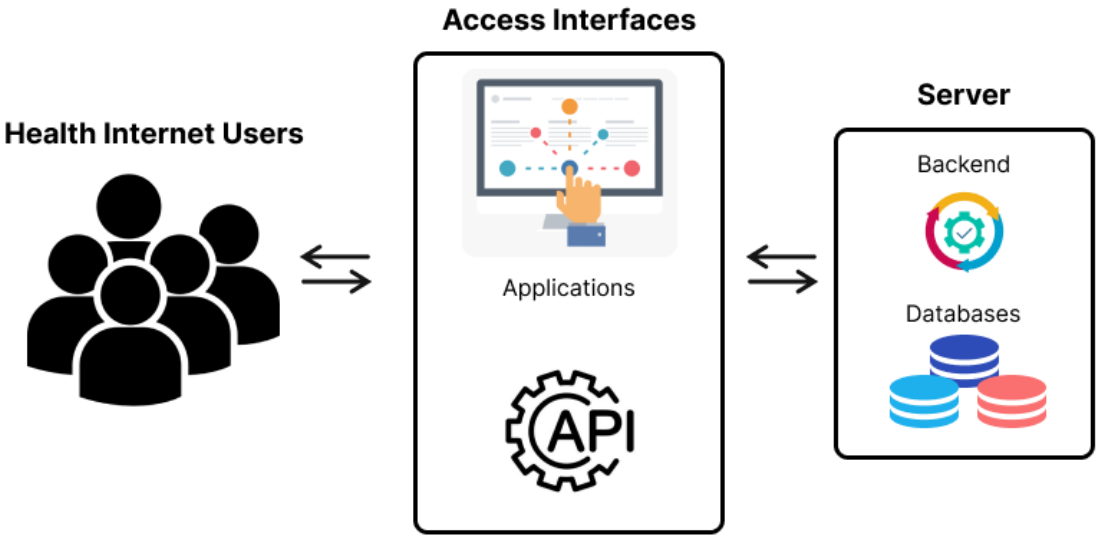


Figure 1.3: Structure of OHIR.

1.1.3.3 National Health Information System (NHIS)

NHIS is the organized and integrated network of resources and processes that contribute to the overall production and communication of nationwide health-related information.

1.1.4 AI and Robotic in Healthcare

As the physical world becomes more digital, computing becomes increasingly prevalent in all domains. Indeed, the digitization of physical health information has allowed subfields of computer science such as AI and robotics to be applied effectively.

1.1.4.1 AI for Health

The emergence of AI with the application of new deep learning algorithms has allowed machines to achieve what is known as "human-level" performance in solving various tasks across different domains. In this regard, the International Telecommunication Union (ITU), in collaboration with the WHO, has established the Focus Group on "Artificial Intelligence for Health" (FG-AI4H) to promote the use of AI in the healthcare domain. Most recent research in this field applied to healthcare has been directed towards medical image recognition, potentially for classification, segmentation, and analysis, as well as Natural Language Processing (NLP), leading to the development of health chatbots [4, 48].

Although the emergence of this field is impressive, it faces numerous challenges regarding the interpretation and explanation of deep learning models, which is crucial because "health data are sensitive and subject to privacy laws" [4, 49].

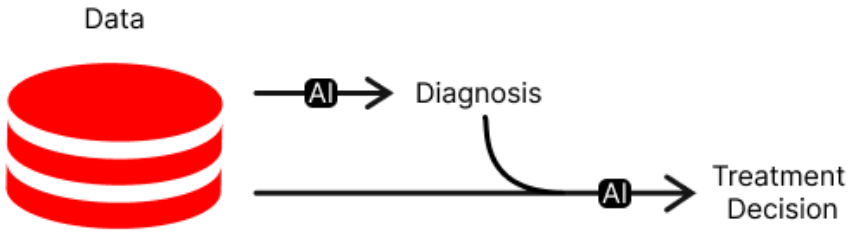


Figure 1.4: Mapping input data to diagnosis and treatment decision. Adapted from [4]

1.1.4.2 Healthcare Robotics

Medical robotics, sometimes complementary to AI in healthcare, refers to the use of autonomous and supervised robotic technologies for "physical and cognitive rehabilitation, surgery, telemedicine, drug delivery, and patient management" . There are three main categories of robots used in the healthcare sector: "inside the body," "on the body," and "outside the body." The three main direct users of these robots are: "direct robots users," who are typically patients using all categories of robots, "clinicians," and "caregivers," who use the "outside the body" category [50].

1.2 From Passive Patient to Autonomous Patient

Recently, patient involvement in their own care process has become increasingly demanded in decision-making, shifting the patient from a passive position (**no involvement**, **dependency**) to an active position (**autonomy**, **shared decision-making**) [51, 52]. While patient independence is highly encouraged, the relationship between the patient and the professional should not be overlooked, as the patient is not alone in this process [53]. This patient-professional interaction has become even easier with the use of ICT.

1.2.1 E-Patient

"A patient is a physical person receiving medical attention or care" is the definition of the term **patient** according to Wikipedia. Variants of the term have been used since antiquity to refer to "one who suffers" [54]. Technically, every human at some point in their life becomes a patient. In the past, the patient occupied a status of "care object," but recent epidemic crises have mobilized several associations, advocating for a status of "rights-bearing subject." Nowadays, the patient wants to be informed about their illness. Additionally, the emergence of ICT, affecting almost all domains and not sparing the patient, has allowed easy access to their technical information [55, 8, 9]. We now refer to the patient as a connected patient or an **e-patient**. Invented in the 1980s by Tom Ferguson, the term e-patient describes "individuals who are equipped, enabled, empowered, and engaged in their health and healthcare decisions" [56, 57].

1.2.2 Patient-Professional Relationships

The existence of healthcare professionals is the first proof that the patient is not alone in their care process. In this process, a good relationship between patients and healthcare professionals facilitates interactions, thereby improving the quality of care. In an interdisciplinary collaborative context, stakeholders (patients and professionals) must maintain an ethic of interdependence, flexibility, collective ownership of goals, collaborative act and reflection on process [58].

- **Interdependence**: Time spent together, oral or written exchange, intrinsic respect for each stakeholder's opinions and contributions;
- **Flexibility**: Stakeholders must be able to face changes, whether planned or unplanned, and demonstrate adaptability;
- **Collective Ownership of Goals**: Each stakeholder must take and understand their responsibilities regarding their role in the care process to achieve the common goal;
- **Collaborative Act**: Stakeholders must be aware of the importance of their collaboration to accomplish tasks they cannot do independently;
- **Reflection on Process**: Stakeholders must communicate to decide on the care process and provide feedback to improve the collaborative relationship and effectiveness.

1.2.3 Patient Empowerment

Empowerment, which emerged in the 1970s following socio-political movements and refers to the action of giving power, was initially used to break the paternalistic, hierarchical, and unequal status [59]. When applied to the patient, the term refers to giving the patient the power to act in their own care process. Most of the application of this notion in the medical context emphasized "participative strategies" [8] for the patient. Furthermore, as the patient becomes increasingly an e-patient, researchers [60] have analyzed the social uses of ICTs for patient empowerment, including:

- **"Consulting health information online"**;
- **"Online drug purchases"**;
- **"Telehomecare"**;
- **"Electronic Health Records"**.

Thus, to empower the patient, it is essential to consider their information and education to reduce the information and knowledge asymmetry compared to healthcare professionals. This includes providing them with complete access to their medical records and all medical information concerning them, enabling them to be autonomous, strengthening their engagement and collaboration, and becoming partners in decision-making regarding their medical condition.

1.2.4 The Patient Acceptance Challenge

Although patient empowerment through ICT is an innovative solution in managing their care process, several acceptance factors come into play, such as social factors, socio-demographic factors, and factors related to the quality of the technology in question.

> **"Technologies cannot help facilitate self-monitoring and self-management or improve patients' health outcomes when patients do not accept the technology"**
>
> *Calvin K.L. Or and Ben-Tzion Karsh*

Conclusion

In conclusion, e-health represents a major transformation in the way healthcare management is implemented by professionals and perceived by patients. HIS combined with ICT have provided easy access to information, enabling active involvement and autonomy for patients in their care process and fostering effective collaboration between healthcare professionals and patients. However, the acceptance of these technologies depends on numerous factors, including social factors, socio-demographic factors, and factors related to their quality. By overcoming these challenges, e-health can significantly improve the patient experience and the quality of care.

After presenting the impact of e-health on the medical field and the patient, the next chapter entitled "Literature Review" and in addition to this chapter, will provide a synthesis of key research and platforms related to our project by presenting their strengths and weaknesses.

Chapter 2
Literature Review

Chapter 2

Literature Review

Introduction

The field of e-health being constantly evolving, it is essential to be aware of the current advances, trends, and challenges to better guide and contextualize our work. In this chapter of literature review or state of the art, we will present related works to our study context, focusing in particular on validation criteria that we will define beforehand to highlight the shortcomings associated with these works and their influence on the design of our system. We will also present the adopted methodology and the types of research activities conducted.

2.1 Research Methodology

During the literature review period, we conducted numerous searches supported by literature review internships during which we were able to interact directly with some of the key platforms related to our study context. We supplemented these searches with internet searches and bibliographic searches in online databases and surveys with various stakeholders in the healthcare field.

2.1.1 Literature review internships

From 2024-02-02 to 2024-03-31, we conducted literature review internships at the "Établissment Public de Santé de Proximité - Tiaret", "Établissment Public de Santé de Proximité - Ain Kermes" and "Centre de Diagnostic Medical EL AMAL- Tiaret" as part of a review on existing current solutions (refer to 6). Our research was supervised by highly competent staff in their field who provided us with all the necessary information regarding the subject matter. During these internships, we were able to directly interact with two of the most used e-health platforms in Algeria: DEM DZ and RayScan. In the "Related Work" section, we will provide a brief presentation of these platforms.

2.1.2 Online Databases

In addition to our literature review internships, we conducted in-depth research on more theoretical topics using various databases of articles and scientific publications and Internet. We specifically looked at :

- **Google Scholar**;
- **Cairn**;

- **ResearchGate**;
- **ScienceDirect**
- and **Érudit**.

2.1.3 Market Study

To support the literature review and prepare us for the specification of requirements, we conducted surveys both in-person and online using tools like Google Forms. This allowed us to collect additional information beyond what was gathered during our literature review internships. We will also present these results in a summarized form in the requirements specification section.

2.2 Related Works

In this section, we will first present the various platforms and key works related to our study context in Algeria and globally. Then, we will provide a critical synthesis of these platforms.

2.2.1 Related Platforms

Numerous platforms and systems have emerged following the digital democratization in the healthcare sector. Most of them facilitate health-related research (news, medications, etc.), while others are used for managing EHR and healthcare facilities. We used information such as the name, type of platform, creation date, developer, access website (if available), platform accessibility (whether access is free or subject to certain conditions), type of HIS used, and the main features offered to primary users to highlight the characteristics of the various platforms we studied in our research. A table containing these characteristics will be presented for this purpose.

2.2.1.1 DEM DZ

DEM DZ, analogous to "Dossier Électronique Médical Algérien", is a locally integrated web platform within public healthcare facilities in Algeria. It manages local patients' EHR and queues to ensure the provision of medical services, improves patient reception conditions, and guides them based on the specific needs of each case. During our internships at the EPSP-Tiaret, we were able to interact with this platform in a patient admission scenario. The figure 2.1 illustrates the dashboard in DEM DZ, where statistics on patient flow and the number of personnel in the facility can be seen.

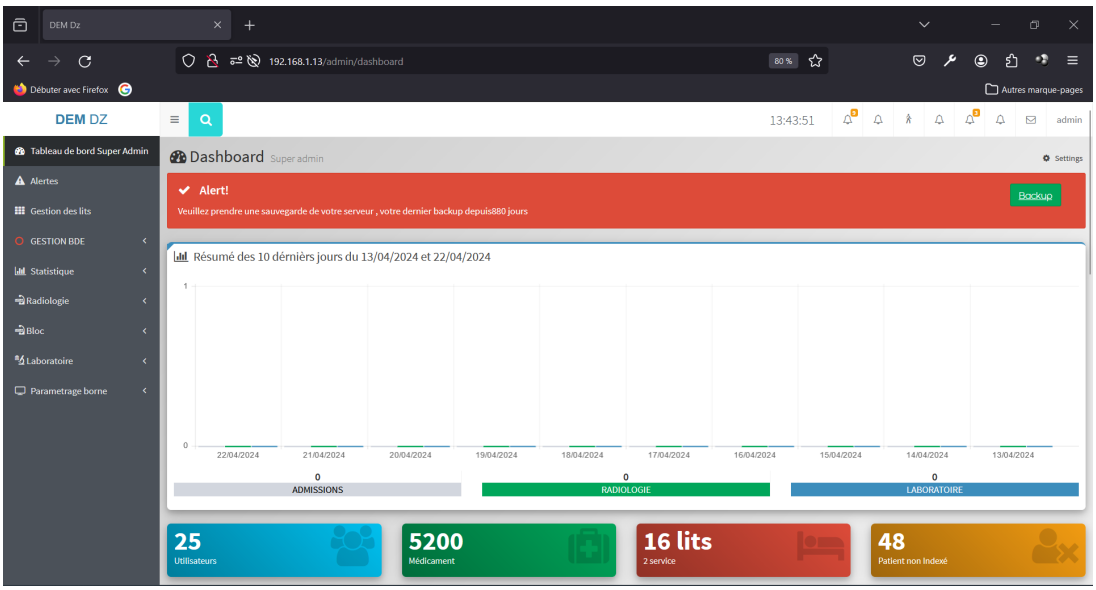


Figure 2.1: DEM DZ Dashboard

The table 2.1 below presents the characteristics of DEM DZ.

DEM dz	
Platform Type	Web / Mobile (Incomplete Version)
Creation Date	2017
Information System	HIS
Geographic Area	Algeria
Developer	Ministry of Health (Information System and Computer Directorate)
Access	Restricted (Public healthcare facilities only)
Features for Practitioners	Authentication Bed Management Admission Management (patients) Management of visits, procedures, and medical prescriptions Terminal Management - advanced functionality (TV, tickets, etc.)
Features for Patients	History of his visits Get a medical record.

Table 2.1: Characteristics of DEM DZ.

2.2.1.2 Pharm'Net

Pharm'Net is an Algerian web application that follows the official nomenclature of medications used in Algeria, allowing users to consult package inserts, view equivalents, and drug interactions, as well as other characteristics[61]. The figure 2.2 illustrates the Pharm'Net website home page.

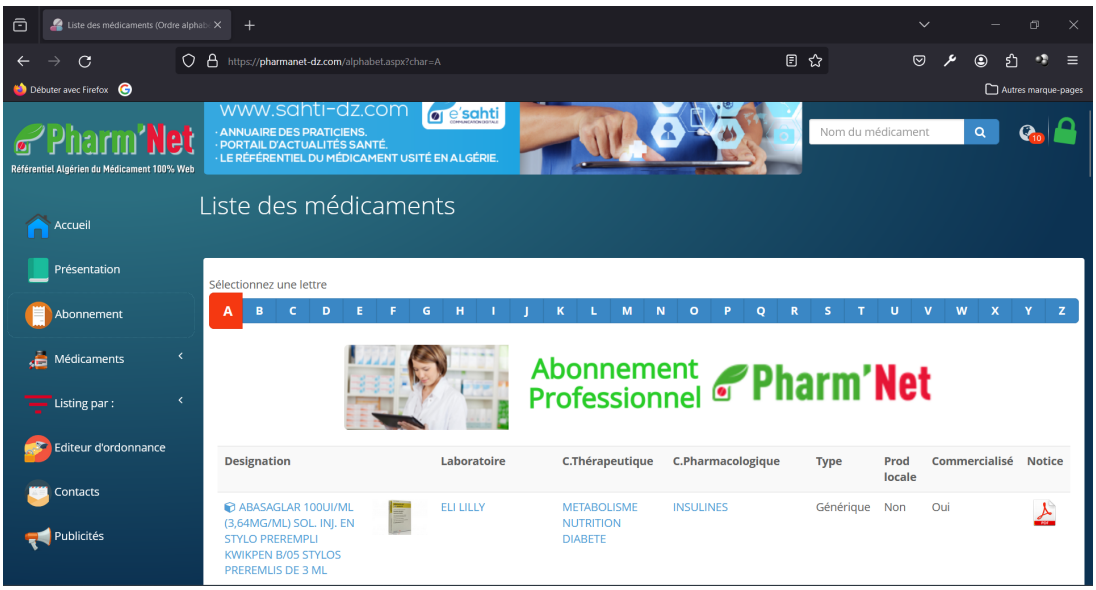


Figure 2.2: Pharm'Net website.

The table 2.2 below presents the characteristics of Pharm'Net.

Pharm'Net	
Platform Type	Web
Website Address	`http://www.pharmnet-dz.com/`
Creation Date	2018
Information System	CDSS / OHIR
Geographic Area	Algeria
Developer	ESAHTI Sarl
Access	Free (limited) / Paid (all access subscription-based)
Features for Practitioners	Authentication; Access to medication information (package inserts, interactions, etc.); Supervised prescription ordering (verification of drug interactions)

Table 2.2: Characteristics of PharmNET.

2.2.1.3 Sante-dz

Sante-dz is a set of informative guide platforms in the field of healthcare in Algeria. Among other things, it provides a directory of various healthcare professionals, advice on human health, and upcoming events in the healthcare domain.
It is divided into four major main platforms, three of which are functional:

- **santedz**
  This platform, accessible via the link `https://www.sante-dz.com/`, is the main platform of the company. It provides useful information on human health with a news system. The figure 2.3 illustrates santedz website.

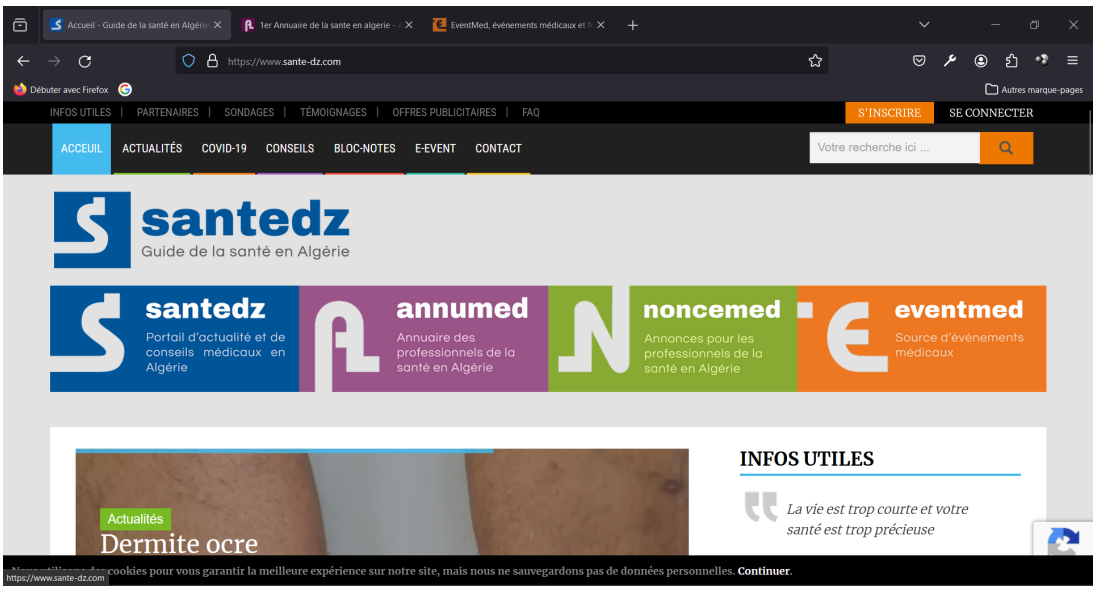


Figure 2.3: santedz website.

- **annumed**
  This platform, accessible via the link `https://annumed.sante-dz.com/`, provides a directory of healthcare professionals, along with its search system (by name, by locality). The figure 2.4 illustrates the annumed website.

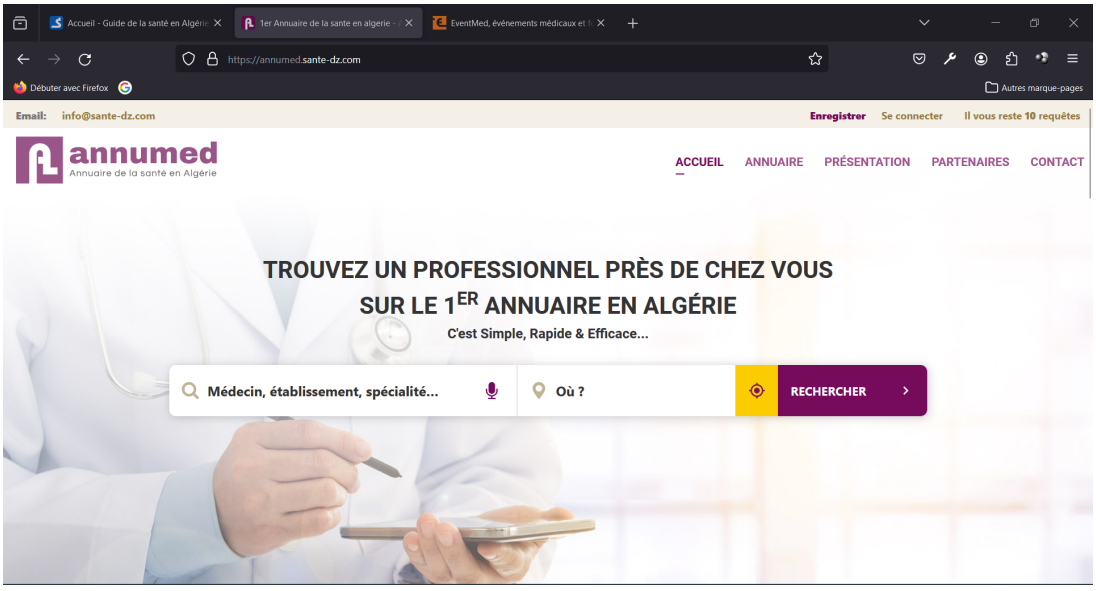


Figure 2.4: annumed website.

- **eventmed**
  This platform, accessible via the link `https://eventmed.sante-dz.com/`, provides an overview of upcoming events in the medical field. The figure 2.5 illustrates the eventmed website.

Figure 2.5: eventmed website

- **noncemed**
  This platform is intended to publish announcements in the medical field, but it is not functional at the moment. It is an advertising platform (possibly a source of revenue in their business model.

The table 2.3 below presents the characteristics of Sante-dz.

Sante-dz	
Platform Type	Web
Creation Date	2006
Site Address	`https://www.sante-dz.com/`
Information System	OHIR
Geographic Area	Algeria
Developer	Softart-dz
Access	Free / Paid (Access to exclusive content)
Features for Practitioners	Authentication; Access to information regarding announcements, events, and health.
Features for Patients	Authentication; Access to a directory of doctors with the ability to schedule an appointment (contact establishment)

Table 2.3: Characteristic of Sante-dz

2.2.1.4 Updox

Updox is a comprehensive healthcare communication platform designed to streamline administrative tasks, improve patient engagement, and enhance collaboration among

healthcare providers. It offers a range of features and services tailored to the needs of healthcare practice by a variety of software. The figure 2.6 illustrates an overview of Updox platform.

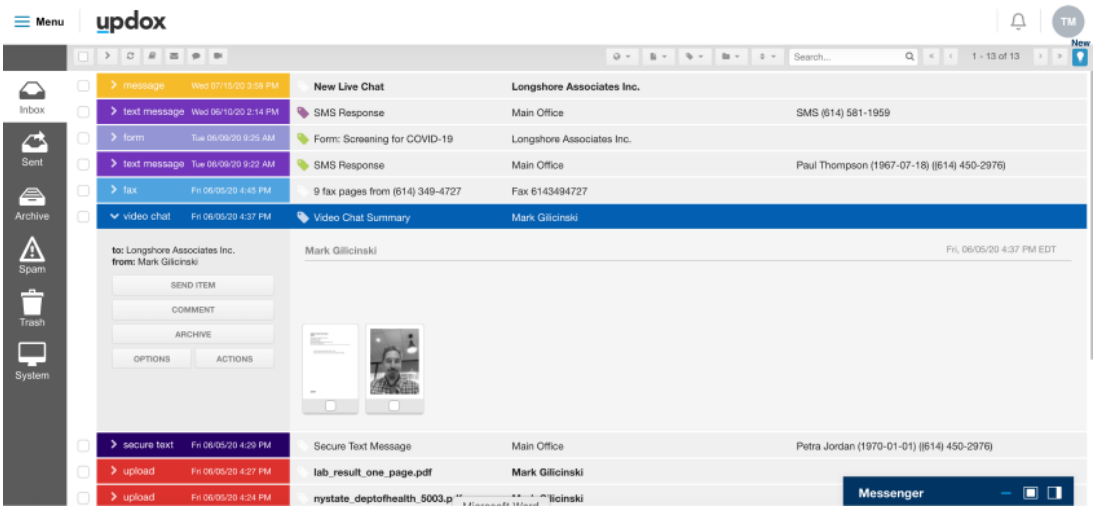


Figure 2.6: Updox overview from [5].

The table 2.4 below presents the characteristics of Updox.

Updox	
Platform Type	Web / Desktop Software
Site Address	`https://www.updox.com/`
Creation Date	2008
Information System	HIS
Geographic Area	United States
Developer	Updox LLC
Access	Paid (based on the needs of the client company)
Features for Practitioners and Patients	Direct Secure Messaging Telehealth Service Integration Appointment Reminders Patient Portal Broadcast Messaging e-Form e-Fax Secure Messaging

Table 2.4: Characteristics of Updox

2.2.1.5 RayScan

2.2.1.5.1 During our internships at the "Centre De Diagnostic Medical EL AMAL - Tiaret," we were able to interact with RayScan and the software used to operate it. RayScan is a Cone Beam Computed Tomography (CBCT)[1] system developed by the South Korean company Ray Co., provided through four series: s, α+, α, and m+. The system integrates with a SIR to transmit radiological data. The figure 2.7 illustrates the software used to manipulate RayScan.

[1]CBCT is a three-dimensional medical imaging technique based on the numerical analysis of the absorption of a cone beam of X-rays and particularly suitable for exploring the dento-maxillary system

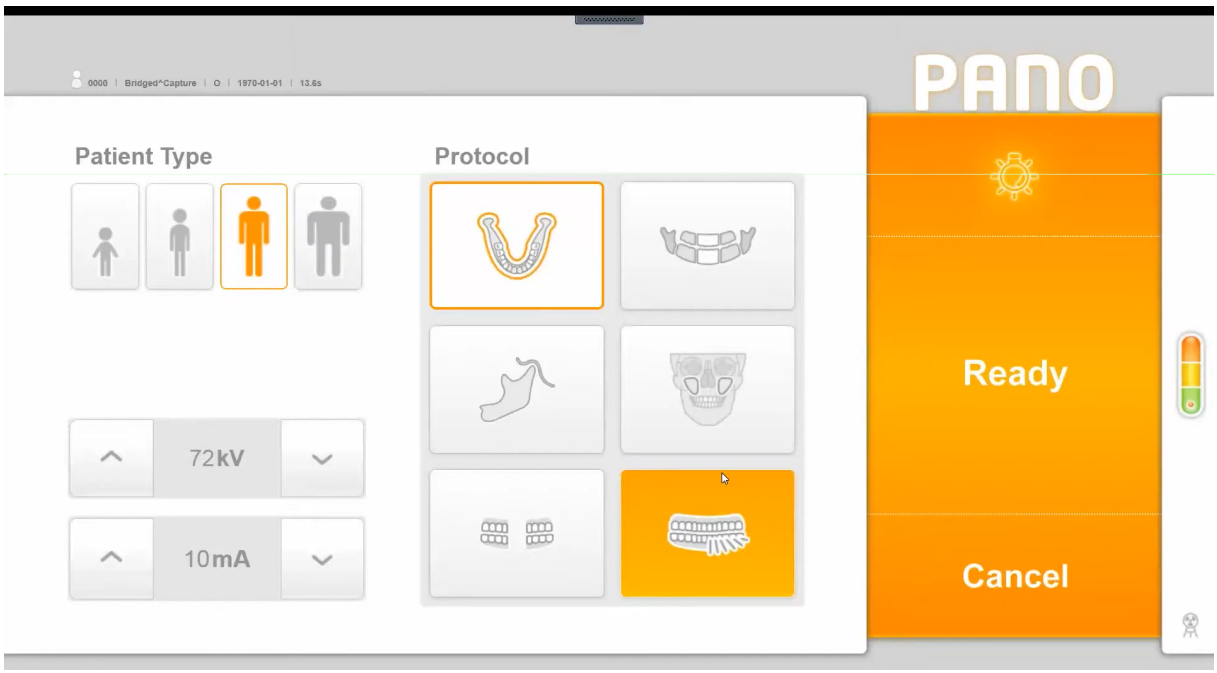


Figure 2.7: RayScan Manipulation Software

The table 2.5 below presents the characteristics of RayScan.

RayScan	
Platform Type	Hardware and Software System
Creation Date	n.d
Information System	RIS
Geographic Area	Global
Developer	Ray Co.
Access	Paid (Equipment purchase)
Features for Practitioners	Acquisition, storage, archiving, interpretation, and diagnosis of radiological images; Integration of a Radiology Information System; Interface with other information systems for data transfer

Table 2.5: Characteristics of RayScan

2.2.1.6 Doctolib

Doctolib is a French company offering web-based software solutions for healthcare professionals and a mobile service for online appointment booking for patients. Figures 2.8 and 2.9 illustrate an overview of the Doctolib mobile application and the website `https://doctolib.fr`, respectively[62].

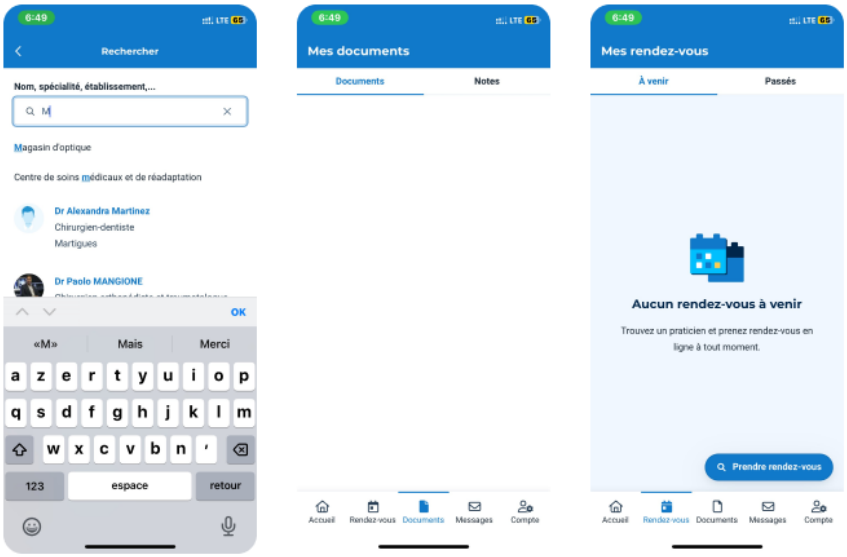


Figure 2.8: Doctolib Mobile Application.

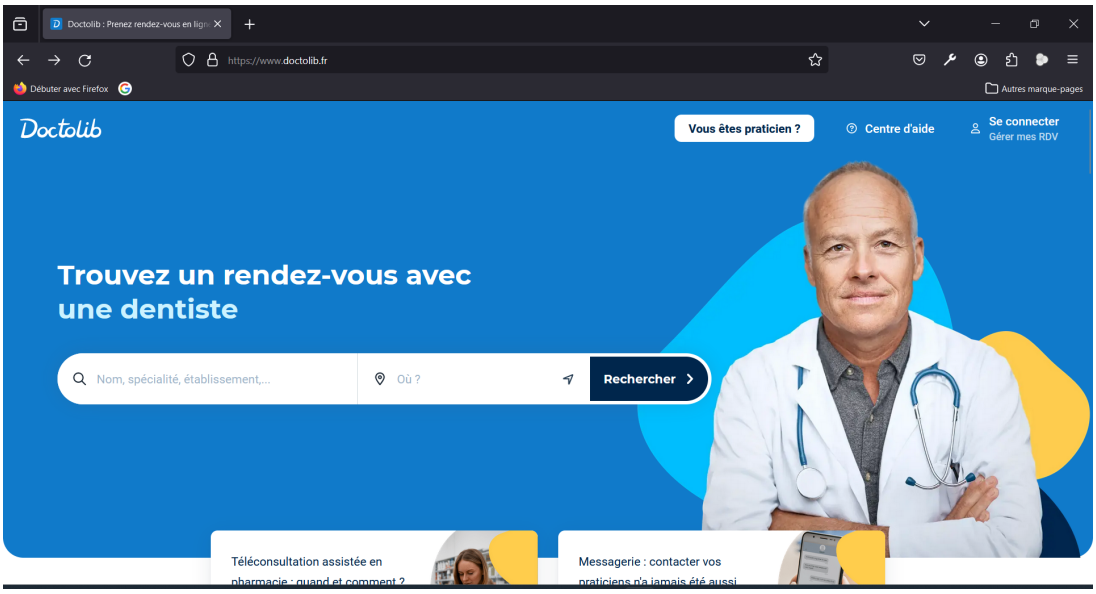


Figure 2.9: Doctolib Website.

The table 2.6 below presents the characteristics of Doctolib platforms.

Doctolib	
Platform Type	Web / Mobile
Site Address	`https://www.doctolib.fr/`
Creation Date	2013
Information System	France
Geographic Area	France, Germany, Italia and Nederland
Developer	Doctolib Enterprise
Access	Free
Features for patients	Patient registration/login; Search for a doctor; Online appointment scheduling; Video consultation with reimbursements; Sharing prescriptions with pharmacies; Medical record management
Features for Practitioners	Document management, patient records, etc.; Appointment scheduling; Online agenda for sharing prescriptions and documents; Instant messaging for healthcare professionals; Secure document sharing

Table 2.6: Characteristics of Doctolib

2.2.1.7 Drugs.com

Drugs.com is a Cross-Platform Service that provides independent medical information in pharmaceutical services and Healthcare services to enhance, the information related to medications, medical conditions, and healthcare topics. It offers a range of features and services tailored to the needs of healthcare practices in this table. The figure 2.10 illustrates the Drugs.com website.

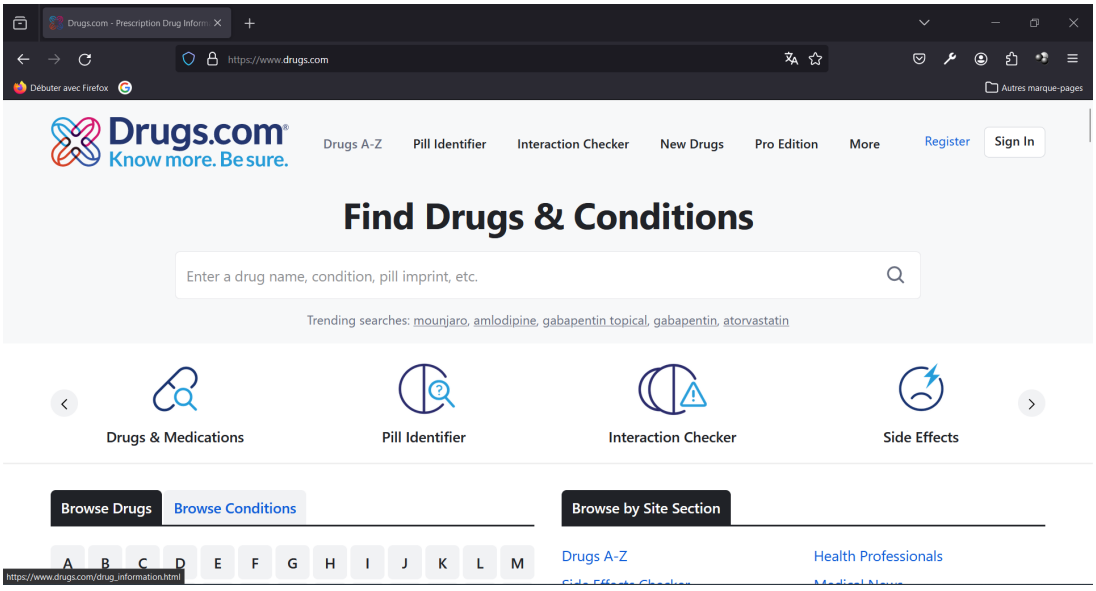


Figure 2.10: Drugs.com website.

The table 2.7 below presents the characteristics of Drugs.com.

Drugs.com	
Platform Type	Web / Mobile
Website Address	`https://www.drugs.com/`
Creation Date	1998
Information System	OHIS / PIS
Geographic Area	Global
Developer	Karen Ann and Philip Thornton
Access	Free
Features for Users	Information about medications (package inserts, INN, etc.); Verification of drug interactions with recommendations; Pharmaceutical news.

Table 2.7: Characteristics of Drugs.com

2.2.1.8 OpenFDA

OpenFDA is a research project aimed at providing open API, raw data downloads, documentation, and examples, as well as a developer community for a large collection of public FDA datasets [63]. Figures 2.11 and 2.12 respectively represent a response from an endpoint of the OpenFDA API and statistics on the general usage of the API.

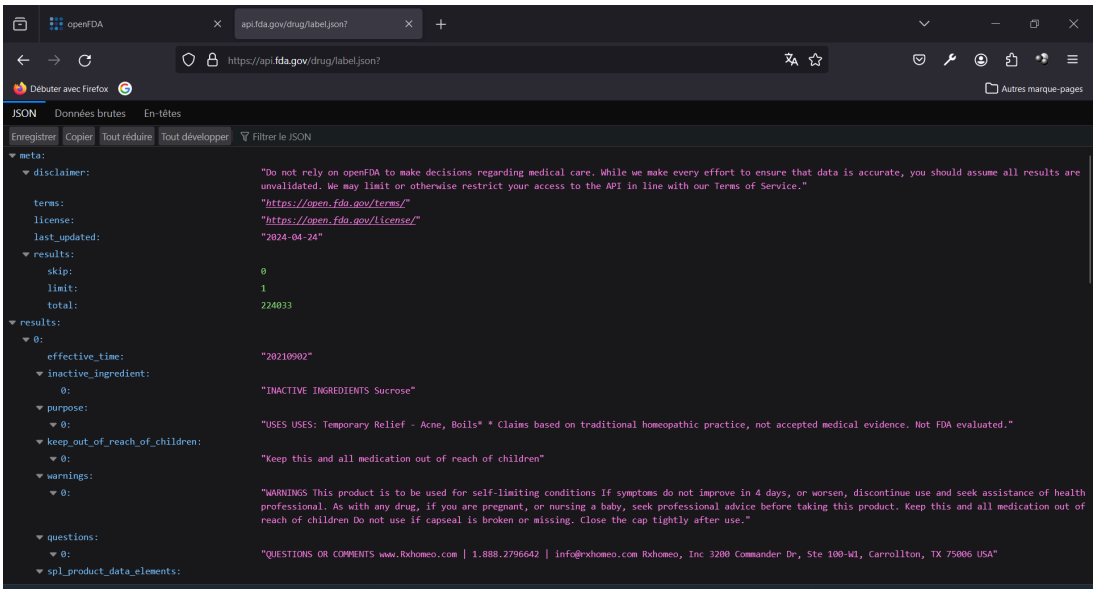


Figure 2.11: Response of **GET** `https://api.fda.gov/drug/label.json?`

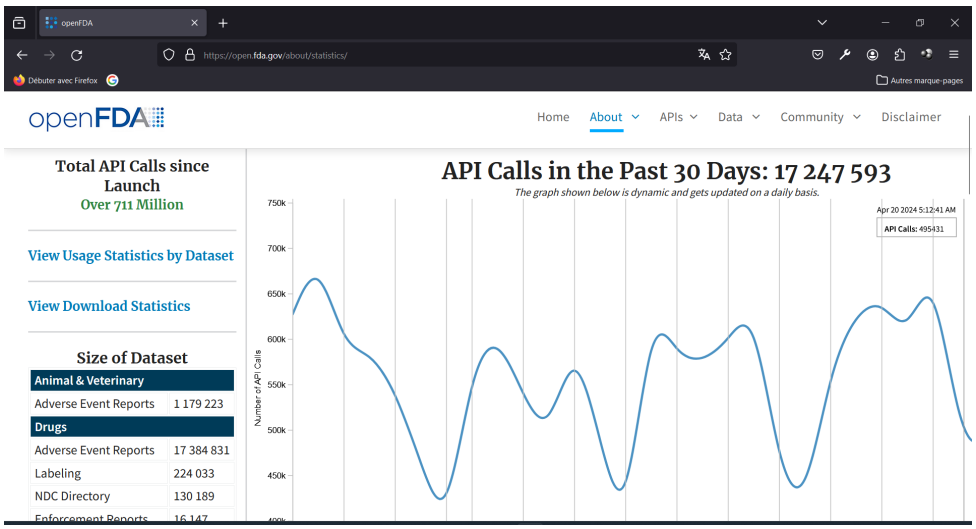


Figure 2.12: OpenFDA API calls statistics.

The table 2.8 below presents the characteristics of OpenFDA.

OpenFDA	
Platform Type	Web
Creation Date	2014
Information System	OHIS / PIS
Geographic Area	Global
Developer	Food and Drug Administration (FDA)
Access	Free (CC0-1.0 license)
Features for Internet Users	API on information regarding drugs, medical devices, food, and cosmetic products with its documentation

Table 2.8: Characteristics of OpenFDA

2.2.1.9 Ada

Ada is a medical diagnostic application based on artificial intelligence, which assists users in identifying possible causes of their symptoms and suggesting appropriate actions. Figure 2.13 illustrates a symptom evaluation scenario in the Ada application.

Figure 2.13: Symptom Evaluation in the Ada Application.

The table 2.9 bellow presents the characteristics of Ada.

Ada	
Platform Type	Mobile
Creation Date	2016
Information System	CDSS
Geographic Area	Global
Developer	Ada Health
Access	Free
Features for users	Symptom Evaluation Personalized Health Report Consultation History Access to Reliable Medical Information

Table 2.9: Characteristics of Ada.

2.2.2 Thematic Literature Review

As part of an in-depth investigation into topics such as the integration of different components of a HIS and the use of NLP in healthcare, we conducted research to create thematic literature reviews. In this section, we will provide a summary of these research findings.

2.2.2.1 Integration in Healthcare

The emergence of new technologies in the medical field contributes significantly to the creation of a heterogeneous ecosystem in healthcare. This is particularly manifested by a technological inertia behavior among different stakeholders towards legacy systems - obsolete technologies still in use due to the costs and efforts of change, as well as user habituation - and the lack of adoption of a communication standard by developers of

new technologies [64, 65]. Integration is the translation of data across systems [66]. In the ecosystem of a HIS, it is the key to its interoperability, enabling smooth, coherent, and trouble-free communication, but its heterogeneity poses a challenge to achieving this. Many research efforts aim to overcome this challenge. While some focus on adapting legacy systems to new communication standards [65, 67], others seek to make legacy systems self-adaptive to adapt to any changes in their ecosystem [68]. In 2023, the WHO and the HL7 organization signed a collaboration agreement to support the adoption of open interoperability standards globally [69]. There is no doubt that the concept of interoperability is becoming essential in the healthcare domain.

HL7 standards for Interoperability

The HL7 organization is a nonprofit standards development organization that provides a comprehensive framework and related standards for the exchange, integration, sharing, and retrieval of electronic health information that supports clinical practice and the management, delivery, and evaluation of health services [70]. There are several standards, with the most commonly used being version 2 (HL7 V2) and the more modern HL7 Fast Healthcare Interoperability Resources (FHIR), which allows for the use of Application Programming Interface (API) concepts for data exchange. The use of HL7 standards varies depending on the standards and the functionality they offer, but in general, programming languages such as Java, C++, Python, etc., are used to implement HL7 standards, web services such as Simple Object Access Protocol (SOAP) and RESTful web services for web-based information exchange, protocols such as Transmission Control Protocol (TCP)/Internet Protocol (IP), HyperText Transfer Protocol (HTTP), Secure HyperText Transfer Protocol (HTTPS), etc., for communication, and databases such as MySQL, PostgreSQL, etc., for storing information. Pendant que les normes HL7 se basent pratiquement dans l'échange d'information clinique et adminstrative d'autres normes sont conçues pour l'échange des images médicales, on pense notamment à DICOM.

DICOM standard

The DICOM standard is a widely used communication standard in medical imaging to ensure interoperability between medical devices and PACS. Nowadays, it is increasingly difficult to find modern PACS systems that do not provide DICOM connectivity interfaces for receiving images from medical procedures [71, 72]. However, DICOM does not define a PACS or modify its structure; instead, it provides intermediary services between PACS and medical components. The DICOM standard uses the TCP/IP protocol to define the formats for medical images that can be exchanged with the necessary data and quality for clinical use [71, 73].

2.2.2.2 NLP in Drug Interaction Checker and Medical Chatbot

Natural Language Processing (NLP) is a field of Artificial Intelligence (AI) that, as its name suggests, is based on natural language processing. It is used for indexing and searching large texts, information retrieval, classification of text into categories, information extraction, automatic language translation, automatic summarization of texts, question-answering, knowledge acquisition, and text generation/dialogues. NLP is used in the medical domain "to structure information in healthcare systems by extracting relevant information from narrative texts to provide data for decision making" [74], particularly in medication prescribing. Indeed, NLP models are being developed to detect

drug interactions during the prescription of medications by healthcare professionals. We are particularly thinking of BioBERT model.

BioBERT model for detecting drug interactions

BioBERT is a specialized version of the Bidirectional Encoder Representations from Transformers (BERT) model that is trained on a vast corpus of biomedical texts, including scientific articles, clinical databases, and research documents [6]. BioBERT inherits all of BERT's capabilities, already excelling in understanding the context of words in both directions. Introduced in the context of biomedical text mining, BioBERT's application extends to the extraction, analysis, relationship recognition, and classification of biomedical entities. Since drugs are part of these entities, BioBERT is particularly useful in detecting drug interactions—adverse events to drugs "that are noxious, unintended, and occur at doses normally used in man" [75, 76]. Already pre-trained on a large biomedical corpus, the BioBERT model is then fine-tuned[2] to perform Named Entity Recognition (NER), Relation Extraction (RE), and Question Answering (QA). Figure 2.14 illustrates the three tasks that the fine-tuned BioBERT model can accomplish.

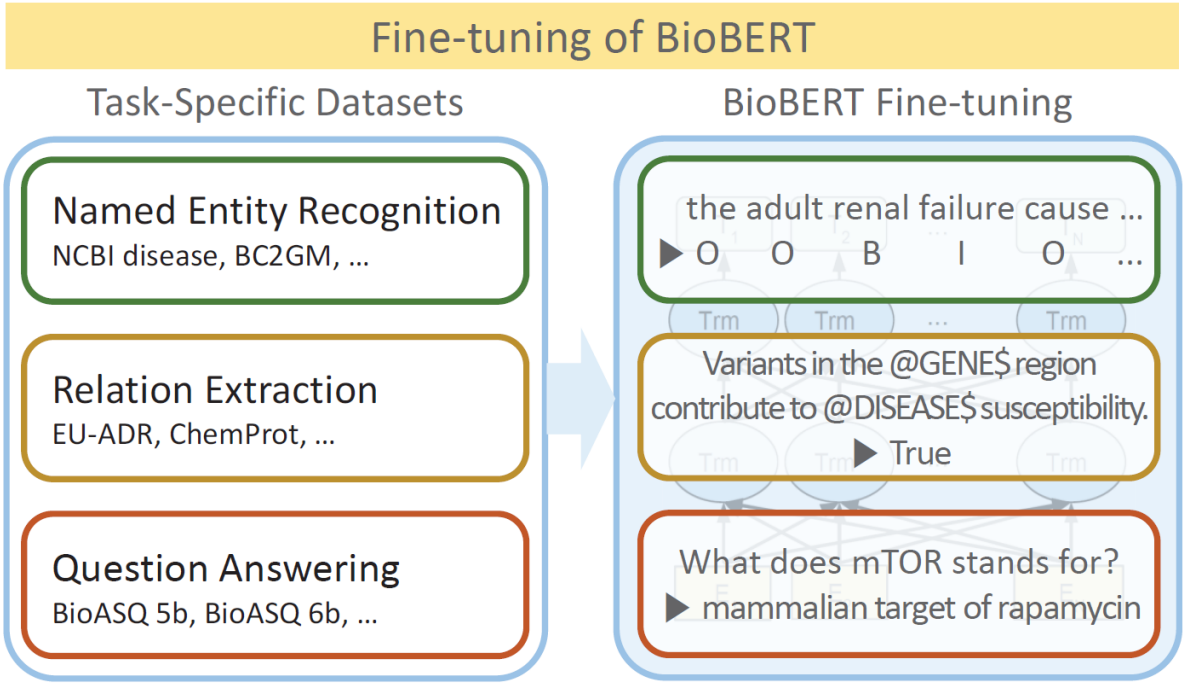


Figure 2.14: Fine-tuning of BioBERT. From [6]

Thus, these three tasks allow us to:

- NER: Identify the names of drugs, diseases, treatments, and other biomedical entities in research articles.
- RE: Detect interactions between drugs, causal relationships between symptoms and diseases, or side effects of treatments.
- QA: Answer clinical questions posed by healthcare professionals or patients using medical databases or scientific publications.

[2]Fine-tuning a model refers to the process of taking a pre-trained model and making small adjustments to it in order to adapt it to a specific task or dataset

Medical Chatbot

With the recent emergence of Natural Language Processing (NLP) language models such as Generative Pre-trained Transformer (GPT), Bidirectional Encoder Representations from Transformers (BERT), etc., AI is becoming increasingly prevalent in content generation (text, image, sound), search optimization, etc. Chatbots, born from this emergence due to AI's understanding of human language, are autonomous systems that can memorize conversational flows to become more proficient in responses. Many initially dismissed mild symptoms have serious consequences, often due to the reluctance of symptomatic individuals to visit a doctor. To address this, seeking information on online health forums is an effective means to motivate seeking medical consultation. However, the difficulty of obtaining an immediate response, the limited availability of experts to respond, and the poor understanding of responses due to the use of technical terms are recurrent issues in online symptom searching. Medical chatbots are practical solutions to these problems [77, 78]. Indeed, thanks to their powerful understanding of human language, they can interact with users and provide them with medical information, health advice, or personalized assistance based on their symptoms, concerns, or questions.

2.2.3 Evaluation criteria

To classify and compare the related platforms presented above, we selected evaluation criteria aligned with the objectives we aim to achieve regarding patient collaboration with healthcare professionals through e-health platforms. Some criteria will be represented as a percentage of their completion rate. Thus, we will sum up the achievement of these criteria, which will be scored out of 6. We will provide a synthesis based on these criteria in the section "Synthesis and Critical Analysis." These criteria are:

2.2.3.1 Collaboration

We chose this criterion to refer to whether the platforms have the capability to ensure collaboration between patients and healthcare professionals, with the patient as an active participant in the care process.

2.2.3.2 EHR Management

This criterion was chosen based on the ability to provide EHR management services. Its effective value is 100% when the management is bidirectional (patient-professional).

2.2.3.3 Telemedicine

This criterion refers to the ability to support telemedicine activities, including teleconsultation, telemonitoring, teleassistance, teleexpertise, and regulation. Its value is 20% per telemedicine activity.

2.2.3.4 Integrate to the Algerian NHIS

This criterion refers to the ability to integrate with the NHIS. This includes the use of ICT such as cloud computing to ensure the availability of information nationwide. Its value is 80% when the platform is integrated into the NHIS and 20% when the platform uses the cloud. The effective value is the sum of both values.

2.2.3.5 Integration with medical devices

This criterion is the ability to integrate medical devices by providing connection interfaces with them.

2.2.3.6 Drug Interaction Checker

This criterion refers to the ability to provide drug interaction checking services.

2.2.3.7 Medical Chatbot

This criterion refers to the ability to provide medical chatbots to interact with users in a medical context.

2.2.4 Synthesis and Critical Analysis

In this section, we will conduct a critical analysis of the mentioned platforms, highlighting their strengths and weaknesses. Subsequently, we will synthesize to evaluate how this literature review contributes to the development of our project. Some related works, such as RayScan and OpenFDA, are excluded because they have a score of 0 and are not relevant to the comparison.

2.2.4.1 DEM DZ

DEM DZ is an Algerian platform integrated within public healthcare facilities. As implied by its name, it facilitates the management of the patient's EMR within the facility and locally. Well-structured and designed for EMR management, it also provides services for cooperation among healthcare professionals in the care process, including queue management, inter-professional patient flow, prescribed procedures, patient admissions and discharges, and patient bed allocation. Although it is a powerful tool for healthcare professionals, the platform's localization to a single site prevents the sharing of EMR across facilities, which could be a significant asset in tracking patient history. Additionally, the platform does not provide a portal for patients to collaborate with professionals and empower themselves. The patient is treated as an object within the system rather than an active participant. Table 2.10 below presents the evaluation of DEM DZ according to the assessment criteria.

DEM DZ	
Collaboration	No collaboration with patient
Telemedicine	20% (Teleexpertise)
EHR Management	Avalaible
Integrate to the Algerian NHIS	80%
Integration with medical devices	Available
Drug Interaction Checker	No Available
Medical Chatbot	No Available
Score	**3/7**

Table 2.10: DEM DZ evaluation.

2.2.4.2 Pharm'Net

Pharm'Net is an Algerian platform that provides services related to medication prescription. Originally designed as a tool for healthcare professionals, it offers e-prescription functionalities and information about official medications used in Algeria (including a drug interaction checker). However, access to the drug interaction checking feature is paid (5000 DA/year according to their official website `https://www.pharmnet-dz.com/abonnement.aspx`), whereas it is free on similar international platforms such as Drugs.com and DrugBank. Table 2.11 below presents the evaluation of Pharm'Net according to the assessment criteria.

Pharm'Net	
Collaboration	No collaboration with patient
Telemedicine	0%
EHR Management	No Avalaible
Integrate to the Algerian NHIS	No Integrated
Integration with medical devices	No Available
Drug Interaction Checker	Available (Paid)
Medical Chatbot	No Available
Score	**1/7**

Table 2.11: Pharm'Net evaluation.

2.2.4.3 Sante-dz

The Sante-dz platforms collectively serve as both a directory of healthcare professionals, a means of visibility for these professionals, and a repository of medical information. While the platforms offer functionalities for connecting with healthcare professionals, notably through the directory and discussion forums, these interactions are limited to informational purposes only. Table 2.12 below presents the evaluation of Sante-dz according to the assessment criteria.

Sante-dz	
Collaboration	No collaboration with patient
Telemedicine	0%
EHR Management	No Avalaible
Integrate to the Algerian NHIS	100%
Integration with medical devices	No Available
Drug Interaction Checker	No Available
Medical Chatbot	No Available
Score	**1/7**

Table 2.12: Sante-dz evaluation.

2.2.4.4 Updox

The strength of Updox lies in its versatility in terms of functionalities. Indeed, it offers a range of features designed for both healthcare professionals and patients. However, access to these services is only available in the United States. Table 2.13 below presents the evaluation of Updox according to the assessment criteria.

Updox	
Collaboration	Available
Telemedicine	100%
EHR Management	Avalaible
Integrate to the Algerian NHIS	No Integrated
Integration with medical devices	Available
Drug Interaction Checker	Available
Medical Chatbot	No Available
Score	**5/7**

Table 2.13: Updox evaluation.

2.2.4.5 Doctolib

The solutions provided by Doctolib are effective in allowing patients to manage their EMR themselves. These solutions offer the possibility of teleconsultation and sharing medical documents with healthcare professionals. Although anyone can use Doctolib, healthcare professionals are only available in the accessible regions mentioned. Table 2.14 below presents the evaluation of Doctolib according to the assessment criteria.

Doctolib	
Collaboration	Available
Telemedicine	40% (Teleconsultation and Teleassistance)
EHR Management	Avalaible
Integrate to the Algerian NHIS	No Integrated
Integration with medical devices	No Available
Drug Interaction Checker	No Available
Medical Chatbot	No Available
Score	**3.4/7**

Table 2.14: Doctolib evaluation.

2.2.4.6 Drugs.com

Drugs.com offers all the functionalities regarding drug information search and medication interaction checking. Being a CDSS and an OHIR, it remains a powerful tool for internet users. Table 2.15 below presents the evaluation of Drugs.com according to the assessment criteria.

Drugs.com	
Collaboration	No Available
Telemedicine	0%
EHR Management	No Avalaible
Integrate to the Algerian NHIS	No Integrated
Integration with medical devices	No Available
Drug Interaction Checker	Available
Medical Chatbot	No Available
Score	**1/7**

Table 2.15: Drugs.com evaluation.

2.2.4.7 Ada

Ada is a CDSS that implements a chatbot to assess symptoms. This information can be shared with healthcare professionals. Table 2.16 below presents the evaluation of Drugs.com according to the assessment criteria.

	Ada
Collaboration	No Available
Telemedicine	0%
EHR Management	No Avalaible
Integrate to the Algerian NHIS	No Integrated
Integration with medical devices	No Available
Drug Interaction Checker	No Available
Medical Chatbot	Available
Score	**1/7**

Table 2.16: Ada evaluation.

2.2.4.8 Synthesis and Comparison

The majority of the platforms mentioned above struggle to exceed the average score. While all these platforms perform well in accomplishing their tasks, few ensure collaboration between patients and healthcare professionals to enhance the quality of care. The scores of the various platforms evaluate them relative to the state-of-the-art in our context. Some manage to satisfy certain criteria while struggling to check the box for others. Table 2.17 below illustrates the comparison between the scores of the different platforms.

Comparison between related platforms' evaluation score	
Updox	**5**
Doctolib	**3.4**
DEM DZ	**3**
Pharm'Net	**1**
Sante-dz	**1**
Ada	**1**
Drugs.com	**1**

Table 2.17: Comparison table.

2.3 Conclusion

In summary, this literature review has allowed us to highlight major developments in the field of e-health in Algeria and worldwide. The key platforms studied within the context of our research exhibit shortcomings in facilitating effective collaboration between patients and healthcare professionals, despite their ability to efficiently accomplish tasks. This enabled us to compare the current literature with the achievement of our objectives.

We have also shed light on current techniques used to ensure interoperability in the healthcare domain. Among these techniques are medication interaction checking and medical chatbots utilizing NLP, along with ensuring integration through standards such as HL7 and DICOM, which play a crucial role in decision support, interoperability, and patient empowerment.

In conclusion, this review has provided us with the necessary foundation to understand the current state of e-health and the associated challenges. The following chapters will be motivated by achieving a score of 7/7 for our objectives. Armed with this comprehensive understanding, we are now ready to delve into the specifications of requirements in the next chapter titled "Requirements Specification."

Chapter 3
Requirements Specification

Chapter 3

Requirements Specification

Introduction

In project development, the requirements specification phase is crucial. It is during this phase that the expectations and needs of end users, as well as the technical and functional constraints of the project, are clearly and precisely defined. In this chapter, we will explore the needs expressed during surveys conducted as part of a market study, by the various stakeholders we will identify beforehand. We will also present the methodology used and the corresponding use case diagrams for each needs.

3.1 Market Study

As part of our market study aimed at understanding the trends and behaviors of different end users in the healthcare sector, we conducted face-to-face surveys during our literature review stages, complemented by online surveys on a small sample. The sample consisted of 51 individuals between the ages of 21 and 62, including both healthcare service consumers and healthcare professionals. The surveys were conducted using questionnaires that we prepared beforehand to better direct the responses towards our understanding objectives. In this section, we will present the justification for choosing key questions, an overview of the responses obtained, as well as some graphs from the online surveys (conducted with Google Forms).

3.1.1 Key Questions and Answers

A well-posed question leads to a satisfactory answer in terms of understanding. The following list is a non-exhaustive list of key questions we prepared and the answers obtained, these questions include:

3.1.1.1 Q1: "Dans le cadre de la prévention d'un patient quelconque, quel est le moyen de communiquer avec lui?"

Translation: As part of the prevention of any patient, what is the way to communicate with him?

Purpose: We asked this question to healthcare professionals to know what means they used to communicate with patients. The answers to this question will allow us to understand the relationship patients maintain with professionals outside of healthcare facilities.

Answers: The majority of responses to this question were via **"telephone means"**. Indeed, professionals are used to using phone calls and messaging to deliver information to patients.

3.1.1.2 Q2: "Dans le cadre du transfert d'un patient dans votre établissement ou la prise en charge d'un nouveau patient, avez-vous directement accès à son dossier médical?"

Translation: When transferring a patient to your establishment or taking care of a new patient, do you have direct access to their medical file?

Purpose: The purpose of this question was to find out if healthcare professionals had access to patients' medical history in the context of inter-establishment transfer or admission.

Answers: The majority of responses were "No", but professionals stated that they had a local medical file on the patient's visits to their establishment, although a minority responded that in the context of a transfer, the transferring center sent them the file, and in the case of a new patient's admission, they had to create a new medical file. Figure 3.1 illustrates the graph from the Google Forms sample responses.

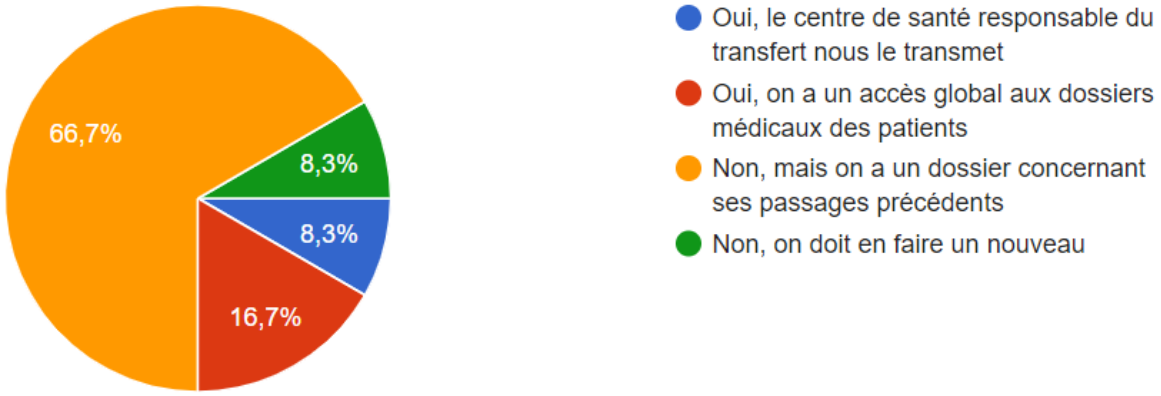


Figure 3.1: Q2 Answers graphic.

3.1.1.3 Q3: "Dans le cadre de la prise en charge d'un patient en urgence dont vous ne pouvez pas déduire l'état général à cause des circonstances d'absence d'accompagnateur fiable (proche), de l'impossibilité de communication avec le patient à cause de son état d'urgence, ou bien d'autres, comment traitez-vous ce cas?"

Translation: In the context of caring for an emergency patient whose general condition you cannot deduce due to the circumstances of absence of a reliable (close) companion, the impossibility of communication with the patient due to his state of emergency, or many others, how do you handle this case?

Purpose: This question aims to highlight the need for healthcare professionals to access medical history in emergency situations.

Answers: Although the patient's health is important and every treatment is meticulous in such conditions, the majority of professionals responded "Blindly" to this question. Some stated that a clinical examination was necessary, while others focused on eliminating the emergency while waiting for reliable information, which can be damaging when time is critical. Figure 3.2 illustrates the graph from the Google Forms sample responses.

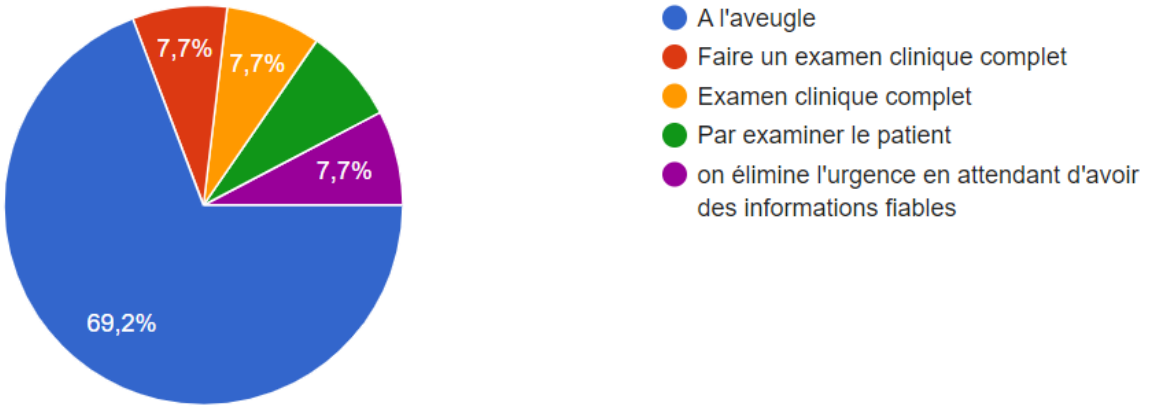


Figure 3.2: Q3 Answers graphic.

3.1.1.4 Q4: "Comment faites pour obtenir de l'information sur la santé?"

Translation: How do you get health information?

Purpose: This question aims to understand how healthcare service consumers obtain health information.

Answers: The responses to this question were distributed, in terms of percentage, between healthcare professionals' demand and the use of the Internet (discussion forums, informational websites, etc.) in two scenarios: in one, individuals stated that it was convenient, but some noted the difficulty in obtaining the desired answers; in the other case, seeking advice from relatives and using chatbots like ChatGPT, Ada, etc., were the responses of a minority of them. Figure 3.3 illustrates the graph from the Google Forms sample responses.

Figure 3.3: Q4 Answers graphic.

3.1.1.5 Q5: "Avez-vous déjà fait une analyse médicale (Radio, Écho, IRM, Labo, etc.)? Si oui comment avez-vous fait pour récupérer les résultats? Est-ce que cela a été pratique?"

Translation: Have you ever done a medical analysis (X-ray, Echo, MRI, Lab, etc.)? If so, how did you go about getting the results? Was this practical?

Purpose: This question, particularly aimed at healthcare service consumers, aims to understand the means used to obtain medical analysis results.

Answers: The majority of responses to this question likely indicated inconvenience in obtaining results. While some said it was impractical, most of them claimed to have adapted to this practice. Among the remaining responses, there was a minority who had experienced sending results via telephone means, admitting it was convenient, while others had never undergone medical tests. Figure 3.4 illustrates the graph from the Google Forms sample responses.

Figure 3.4: Q5 Answers graphic.

3.1.1.6 Q6: "Avez-vous déjà expérimenté une consultation médicale à distance? Si oui est-ce que cela a été pratique pour vous?"

Translation: Have you ever experienced a remote medical consultation? If so, was it practical for you?

Purpose: This question aims to determine if telemedicine is trending among healthcare service consumers.

Answers: The majority of individuals responded that they had never experienced remote medical consultation, while a minority stated that they had. Some claimed it was convenient, while others did not. Figure 3.5 illustrates the graph from the Google Forms sample responses.

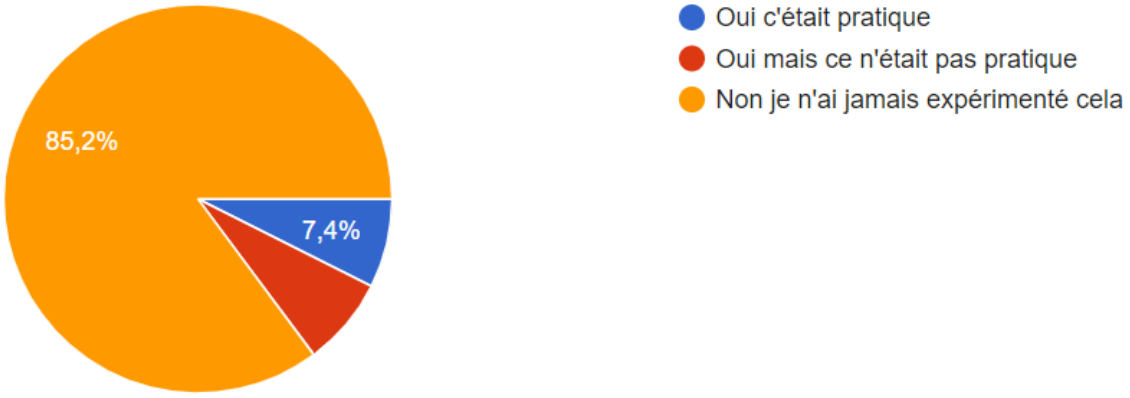


Figure 3.5: Q6 Answers graphic.

3.1.2 Synthesis and Conclusion

The market study allowed us to understand the current trends and needs expressed by users in the healthcare field. The responses to the various questions will guide the features offered by the system to satisfy these needs in terms of novelty and habituation.

3.1.2.1 Contribution of Responses to Requirements Specification

The responses to each question aim to specify a need such as:

- **Q1**: Ensure communication via telephone means (messaging, calls, etc.) between healthcare professionals and patients.
- **Q2 and Q3**: Ensure access and management of the patient's medical file regardless of the transfer or admission establishment and the patient's condition.
- **Q4, Q5, and Q6**: Ensure telehealth services such as information and education of various actors in the healthcare field and telemedicine.

With this foundation, the identification of different actors in the future system, as well as the functional and non-functional requirements it must meet, will be the subjects of the next section.

3.2 Scrum Methodology

Scrum represents an agile methodology providing a tailored approach to managing diverse projects with varying requirements. Its benefits include the flexibility to select requirements for sprints and the absence of rigid procedures to adhere to [12]. Within the Scrum framework, key roles include the Scrum Master, responsible for removing obstacles, the Product Owner, and the Scrum Team. This team is characterized by its cross-functional composition, including developers, testers, and other specialists from relevant domains, fostering the creation of adaptable and creative final products tailored to customer satisfaction. The Scrum process is based on 3 steps:

3.2.1 Product Backlog

The product backlog comprises requirements defined by the product owner, typically referred to as user stories. These requirements are then segmented into sprint backlogs, which are utilized during sprint planning to facilitate the completion of a sprint. Each day concludes with a daily scrum meeting, focusing on the progress of tasks assigned for that day.

3.2.2 Sprint

A sprint in Scrum is the fundamental unit of work, involving a small team focused on specific tasks, typically lasting between 1 to 3 weeks. The tasks for a sprint are determined by a sprint backlog, which documents all the requirements for the current sprint. The product backlog, curated by the product owner and consisting of user stories, serves as a repository of requirements. It is then segmented into sprint backlogs, which are used in sprint planning to outline methods for completing the sprint. Each day concludes with a daily scrum meeting aimed at tracking progress. The primary goal of each sprint is to deliver a potentially shippable product [12].

3.2.3 Sprint Review

3.2.3.0.1 Following each sprint, a sprint review is conducted to present a potentially shippable product. This entails a session with the product owner where the shippable product increment is demonstrated, marking the culmination of each sprint[12].

Figure 3.6 illustrate the scrum process.

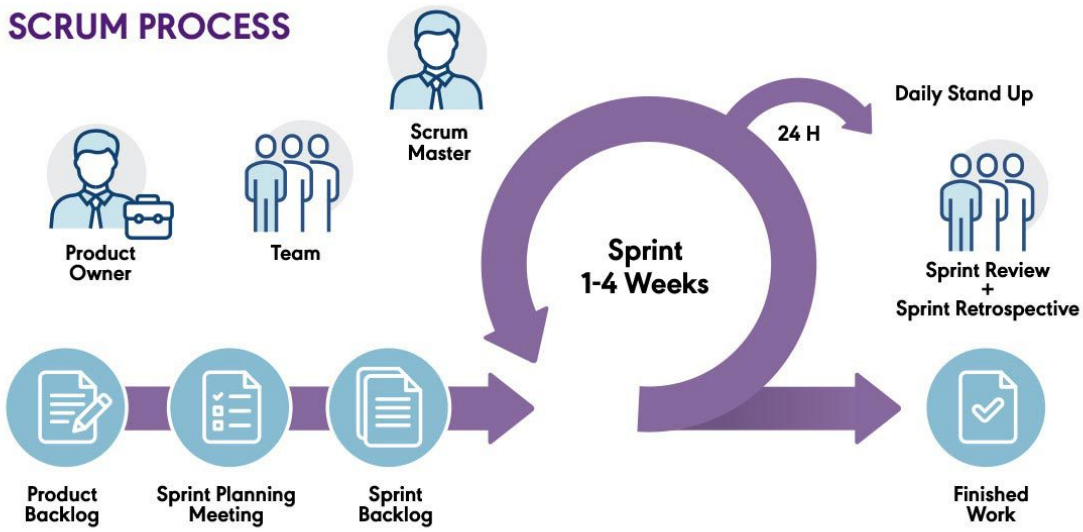


Figure 3.6: Scrum Process. From [7].

3.3 Requirements

In this section, we will identify all the stakeholders and potential users of the system to specify the functional needs related to each of them and the non-functional requirements for the system.

3.3.1 Actors Identification

An actor is the idealization of a role played by an external person, process, or thing that interacts with a system[79]. In our case, we identified 5 main users, namely:

- **Patient**: This is a person who receives or is awaiting to receive medical care within the healthcare management system. They interact with the system primarily to manage their appointments, access their medical records, access medical information via the chatbot, and receive notifications and reminders.
- **Doctor**: This is a healthcare professional who provides medical services to patients. They interact with the system to manage the PMR, provide telemedicine services, and access drug interaction detection tools.
- **Nurse**: This is a healthcare professional responsible for the daily care of patients, administering medications, monitoring patient conditions, and documenting care provided. They interact with the system to update the PMR, manage care schedules, and communicate with other healthcare professionals.
- **Paramedical Professional**: This is a healthcare professional responsible for the tests and analyses conducted for patients. They interact with the system to provide test results and analysis results in order to update the PMR.
- **Pharmacist**: This is a healthcare professional specialized in preparing, distributing, and managing medications. They interact with the system to verify prescriptions while accessing the drug interaction detection service, manage medication stocks, and provide medication advice to patients and other healthcare professionals.
- **Administrator**: This is a healthcare professional who has elevated privileges within the system. With these privileges, they can manage the healthcare facility to which they are affiliated as well as the staff of that facility.
- **Super Administrator**: This is a user with the highest privileges in the system. They are responsible for user management, system configuration, and activity monitoring.
- **Medical Device**: This is equipment used to diagnose, monitor, or treat patients. It interacts with the system to send patient condition data, receive treatment commands, or both.
- **Card Production System**: This is a system that produces identification cards for patients. It interacts with the system to receive information about new patients in order to create their medical cards.
- **Bank Service**: It's a banking system that allows online payments. It interacts with the system by providing connection interfaces.

Figure 3.7 illustrates the context diagram of the system showing the interactions between external actors and the system.

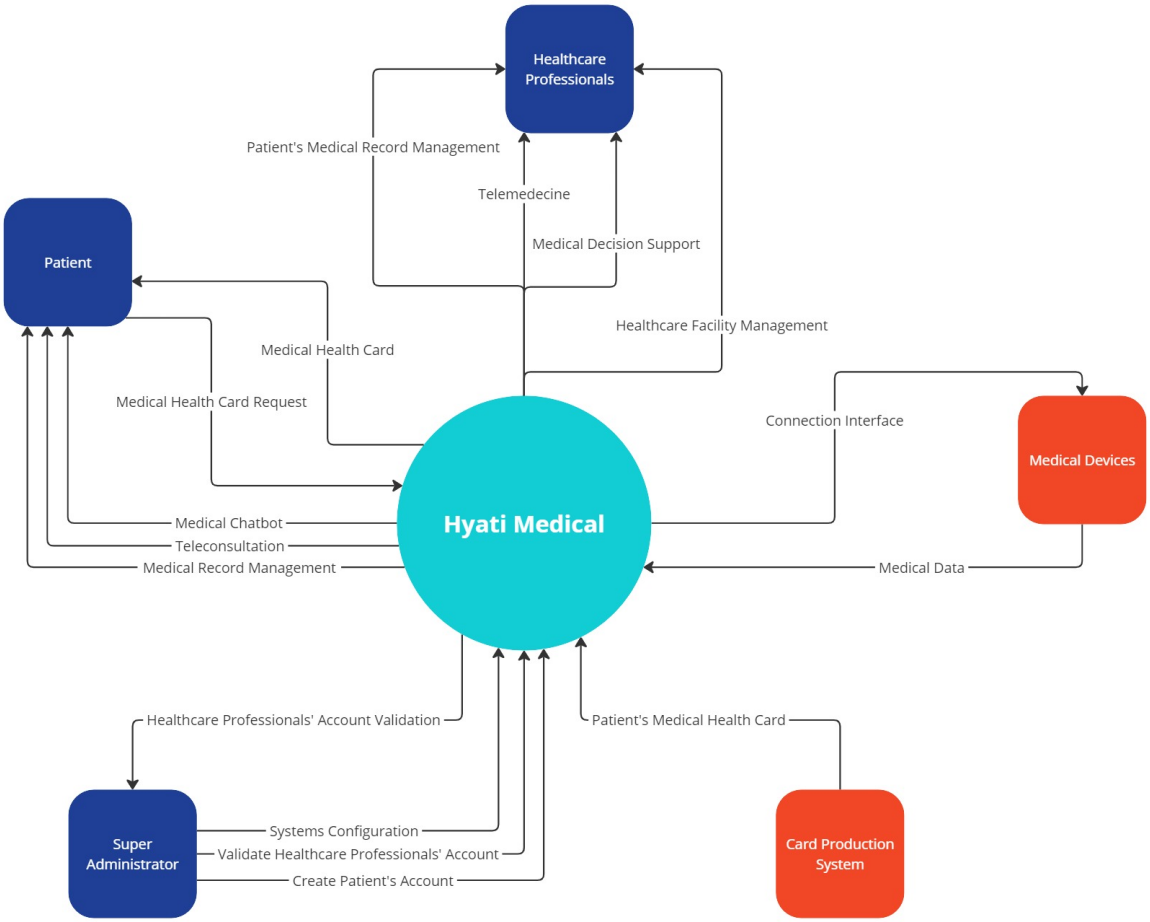


Figure 3.7: Context Diagram.

3.3.2 Functional Requirements

Our project aims to create two main platforms: a mobile one for Patients and a web one for Healthcare Professionals, Administrators, and a company for managing administrative procedures. The key functionalities offered to these various actors include:

- **For the Patient:**
  - He can request the creation of an account and receive a medical card.
  - He can log into their account and manage it.
  - He can access and manage their medical record.
  - He can search for and contact Healthcare Professionals.
  - He can request and manage appointments and teleconsultations.
  - He can request medical information from the system's chatbot.
  - He can access test results.
  - He can manage their medication intake.
- **In general for Healthcare Professionals:**
  - They can create an account and request account activation.
  - They can log into their account and manage it.

  - They can access and manage the PMR.
  - They can search for and contact Patients and other Healthcare Professionals.

- **Specifically for Doctor:**
  - He can provide teleconsultations and manage appointments.
  - He can make AI-assisted medication prescriptions for Patients.

- **Specifically for Pharmacist:**
  - He can manage the stock of their pharmacy.
  - He can access the list of medications consumed by Patients.
  - He can make AI-assisted medication prescriptions for Patients.

- **Specifically for Paramedical Professional:**
  - He can connect their medical device to the system.
  - He can send test and/or analysis results to Patients.

- **For the Administrator:**
  - He can manage the healthcare facility to which they are affiliated.
  - He can manage the staff of the healthcare facility to which they are affiliated.

- **For the Super Administrator:**
  - He can create Patient accounts.
  - He can validate Healthcare Professionals' accounts.
  - He can manage privileges.
  - He can access usage statistics of the various platforms.
  - He can manage the system configuration.

3.3.3 Non-functional Requirements

Non-functional requirements describe the qualities of the system. Here are the main non-functional requirements identified for our system:

1. **Performance**: The system must be able to respond quickly to user requests, even when subjected to high loads.
2. **Security**: The system must ensure the confidentiality and integrity of patient data in accordance with Algerian laws on protection [80, 81]. It must also be protected against unauthorized access and malicious attacks.
3. **Reliability**: The system must be reliable and available at all times, thus minimizing downtime and service interruptions.
4. **Usability**: The system's user interface must be intuitive and easy to use, to facilitate user adoption and reduce the need for training.
5. **Compatibility**: The system must be compatible with different web browsers and operating systems, to ensure maximum accessibility for users.

6. **Maintainability**: The system must be designed in a modular and easy-to-maintain manner, thus allowing for easy modifications and updates.

7. **Scalability**: The system must be scalable, capable of adapting to increasing numbers of users and the addition of new features in the future.

3.4 Use Case Diagrams

An UCD is an Unified Modeling Language (UML) diagram that graphically represents the functional requirements of a system by illustrating the interactions between users (actors) and the system itself. It describes the different ways in which users can use the system to accomplish specific tasks [79]. In this section, we will present the different use case diagrams related to each of the functional requirements presented above.

3.4.1 Patient's Use Case Diagrams

The system allows the patient to request the creation of an account and receive a medical card. Once logged in, the patient can manage their account, access and manage their medical record, and consult test analysis results. The patient has the ability to search for and contact healthcare professionals, request and manage appointments as well as teleconsultations. Additionally, they can obtain medical information via the system's chatbot and manage their medication intake.

Figure 3.8 illustrates the interactions in the System Society for account creation and obtaining login information and the medical card.

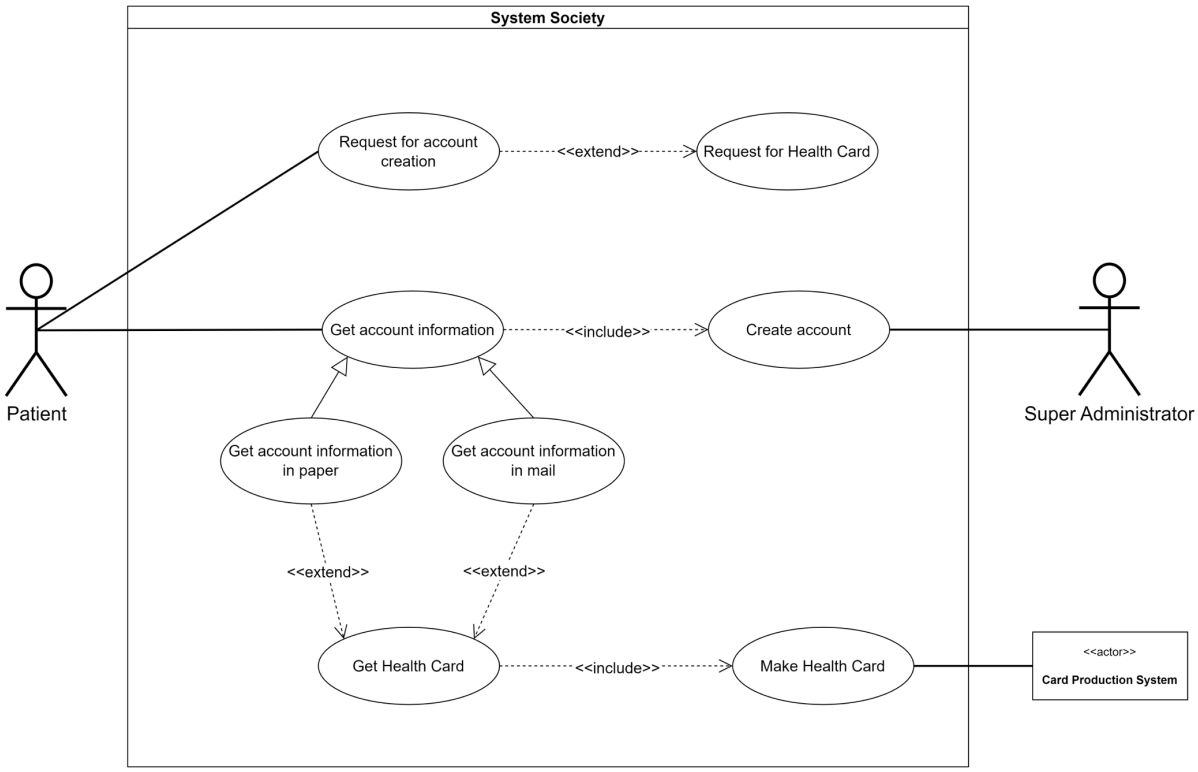


Figure 3.8: Patient's UCD #1: Get account.

Figure 3.9 illustrates all interactions between the Patient and the System Mobile App.

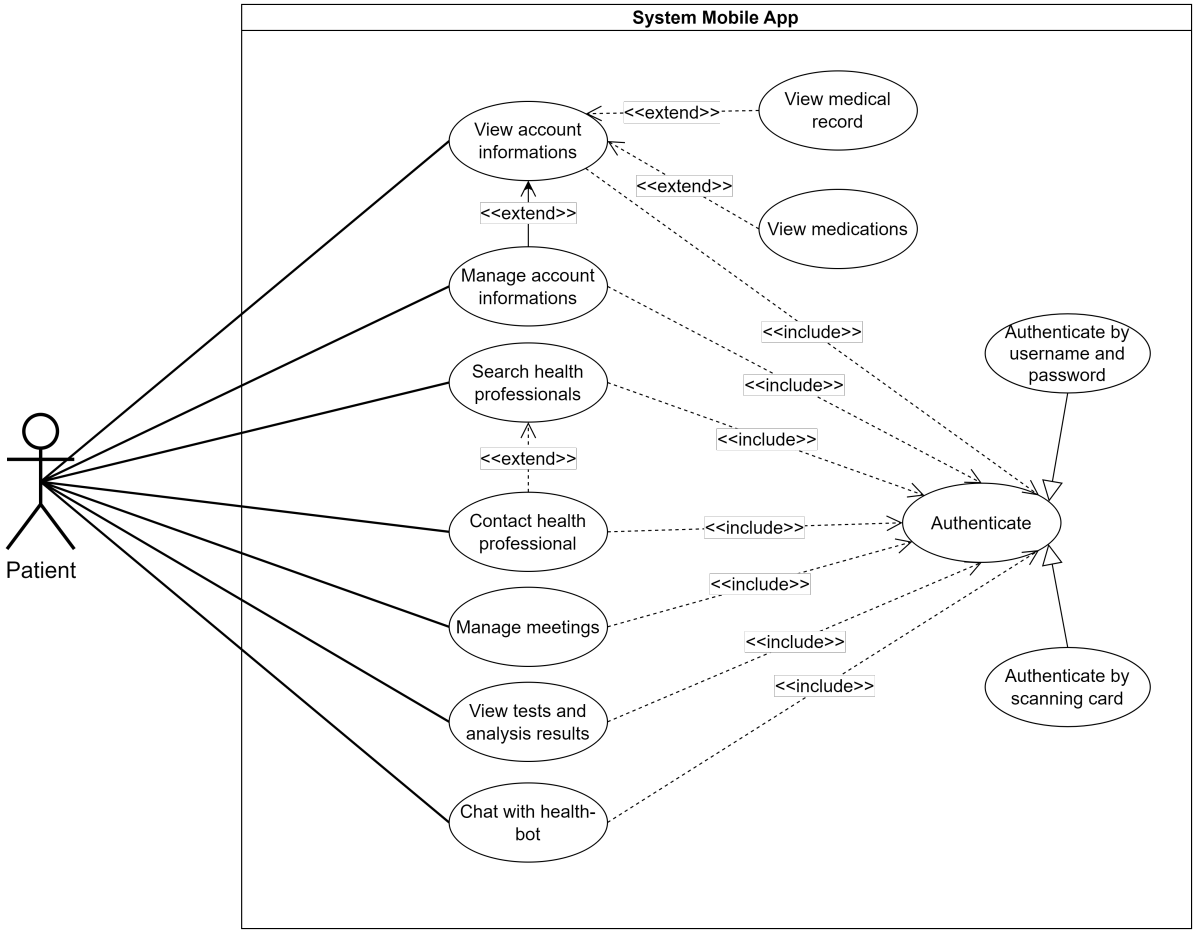


Figure 3.9: Patient's UCD #2: All System Mobile App use cases.

Figures 3.10, 3.11, and 3.12 illustrate interactions in the System Mobile App for managing the account and medical record.

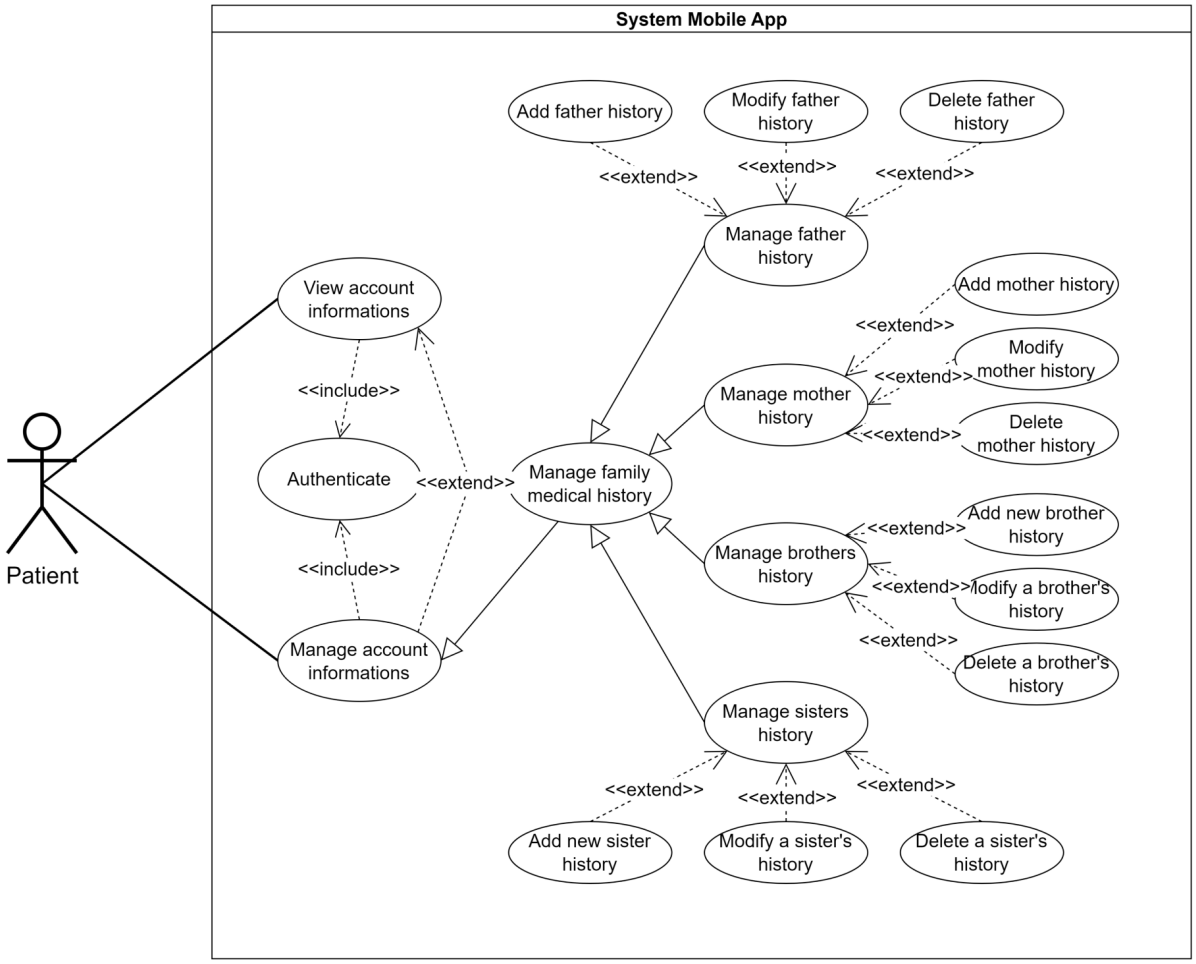


Figure 3.10: Patient's UCD #3.1: Account and Medical Record Management #1.

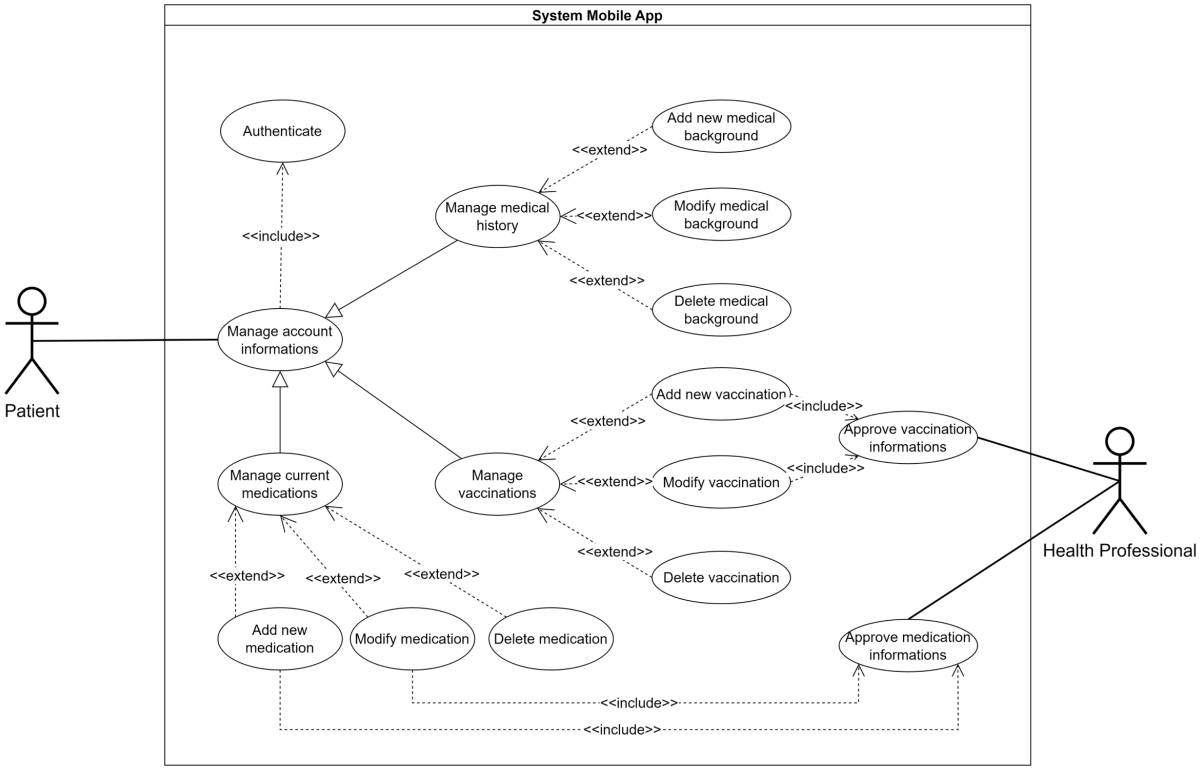


Figure 3.11: Patient's UCD #3.2: Account and Medical Record Management #2.

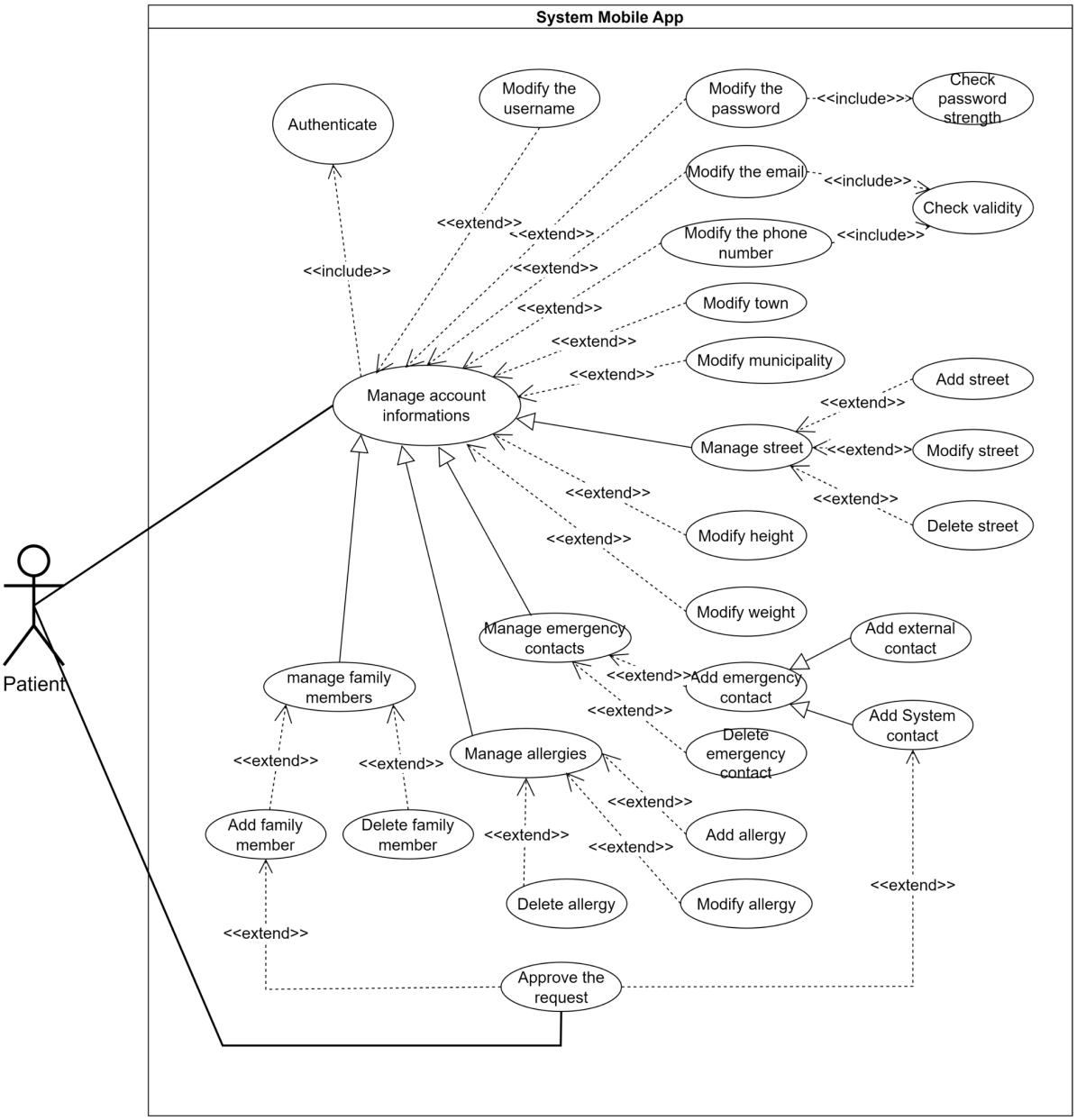


Figure 3.12: Patient's UCD #3.3: Account and Medical Record Management #3.

Figure 3.13 illustrates interactions for searching and contacting a healthcare professional.

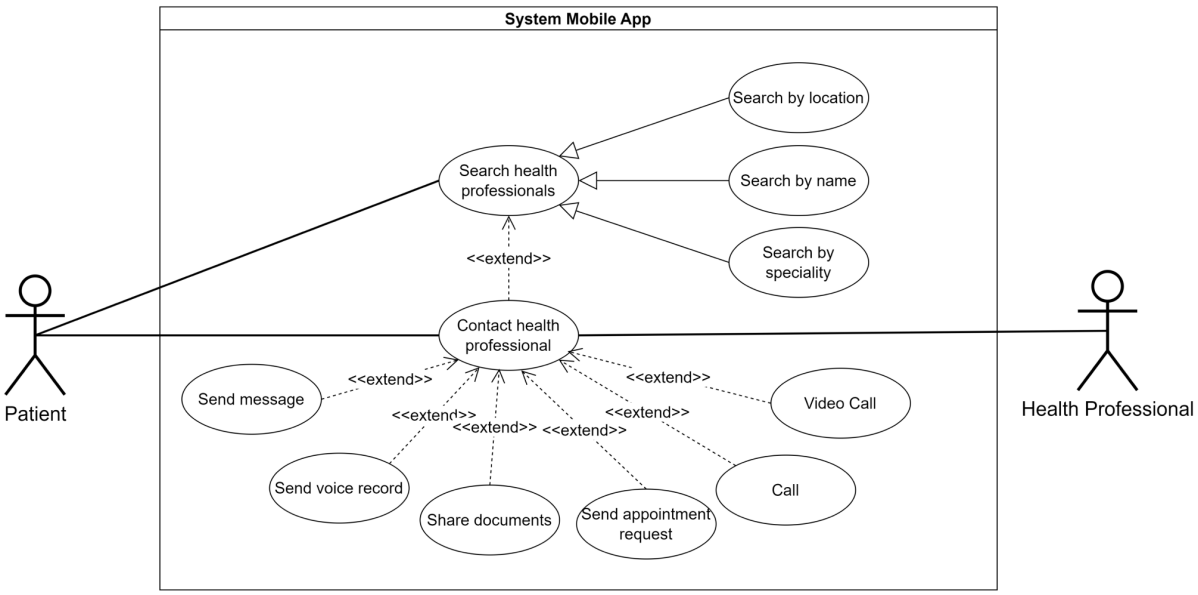


Figure 3.13: Patient's UCD #4: Search and Contact Health Professionals.

Figure 3.14 illustrates interactions for managing appointments and reporting an emergency.

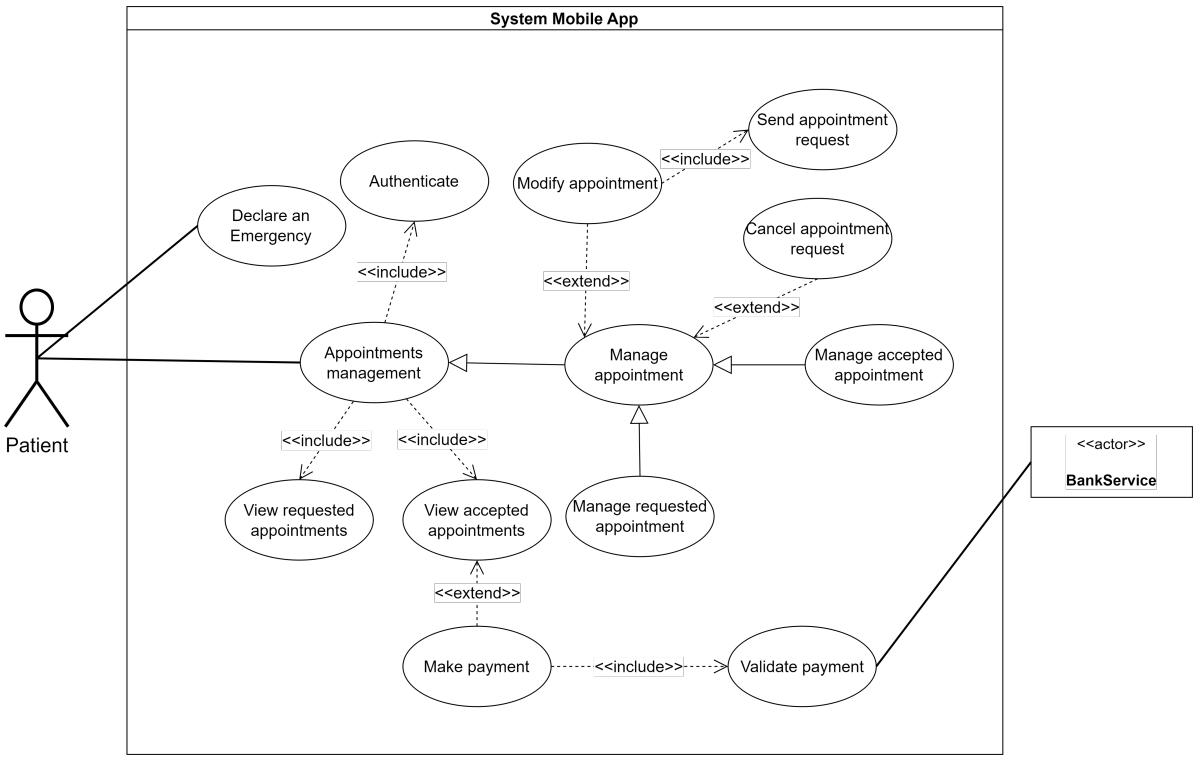


Figure 3.14: Patient's UCD #5: Appointments Management and Emergency Reporting.

3.4.2 Healthcare Professionals' Use Case Diagrams

Healthcare professionals can create and activate their account, log in, and manage their profile. They have access to the PMR (Patient Medical Record) which they can view and manage, and can search for and contact patients as well as other healthcare professionals.

Doctors have the ability to provide teleconsultations, manage appointments, and

make AI-assisted medication prescriptions for patients. Pharmacists can manage the stock of their pharmacy, access the list of medications consumed by patients, and also make AI-assisted medication prescriptions. Paramedical professionals can connect their medical devices to the system and send test or analysis results to patients.

Healthcare professionals are generalized by a single actor "Healthcare Professional". Figure 3.15 illustrates this generalization.

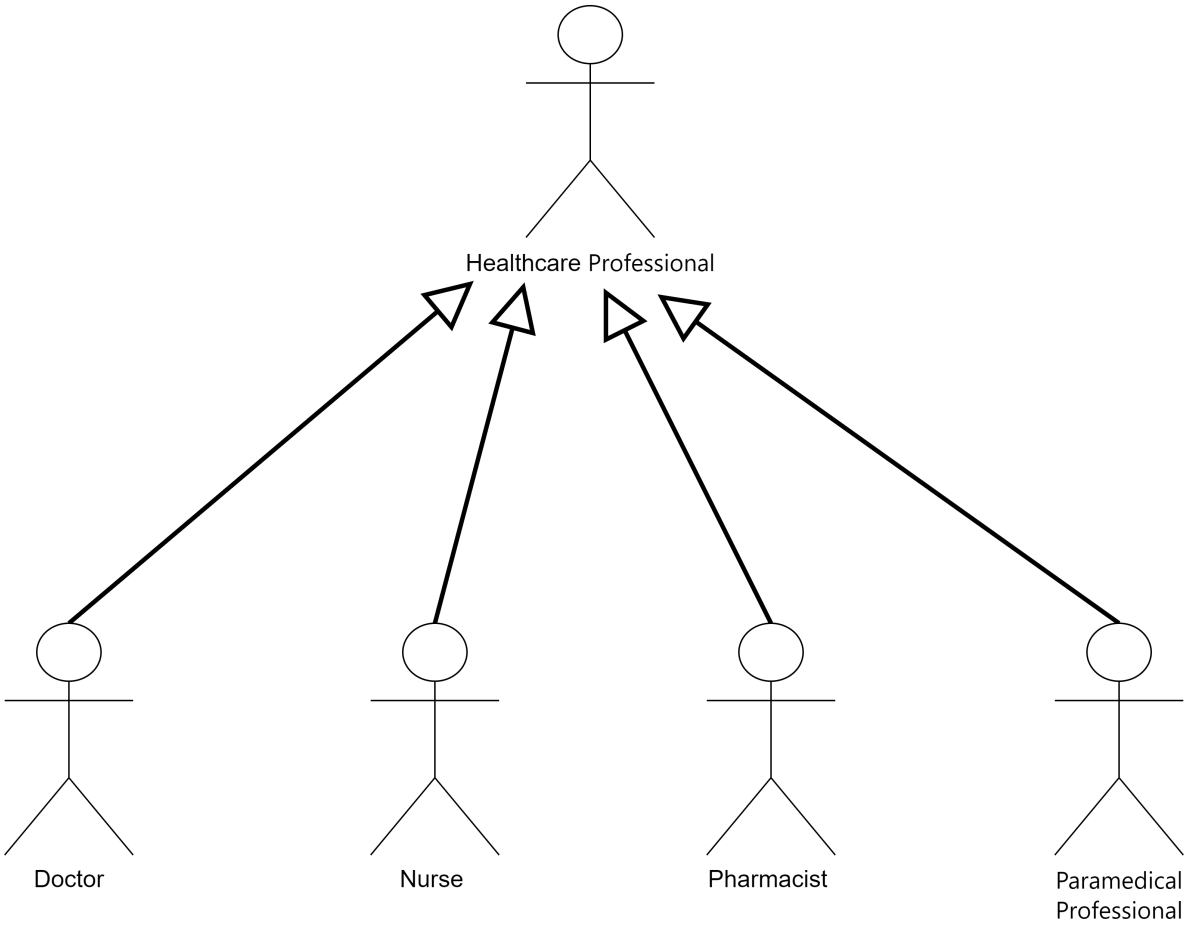


Figure 3.15: Healthcare Professionals Generalization.

Figure 3.16 illustrates all interactions between healthcare professionals and the System Web App.

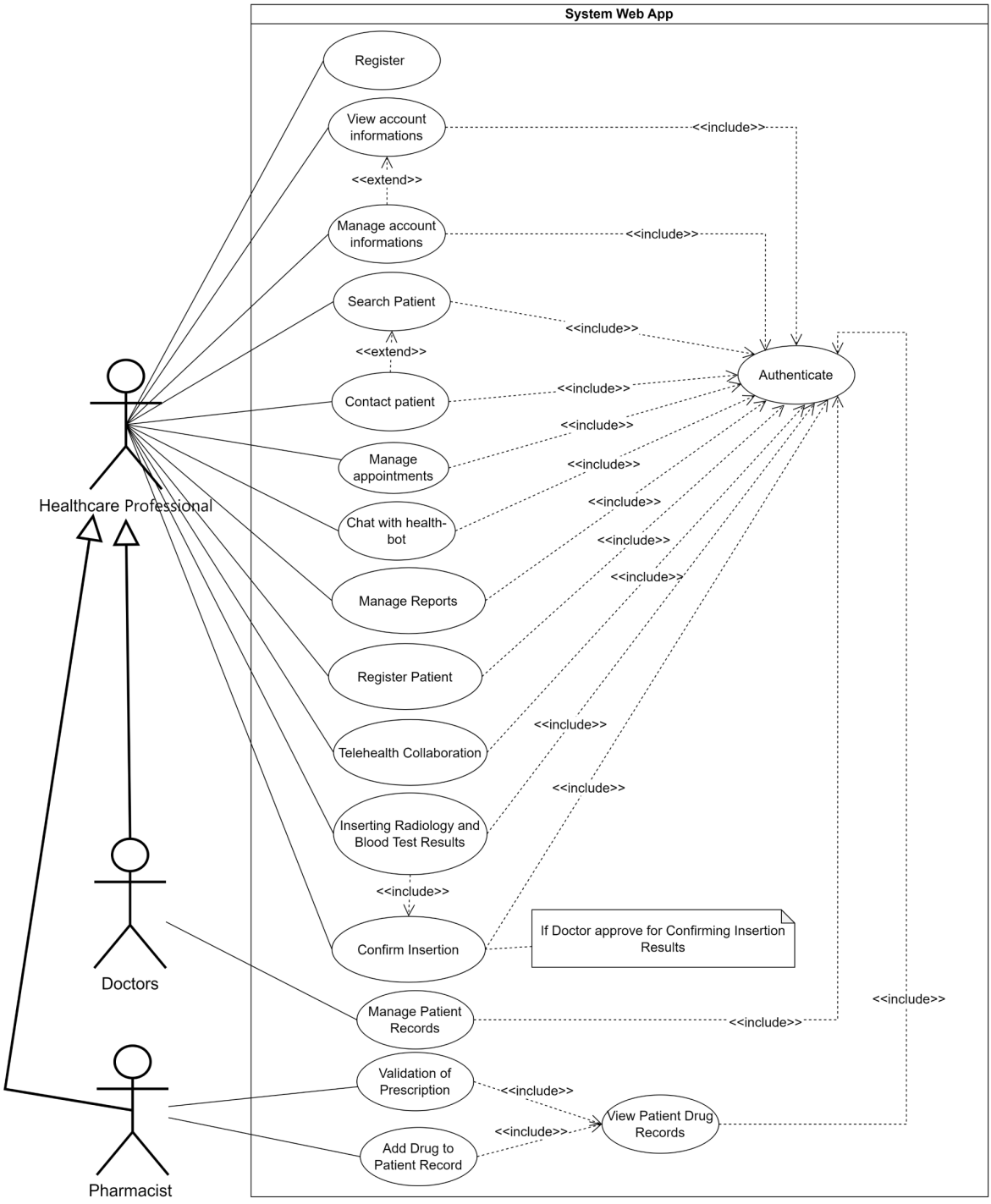


Figure 3.16: Healthcare Professionals' UCD #1: All System Web App use cases for Healthcare Professionals.

Figure 3.17 illustrates interactions between Healthcare Professionals and the System Web App for managing their account.

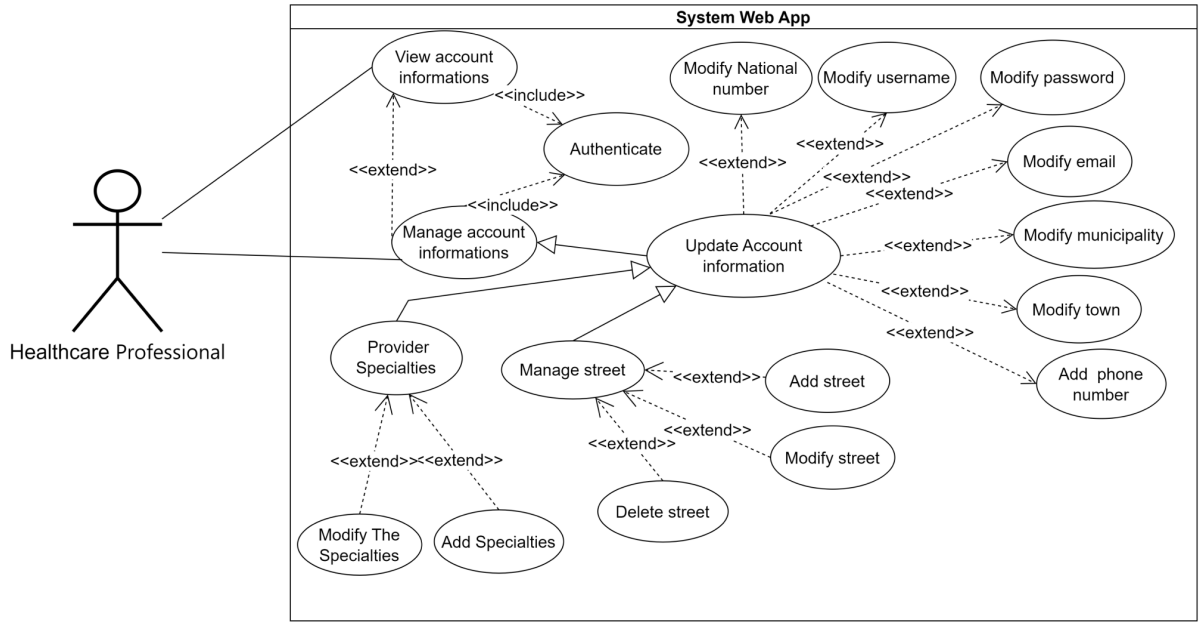


Figure 3.17: Healthcare Professionals' UCD #2: Account Management.

Figures 3.18 and 3.19 illustrate interactions for searching for Patients and Healthcare Professionals, and contacting them.

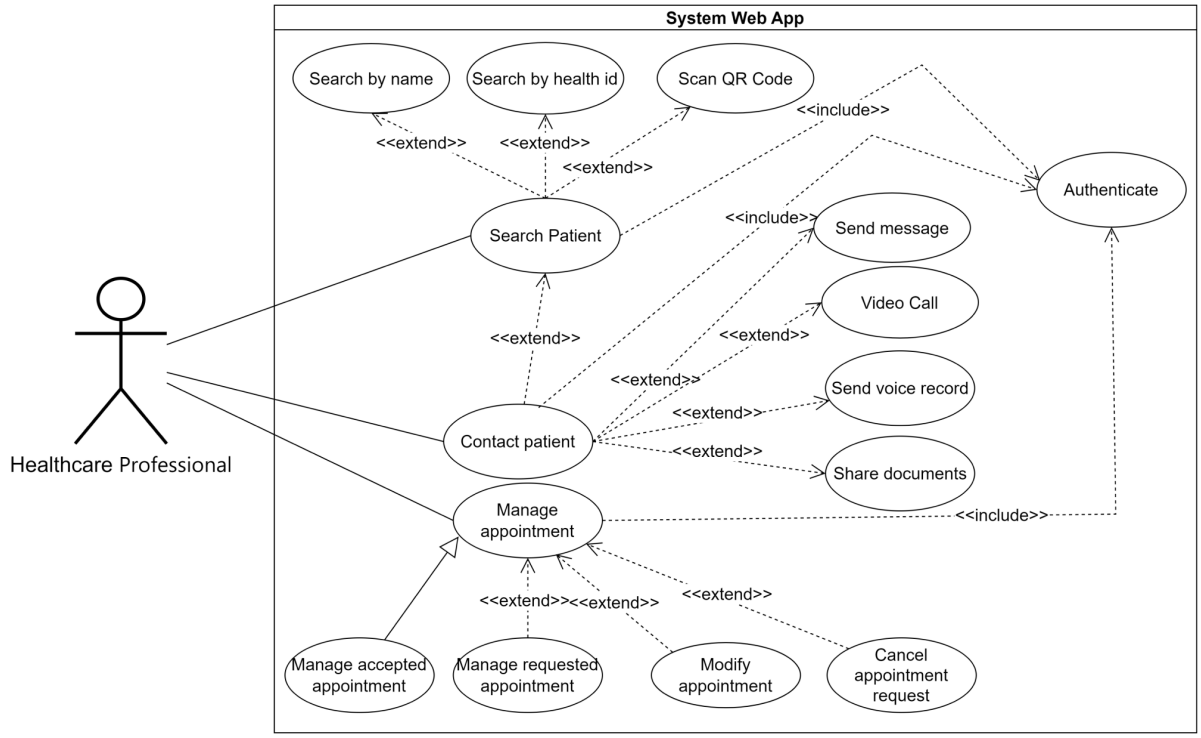


Figure 3.18: Healthcare Professionals' UCD #3: Search Patient and Contact him.

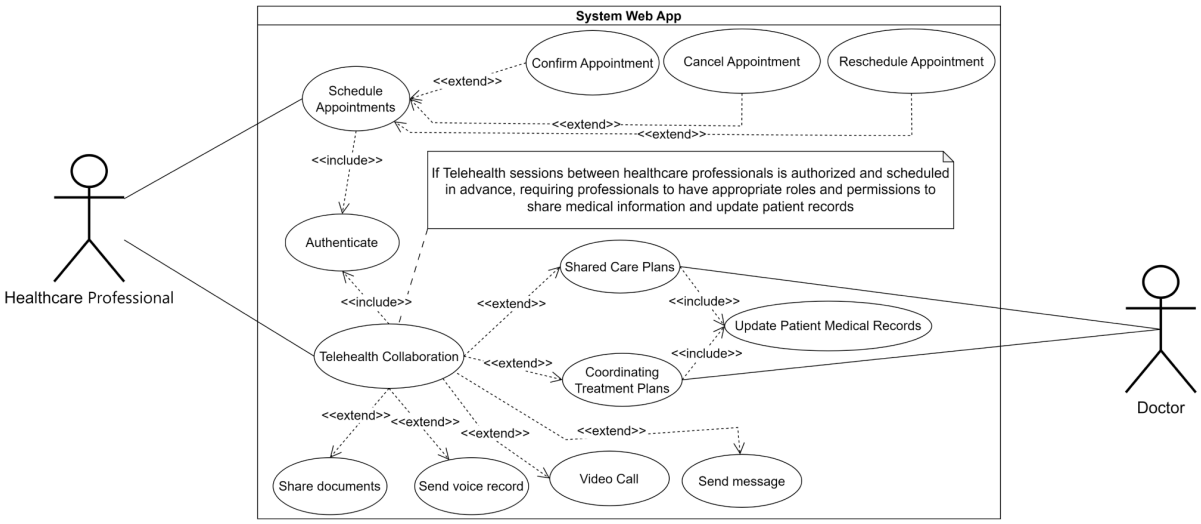


Figure 3.19: Healthcare Professionals' UCD #4: Collaborate with Professionals.

Figures 3.20 and 3.21 illustrate interactions for managing the PMRs.

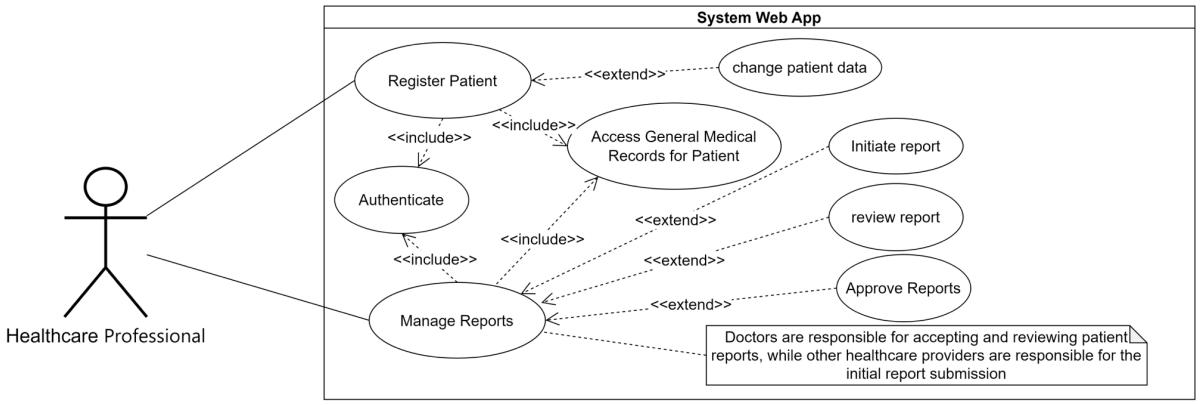


Figure 3.20: Healthcare Professionals' UCD #5: PMRs Management #1.

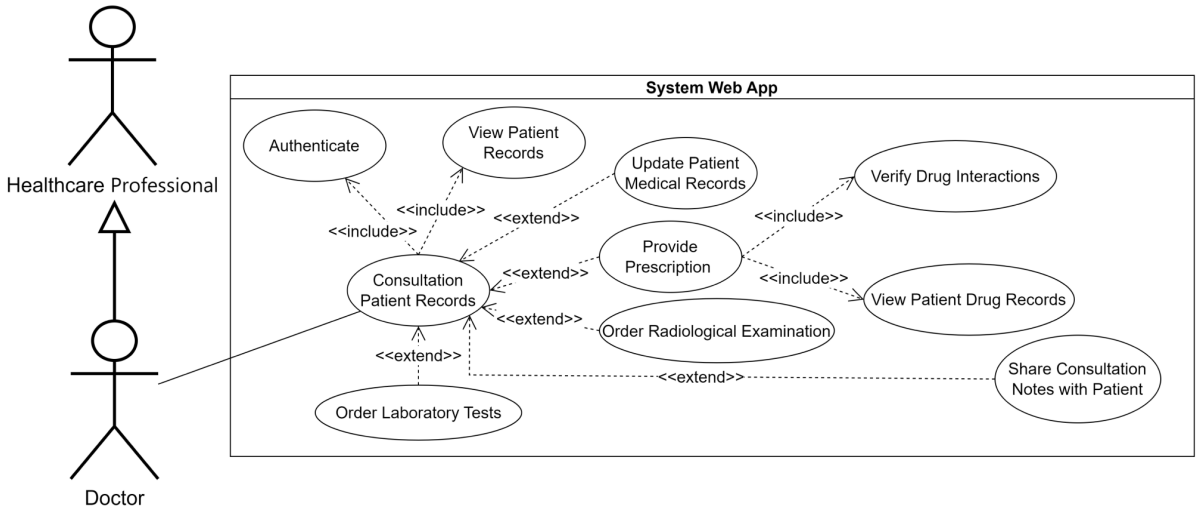


Figure 3.21: Healthcare Professionals' UCD #6: PMRs Management #2.

3.4.3 Administrators' Use Case Diagrams

Administrators can manage the healthcare facility and the affiliated personnel. Super administrators have extended responsibilities, including creating accounts for patients, validating healthcare professionals' accounts, managing privileges, accessing statistics of platform usage, and configuring the system. Figure 3.22 illustrates all interactions between the two types of Administrators and the System Web App.

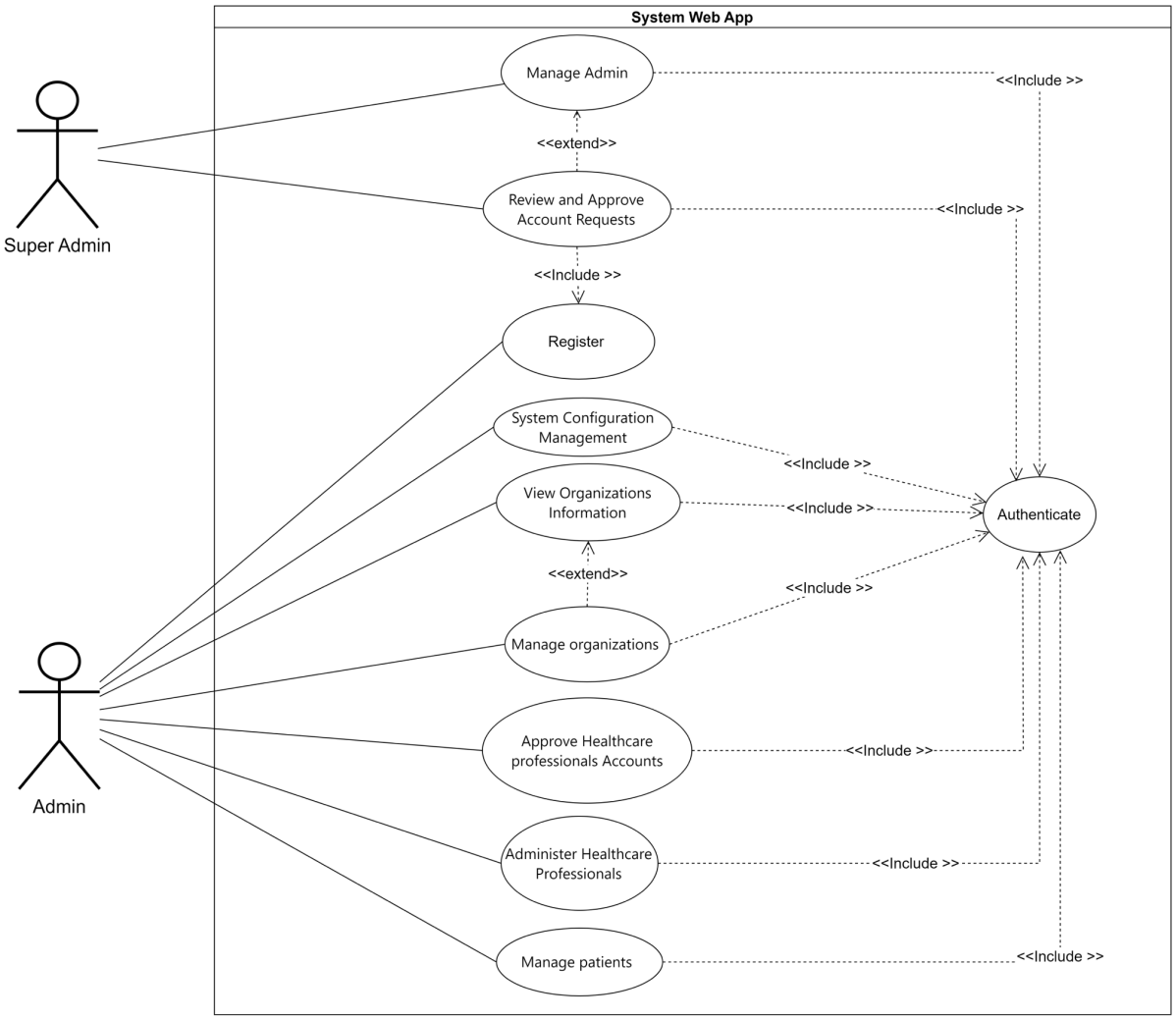


Figure 3.22: Administrators' UCD #1: All System Web App use cases for Administrators.

Figures 3.23, 3.24, and 3.25 illustrate interactions between the Super Administrator and the System Web App for user and privilege management.

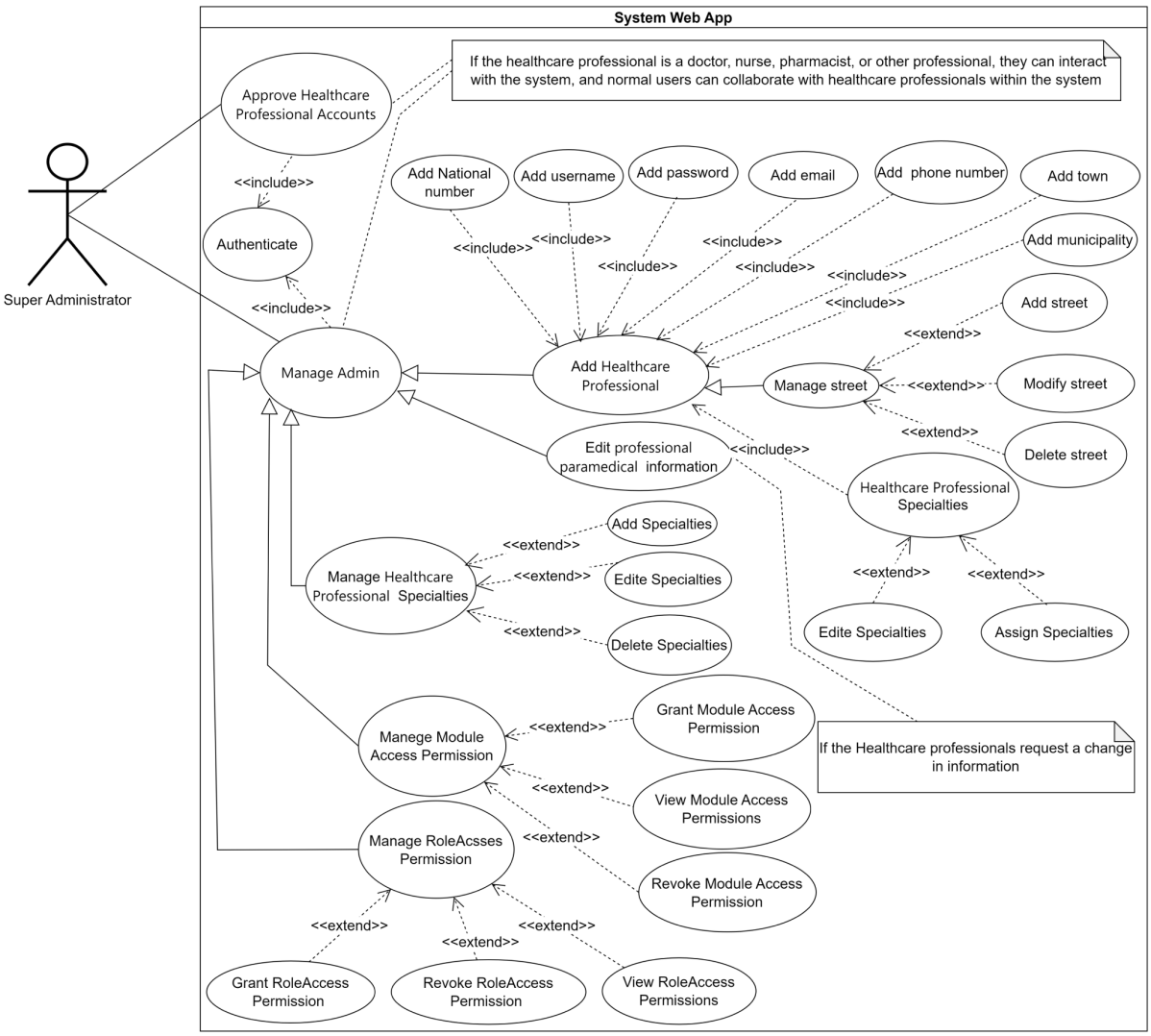


Figure 3.23: Administrators' UCD #2: Users Management #1.

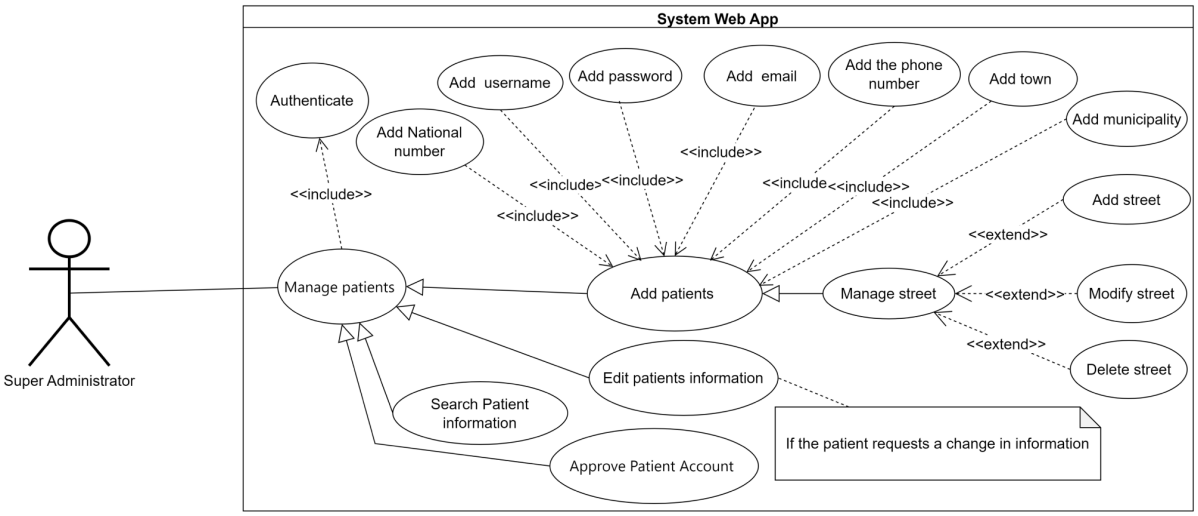


Figure 3.24: Administrators' UCD #3: Users Management #2.

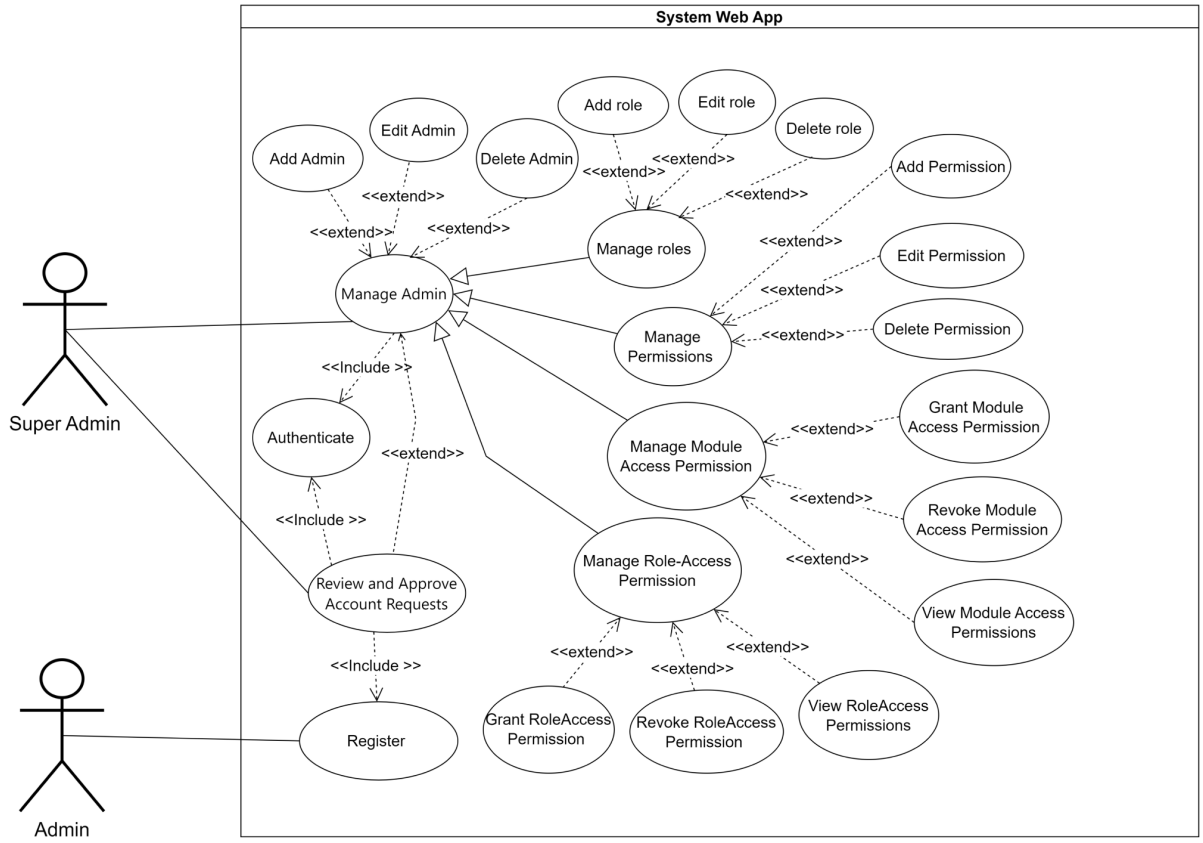


Figure 3.25: Administrators' UCD #4: Users Management #3.

Figure 3.26 illustrates interactions between the Administrator and the System Web App for managing the healthcare facility and affiliated personnel.

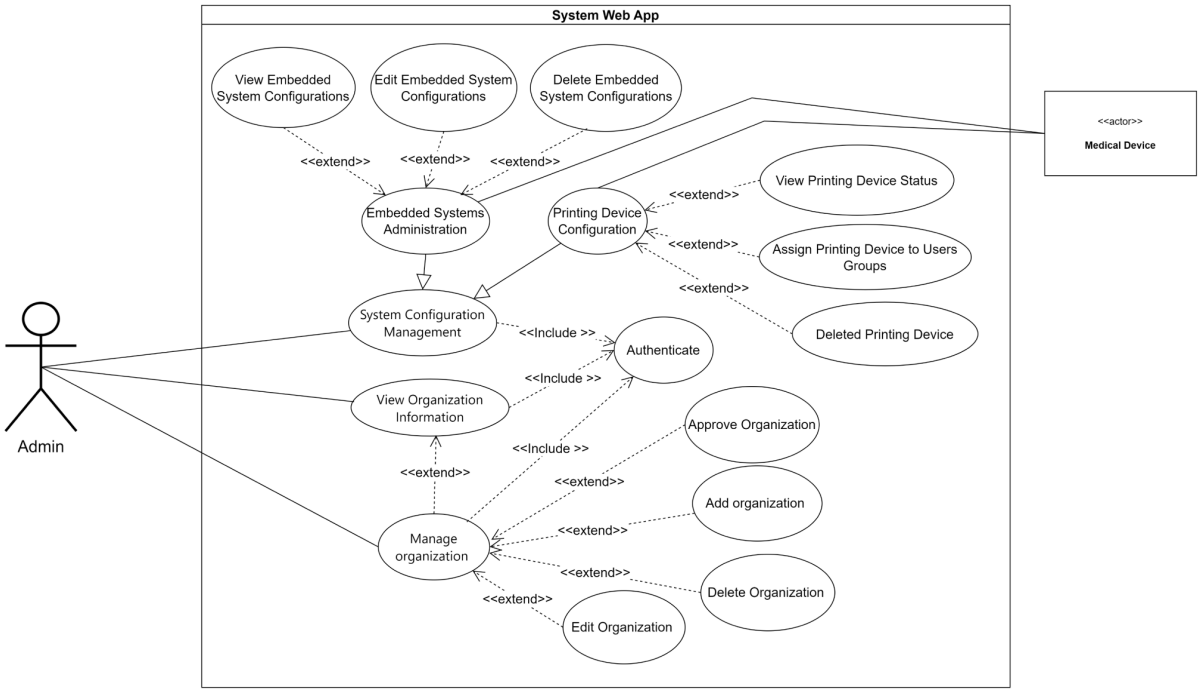


Figure 3.26: Administrators' UCD #5: Organization Management.

Conclusion

In summary, this chapter has extensively presented the various functional and non-functional requirements, the method of identifying these requirements, as well as the context diagram and the use case diagrams for our system. Through these diagrams, we have examined the various interactions among the system actors, such as patients, healthcare professionals, administrators, super administrators, and the system itself.

These diagrams provide an overview of the system's functionalities and interactions, thus laying a solid foundation for the analysis and design, which will be the subject of the next chapter, and the implementation of our system that follows.

Chapter 4
Analysis and Design

Chapter 4

Analysis and Design

Introduction

Analysis and Design is a stage that follows the Requirements Specification, where the needs and functionalities of the system have been defined. Its objective is to transform these requirements into a detailed architecture and precise design that will serve as a foundation for the system's implementation. In this chapter, we will start with the development of the conceptual model using class diagrams. Next, we will detail the dynamic interactions of some key features through sequence diagrams. Finally, we will describe the overall system architecture, including the database schema, main components, and their interactions. We will also present the UX/UI design to provide a prototypes overview of the future system. Then we will finish with the presentation of the BMC. These elements will provide a solid foundation for the implementation phase, ensuring that the system will be built in a consistent and efficient manner.

4.1 Class Diagram

The class diagram is considered to be the most important diagram when designing a system, as it is the only one that is mandatory in modelling. It is used to represent the classes that the system uses, as well as their links, whether these represent a conceptual nesting (inheritance) or an organic relationship (aggregation). 'A class is the formal description of a set of objects with common semantics and characteristics'. [79]. The figure 4.1 shows the class diagram for the system.

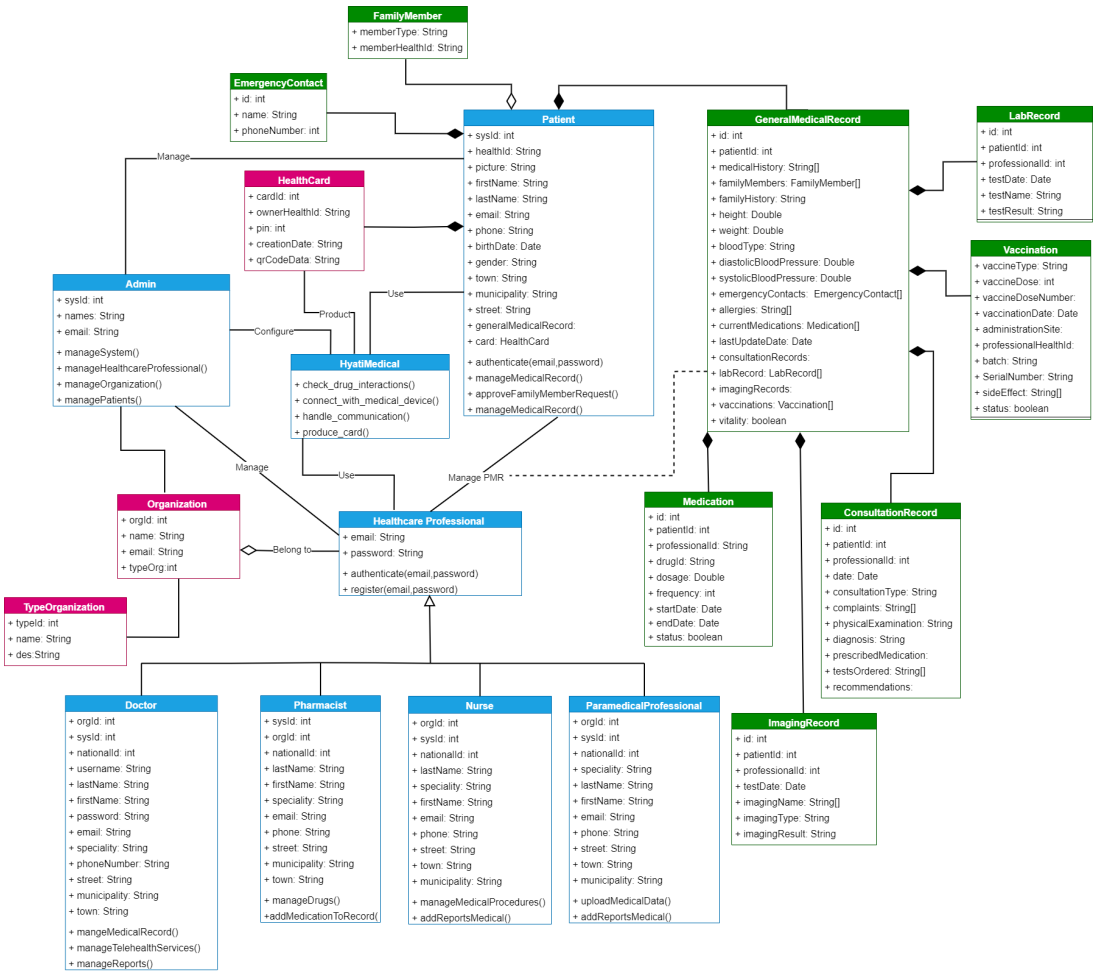


Figure 4.1: Class Diagram.

4.2 Sequence Diagram

The sequence diagram is a behavioral UML diagram representing the chronological sequence of operations performed by an actor. It shows the objects the actor will manipulate and the operations that transition from one object to another [79]. The sequence diagram of certain key and complex functionalities can be beneficial in understanding the process of executing these functionalities. Among these functionalities, we notably include:

- **The appointment request and approval functionality** : This feature, from the appointment request by the Patient to its approval by the Healthcare Professional, highlights teleconsultation services. Figures 4.2 et 4.3 illustrate the different interactions during this process.

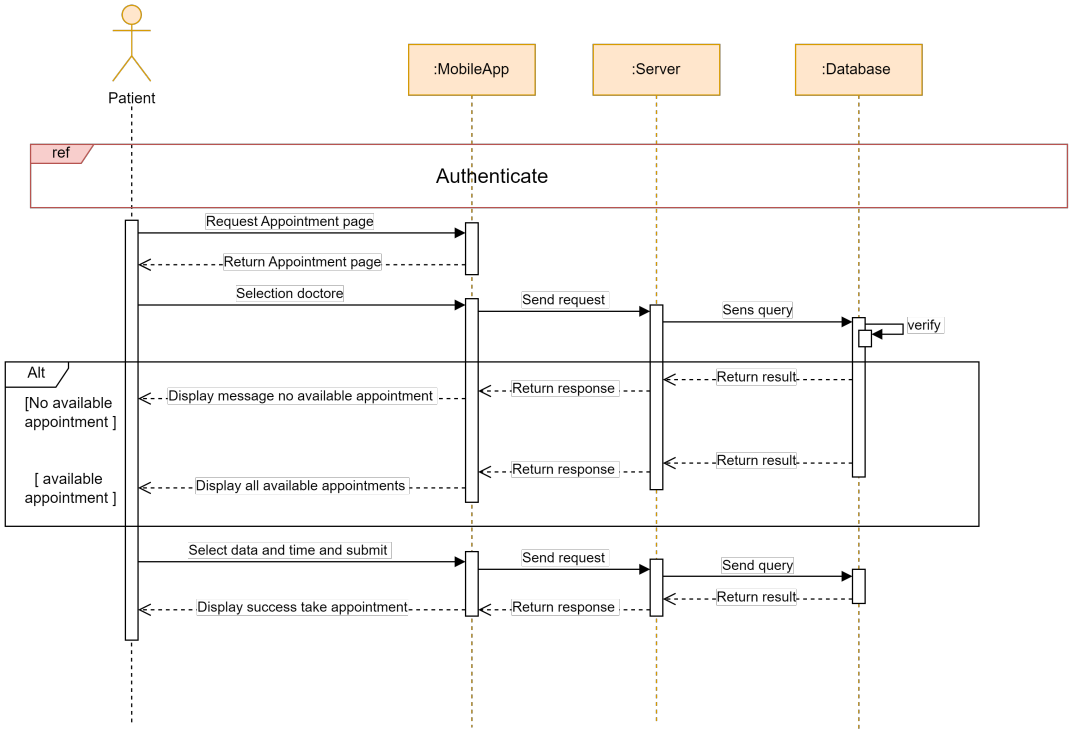


Figure 4.2: Appointments Sequence Diagram #1.

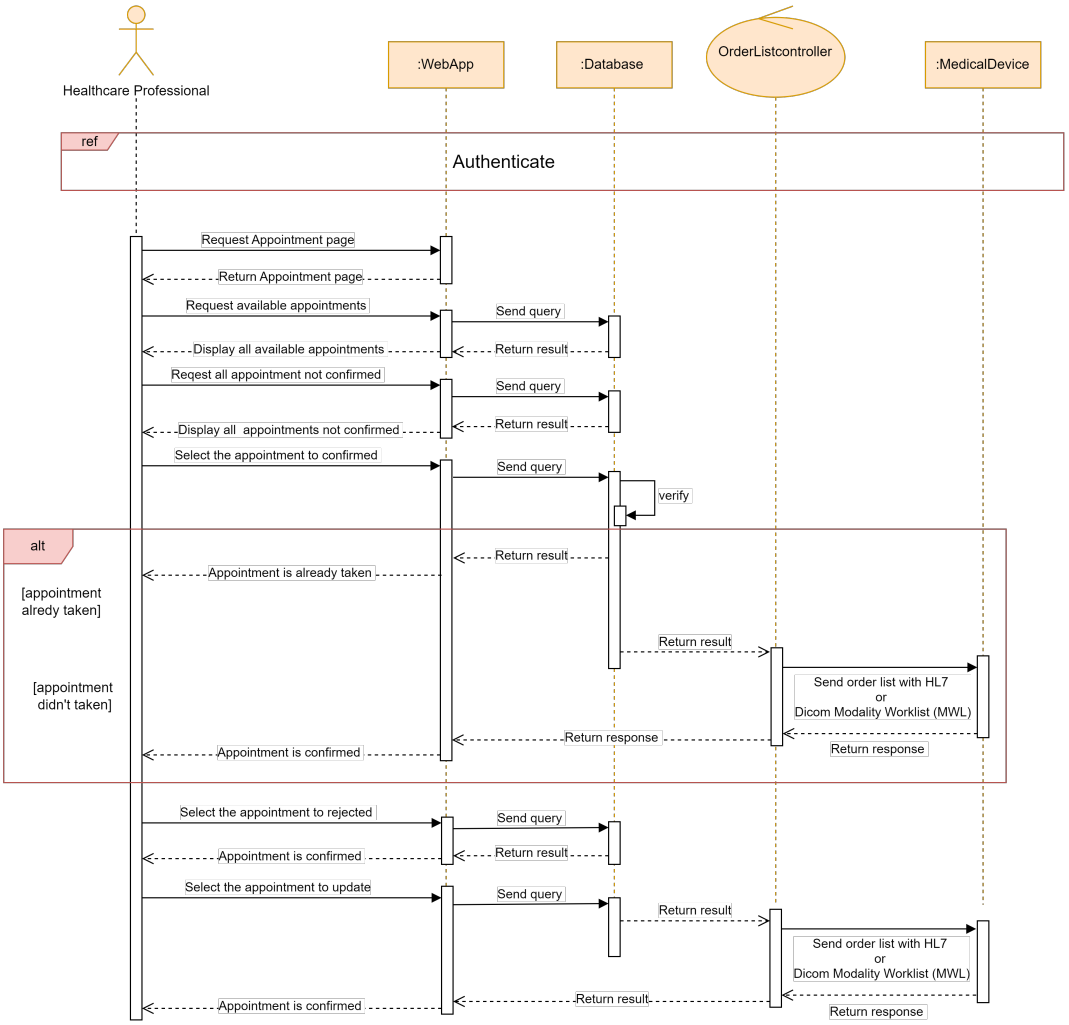


Figure 4.3: Appointments Sequence Diagram #2.

- **The medication prescription functionality for the Patient**: It highlights the ability of healthcare professionals such as Doctors and Pharmacists to prescribe medication to the Patient. The interaction emphasizes the drug interaction check to aid decision-making regarding the medication prescription. Figure 4.4 illustrates the different interactions during this process.

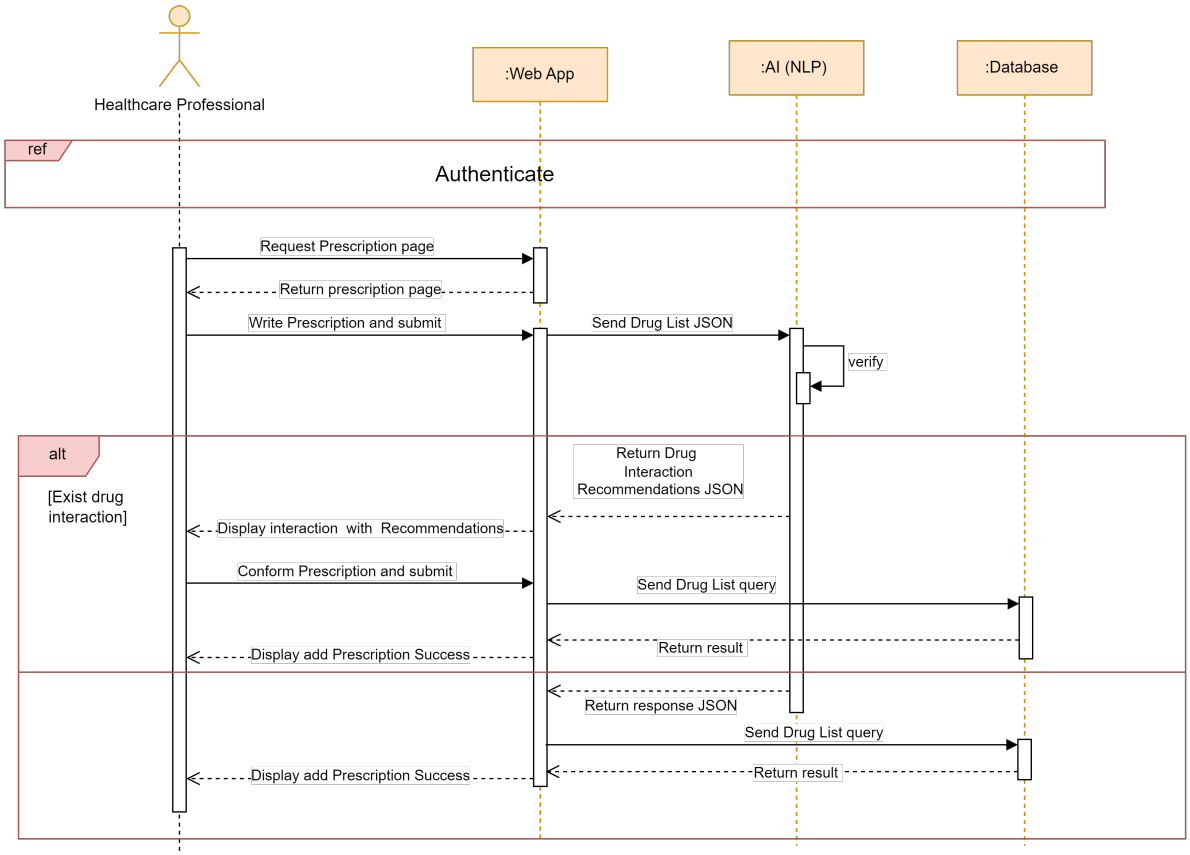


Figure 4.4: Prescription Sequence Diagram.

- **The system configuration functionality**: It highlights the interactions involved in configuring the system by the Administrator. Figure 4.5 illustrates the different interactions in this process.

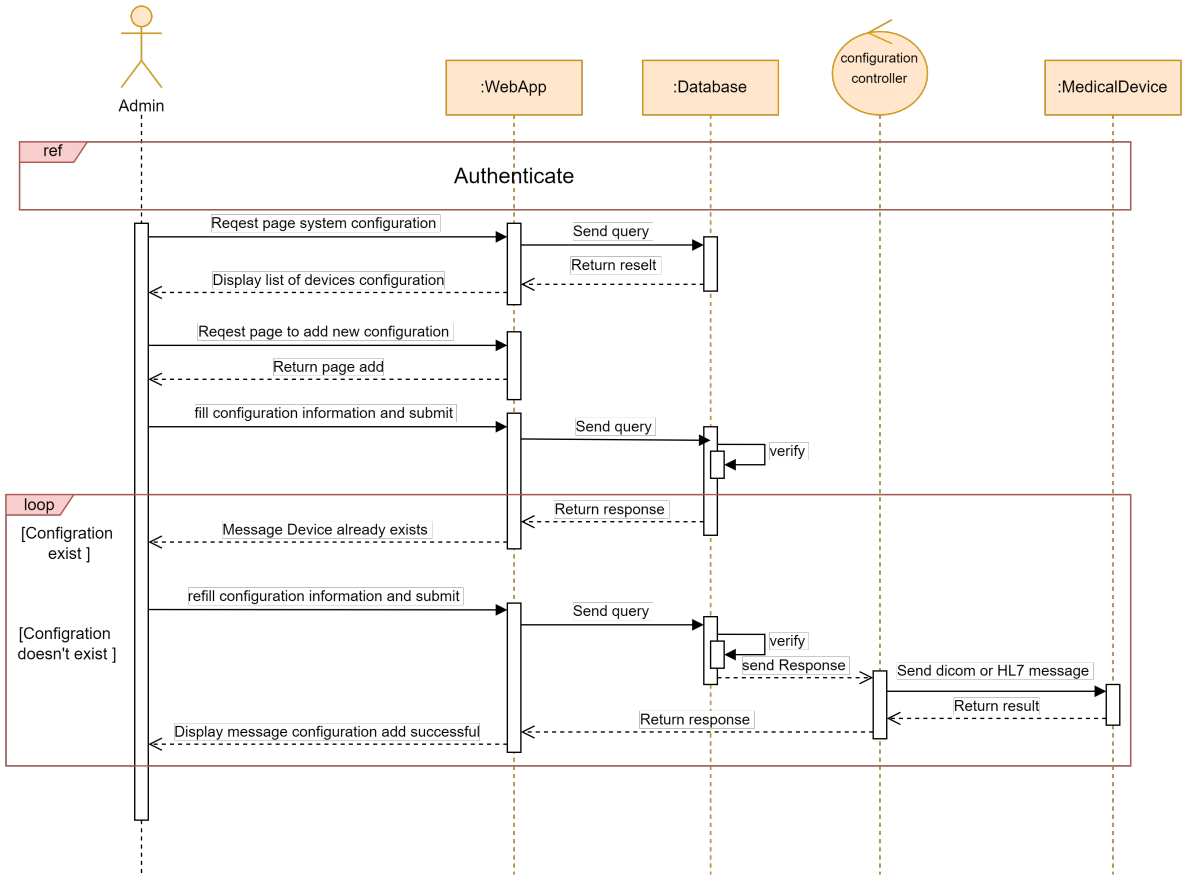


Figure 4.5: System Configuration Sequence Diagram.

4.3 System Architecture

The system architecture forms the technical foundation upon which the entire functioning of our system rests. At the start of our project, we opted for a classic client-server architecture, with authentication for Healthcare Professionals and Administrators based on our own infrastructure. However, as development progressed, we decided to migrate to a serverless architecture, using Google Firebase for Patient authentication and automatic server-side infrastructure management. This decision was driven by time constraints and the need to simplify infrastructure management. Among the multiple advantages of adopting this type of architecture, we can include:

- **Reduction of Complexity**: By delegating authentication to Firebase, we simplified our architecture and reduced the burden of infrastructure management.
- **Improved Scalability**: Firebase enables automatic scalability, ensuring that our application can rapidly increase the number of users without manual intervention.
- **Time Savings**: Using Firebase's integrated services allowed us to develop and deploy more quickly, meeting our tight deadlines.

Figure **??** illustrates the final system architecture.

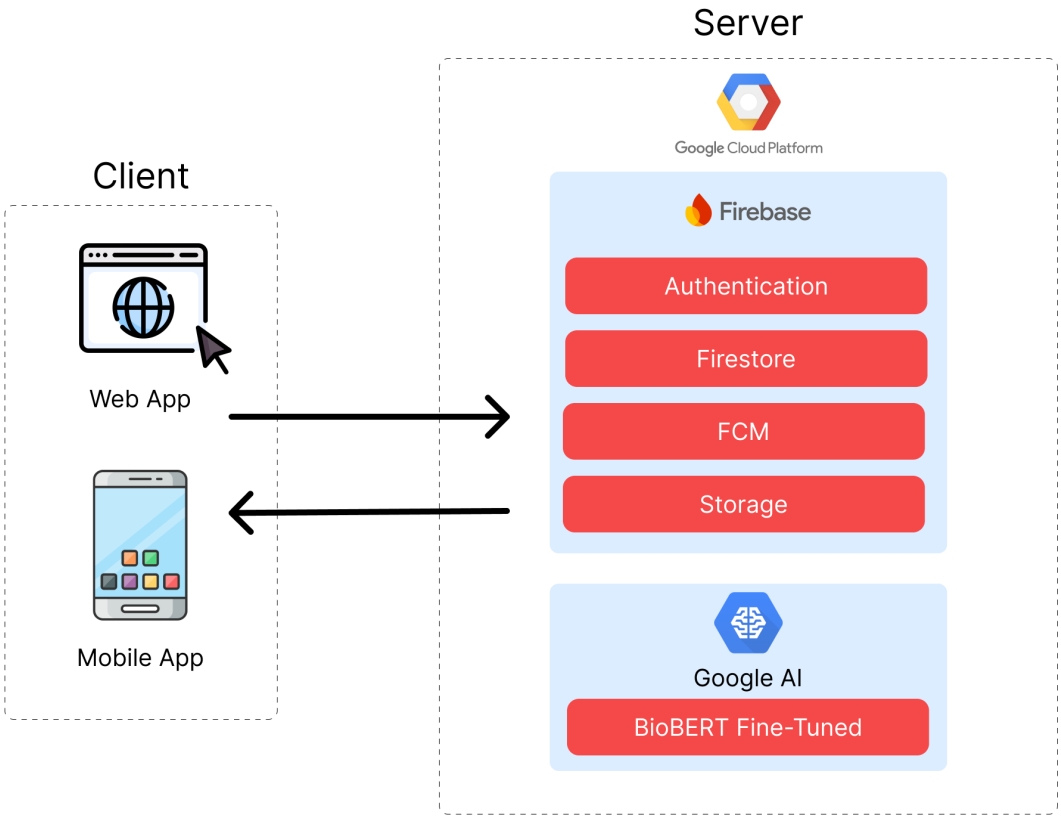


Figure 4.6: System Architecture.

4.3.1 Database Structure

The Firestore database in Firebase is a Not Only SQL (NoSQL) database based on collections of documents. These documents are represented as JavaScript Object Notation (JSON) objects. Code 4.1 is an example of the structure of a document in the "patients" collection.

```
{
  "id": "string",
  "healthId": "string",
  "picture": "string",
  "firstName": "string",
  "lastName": "string",
  "email": "string",
  "phoneNumber": "string",
  "birthDate": 0,
  "gender": "string",
  "town": "string",
  "municipality": "string",
  "street": "string",
  "generalMedicalRecord": {
    "medicalHistory": ["string"],
```

```
        "fatherHealthId": "string",
        "motherHealthId": "string",
        "familyHistory": "string",
        "bloodType": "string",
        "metrics": [
          {
            "heightInCentimeter": 0.0,
            "weightInKilogram": 0.0,
            "systolicBloodPressure": 0.0,
            "diastolicBloodPressure": 0.0,
            "measureDate": 0
          }
        ],
        "emergencyContacts": [
          {
            "names": "string",
            "phoneNumber": "string"
          }
        ],
        "allergies": ["string"],
        "currentMedications": [
          {
            "professionalId": "string",
            "drugId": "string",
            "dosage": 0,
            "frequency": 0,
            "startDate": 0,
            "endDate": 0,
            "isFinished": true
          }
        ],
        "consultationRecords": [
          {
            "professionalId": "string",
            "date": "2023-06-08T00:00:00",
            "type": "string",
            "complaints": ["string"],
            "physicalExamination": "string",
            "diagnosis": "string",
            "prescribedMedications": ["string"],
            "testsOrdered": ["string"],
            "recommendations": ["string"],
            "recommendedCenter": ["string"]
          }
        ],
        "labRecords": [
          {
            "professionalId": "string",
            "testDate": 0,
            "testName": "string",
```

```
            "testResult": "string"
          }
        ],
        "imagingRecords": [
          {
            "professionalId": "string",
            "testDate": 0,
            "imagingName": "string",
            "imagingType": "string",
            "imagingResult": "string"
          }
        ],
        "vaccinations": [
          {
            "professionalId": "string",
            "vaccineType": "string",
            "vaccineDose": 0,
            "vaccineDoseNumber": 0,
            "vaccinationDate": 0,
            "administrationSite": "string",
            "batch": "string",
            "serialNumber": "string",
            "sideEffect": ["string"],
            "status": true
          }
        ],
        "vitality": true
      },
      "healthCard": {
        "creationDate": 0,
        "qrCodeData": "string",
        "pinCode": "string",
        "password": "string"
      }
    }
```

Listing 4.1: Firestore Json Structure for Patient Document

4.4 UX/UI Design

The User Experience (UX) design defines the experience a user would go through when interacting with a company, its services, and its products, while User Interface (UI) design defines the visual components that the user can see and interact with [82]. These designs allow for the system to be conceived from the perspective of the end users. When well incorporated into a software project, among many advantages, they increase user retention by offering a good user experience and efficient use of the software in question. In this section, we will present the conception of these two design notions as well as the techniques used to improve UX and make the UI user-friendly.

4.4.1 User Experience

The adoption of certain features and techniques significantly improves UX. Among many, we can mention:

- **Dark Mode**: Switching the application theme to a dark theme is an emerging trend in UX design, both ergonomically and aesthetically [83]. It significantly reduces eye strain, decreases glare, and improves energy efficiency when combined with Organic light-emitting diode (OLED) technology.
- **Consistent Visual Design**: Consistency between different interfaces allows the user to navigate smoothly between them. This includes integrating descriptive icons, a coherent design scheme, and a clear visual hierarchy.
- **Web Content Accessibility Guidelines (WCAG)**: A set of guidelines developed by World Wide Web Consortium (W3C) to make web content more accessible to people with disabilities. These guidelines include **alternative texts**, **keyboard navigation**, etc.

4.4.2 User Interface

Thanks to our extensive experience in handling a large number of web and mobile software, and being users of these software ourselves, we were able to identify the features of the software that appealed to us in terms of modern design, simplicity and minimalism, visual consistency, and choice of color palette. The UI design combines with UX design to enhance the visual and interactive experience of the end user. Figures 4.7 and **??** illustrate some wireframes before the choice of the color palette and logos.

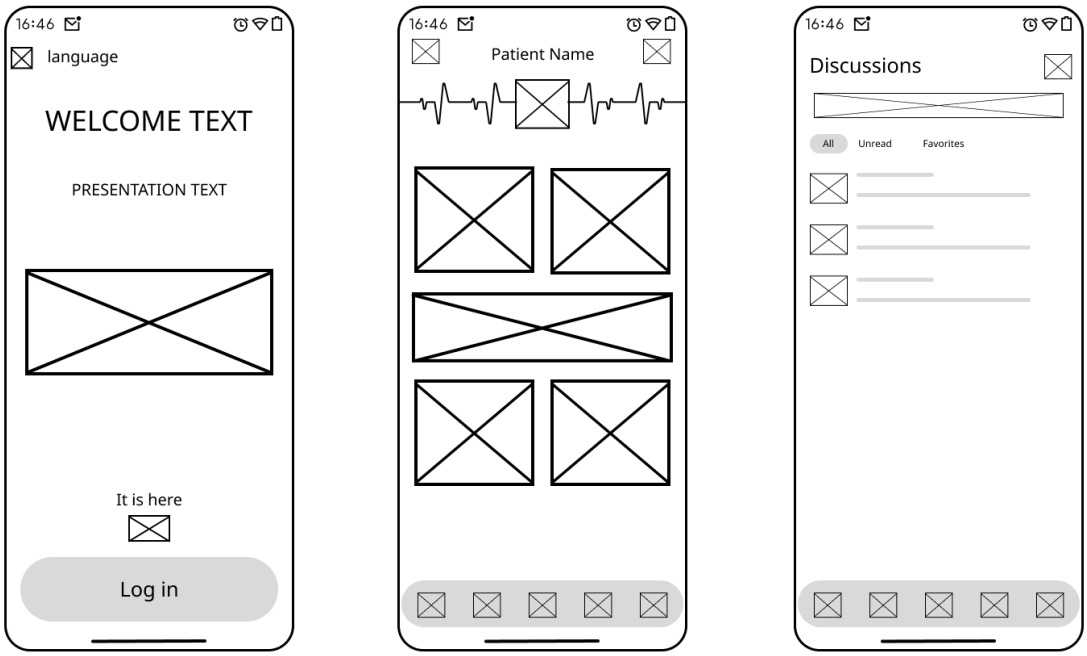


Figure 4.7: Mobile App Wireframe.

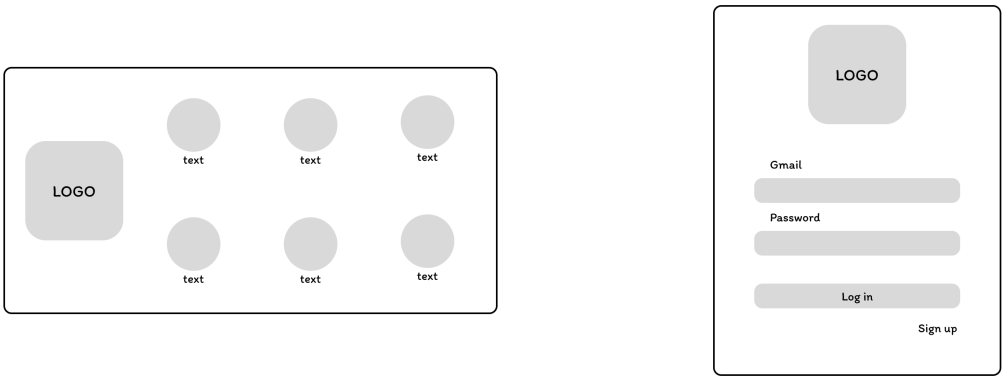


Figure 4.8: Web App welcome and login Wireframe.

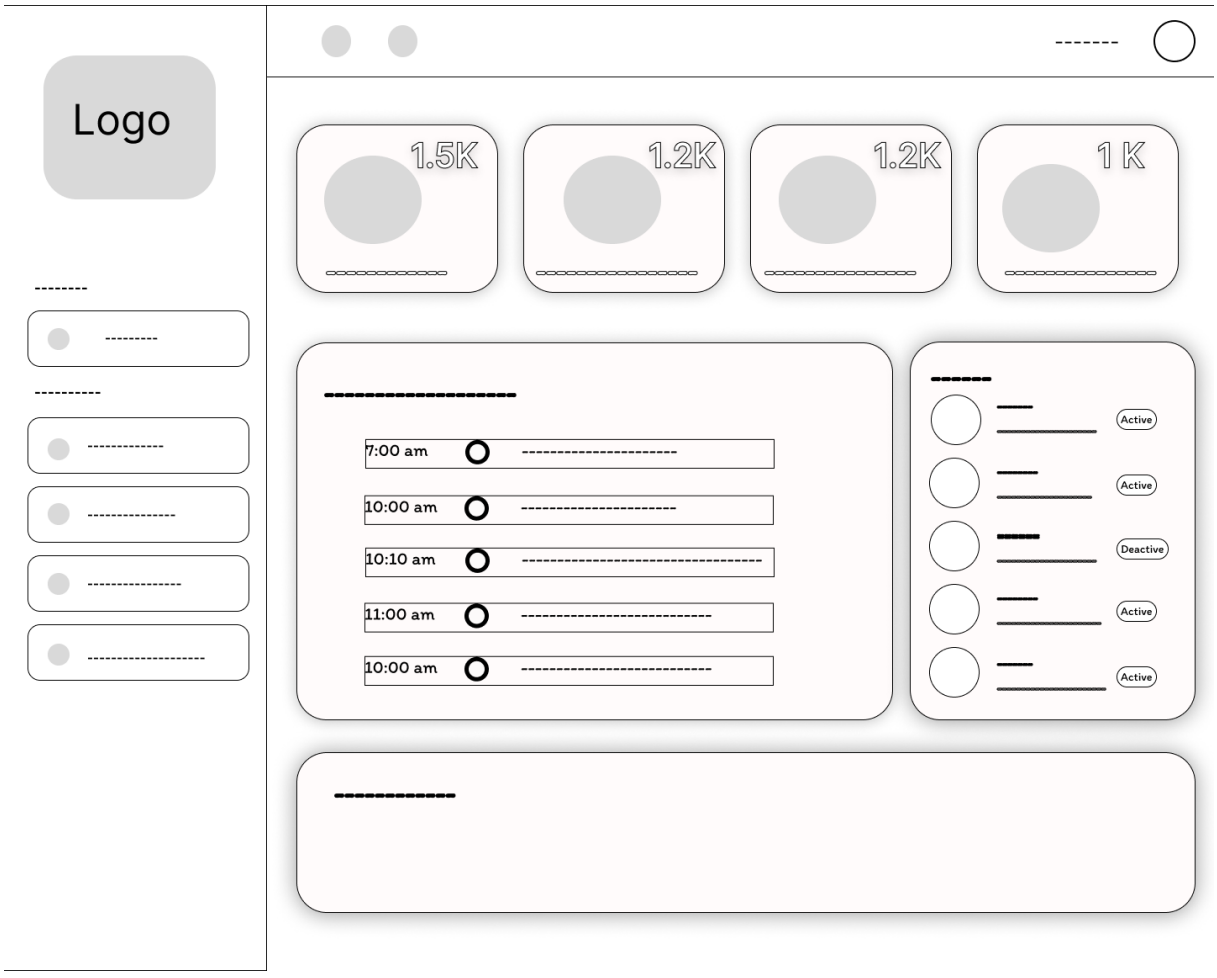


Figure 4.9: Web App Dashboard Wireframe

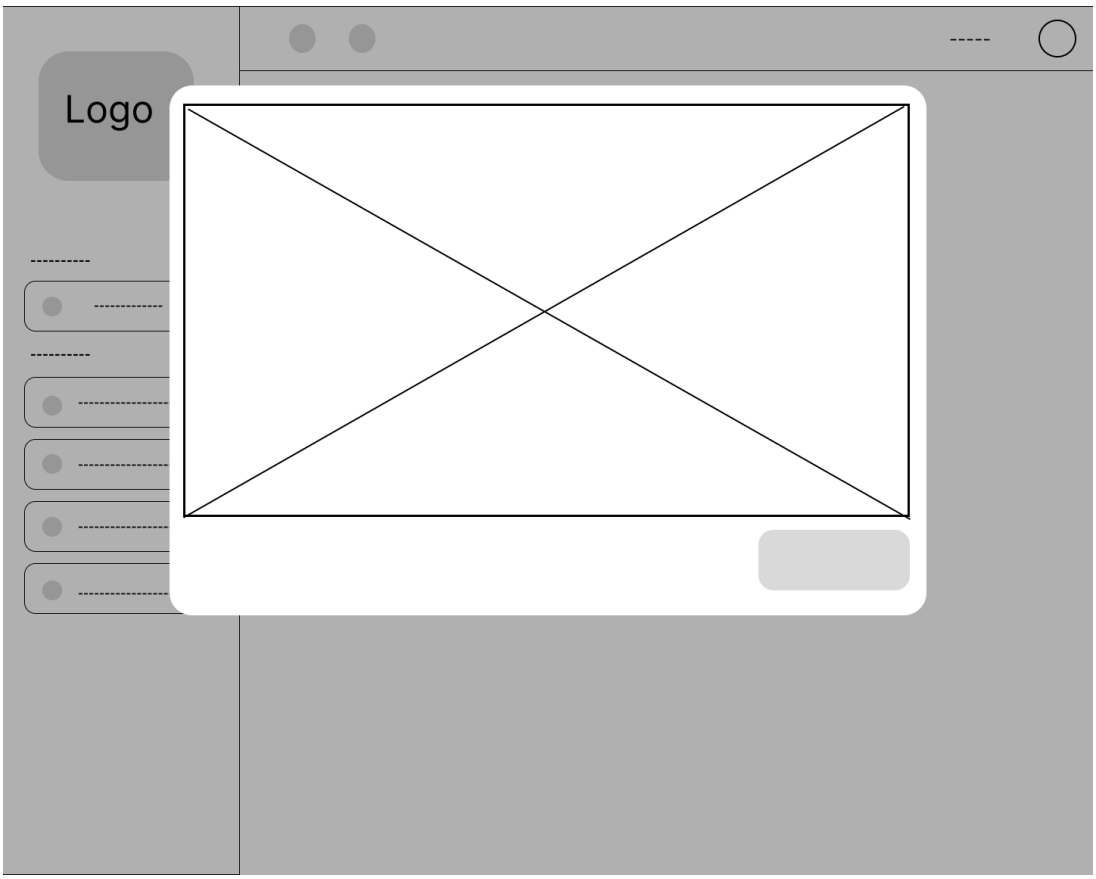


Figure 4.10: Web App for Hover interface

4.4.2.1 Color Palette

The choice of color is crucial for good visual perception by the end users. We chose shades of blue and green because in the medical field, these colors are used more than others, mainly due to their psychological effect. In addition to white, figure 4.11 illustrates the two main colors used in the platforms.

Figure 4.11: Color Palette.

The figures 4.12 and 4.13 illustrate the application of these colors on the wireframes seen above as well as the resulting prototyped design.

Figure 4.12: Mobile Prototypes.

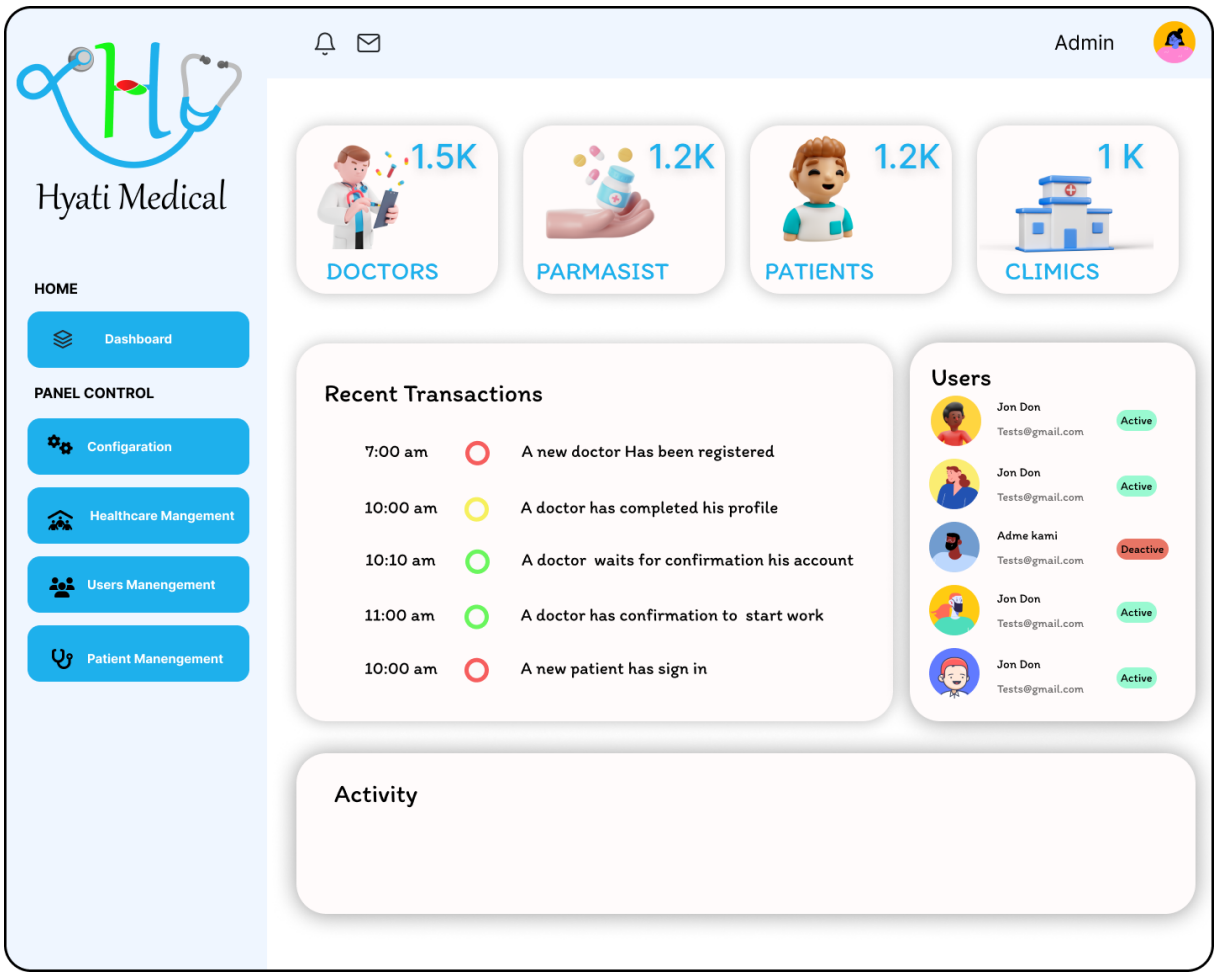


Figure 4.13: Web Prototypes.

4.4.2.2 Logo Design

The "Hyati Medical" Company logo embodies our spirit of innovation and forward-thinking vision that sets us apart in the healthcare sector. Designed with vibrant colors and sleek, modern lines, it symbolizes the dynamism and ambition we are known for.

Shape: The stethoscope, a universal symbol of health, is central to the logo's design. Its form draws the viewer's attention, while the inner part of the stethoscope represents happiness. Additionally, the stethoscope and a letter together form the number twenty-four, symbolizing our commitment to round-the-clock availability and creating a positive impact.

Text: We chose "Hyati Medical" for the text, inspired by the diary of an Algerian citizen who regards health as his most valuable asset. This name resonates with our mission to be close and relatable to our users.

This logo encapsulates our identity and core values. It reflects our dedication to innovation and continuous improvement, aiming to deliver high-quality healthcare services to our customers

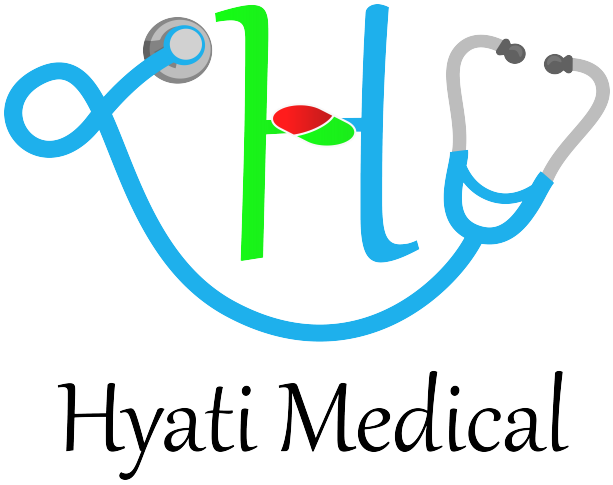


Figure 4.14: Logo.

4.4.2.3 Dicha Chatbot

It's the medical chatbot that interacts with users to provide them with medical information. Its name comes from me**Di**cal **cha**tbot.

4.5 BMC

The BMC is a strategic tool used to develop and document business models. It was designed by Alexander Osterwalder and Yves Pigneur and is presented in the form of a visual canvas comprising nine blocks. Each block represents a key aspect of a business, thereby allowing for the visualization and analysis of the entire business model in a coherent and integrated manner [84]. In our context, these nine blocks provide an overview of our business model. These blocks include:

4.5.1 Key Partners

The Key Partners block describes the network of partners and suppliers necessary to carry out key activities and access key resources. These include:

- **Health Professionals**: Collaborating with doctors, nurses, and other medical professionals to ensure that the platform meets clinical needs and enhances patient care.
- **Medical Institutions**: Encompassing hospitals, clinics, pharmacies, laboratories, etc.
- **Cloud Service Providers**: Such as CERIST "Centre de Recherche sur l'Information Scientifique et Technique," providing web hosting and domain name services in .dz.
- **Computer Equipment Suppliers**: Working with computer equipment suppliers to ensure compatibility and support for necessary hardware, such as servers and networking devices.
- **Medical Insurance Providers**: Partnering with medical insurance companies like CNAS and CASNOS to facilitate integration with insurance systems for claims processing and patient coverage verification.

4.5.2 Key Activities

This block presents the key activities necessary to deliver value propositions, reach markets, maintain customer relationships, and generate revenue. This includes production, marketing, customer relationship management, etc. These activities are:

- **System Development and Maintenance**: Developing and maintaining web and mobile platforms.
- **Data Management**: Integrating and managing data from various healthcare systems for comprehensive patient records.
- **Customer Support**:
  - **Technical Support**: Providing 24/7 support to healthcare providers and patients.
  - **Training**: Offering training sessions and materials for effective platform use.

4.5.3 Key Resources

This block presents the key resources necessary to deliver value propositions, reach markets, maintain customer relationships, and generate revenue. These resources can be physical, intellectual, human, or financial. They include:

- **Human Resources**: Developers, IT support technicians, Healthcare Specialists (doctors, pharmacists).
- **Technology Resources**: Servers and Static IP Addresses for Launching Services and Storing Patient Data.
- **Physical Resources**:
  - **Production Facilities**: Space and equipment for making health cards.

4.5.4 Value Propositions

This block describes the products and services that create value for the customer segment. They include:

- **Streamline Medical Records Management**: Improve the efficiency of managing medical records.
- **Incorporate AI**: Use AI to assist patients by providing a patient chatbot and an AI-powered drug interaction checker for healthcare professionals.
- **Empower Patients**: Engage patients as active participants in the system and foster collaboration between patients and healthcare providers.
- **Create Collaborative Spaces**: Establish collaborative environments for healthcare professionals to enhance teamwork in delivering patient care.
- **Connect Medical Devices**: Integrate medical devices with the platform to facilitate seamless sharing of medical information.

4.5.5 Customer Relationships

This block presents the types of relationships the company establishes with its customer segments. These may include personalized support, online communities, self-service, etc. They include:

- **Client Support**
- **Self-service Options**: Create a user-friendly mobile app for patients to access, view, download, and share their medical records, empowering them in their healthcare journey.
- **Automated Assistance in Platforms**: Provide automated assistance tools for healthcare providers.

4.5.6 Channels

This block describes how the company reaches and communicates with its customer segments to deliver its value propositions. This includes communication, distribution, and sales channels. They include:

- **Direct Sales**: Selling application licenses and offering a trial period for healthcare professionals.
- **Medical Conferences and Events**
- **Healthcare Salons and Networking Events**
- **Online Webinars and Workshops**
- **Web Platform**
- **Mobile Platform**
- **Social Media**

4.5.7 Customers Segments

This block describes the targeted customers of the company. It identifies the different groups of people or organizations that the company seeks to reach and serve. They include:

- **Patients with Chronic Health Conditions**: Including individuals diagnosed with diabetes, high blood pressure, or other long-term diseases, as well as patients needing urgent care and pre-surgical patients.
- **Health Professionals**:
  - Doctors, nurses, pharmacists, and others who manage patients with chronic diseases face problems such as:
    * Collecting and reviewing patient medical history
    * Administrative burdens when managing medical records
    * Lack of cooperation among themselves and collaboration with patients

4.5.8 Cost Structure

This block presents the costs incurred by the business model. It identifies the major costs associated with operating the business, including costs of key resources, key activities, and key partnerships. They include:

- **Fundamental Expenses**: These encompass the acquisition of essential equipment vital for our organization, ranging from office supplies to computers. Additionally, there are expenses associated with leasing a central server headquarters. The total cost required to procure all necessary equipment and essentials for launching the project is estimated at 6,903,400 DA.
- **Fixed Costs**: Our project incurs fixed expenses such as telephone and internet subscriptions, along with other necessary supplies crucial for project continuity, estimated at 351,825 DA.
- **Personnel Expenses**: Staffing costs include salaries for developers and DevOps developers, commencing at 40,000 DA per month. With a requirement for three such professionals, the total monthly staff expenditure amounts to 120,000 DA, totaling an annual estimate of 1,440,000 DA.

4.5.9 Revenue Streams

This section presents how the company generates revenue. It details revenue sources stemming from customer segments, such as product sales, subscriptions, licenses, etc. These sources include:

- **License Sales**: Licenses for medical centers and physicians range from 300,000 DA to 800,000 DA per license, depending on the application's functionality. By selling 10 licenses, the total revenue will amount to 3,000,000 DA. Additionally, we provide a drug interaction tool to assist healthcare professionals. Initially free, this tool costs 4,000 DA per physician after 1,000 prescriptions. For 100 physicians, this amounts to 400,000 DA.

- **Health Card Production**: For each health card produced for patients, we charge 1,000 DA. If we produce 1,000 cards, the total revenue will be 1,000,000 DA.
- **Teleconsultation Service**: Teleconsultations are billed at 60% of the cost of in-person consultations. We take a 15% commission on each teleconsultation. For example, if an in-person consultation costs 2,000 DA, a teleconsultation costs 1,200 DA and our commission is 180 DA per teleconsultation. Assuming 1,000 teleconsultations per day, the daily revenue would be 180,000 DA, and the monthly revenue would be 5,400,000 DA.

Figure **??** illustrates the Business Model Canvas (BMC).

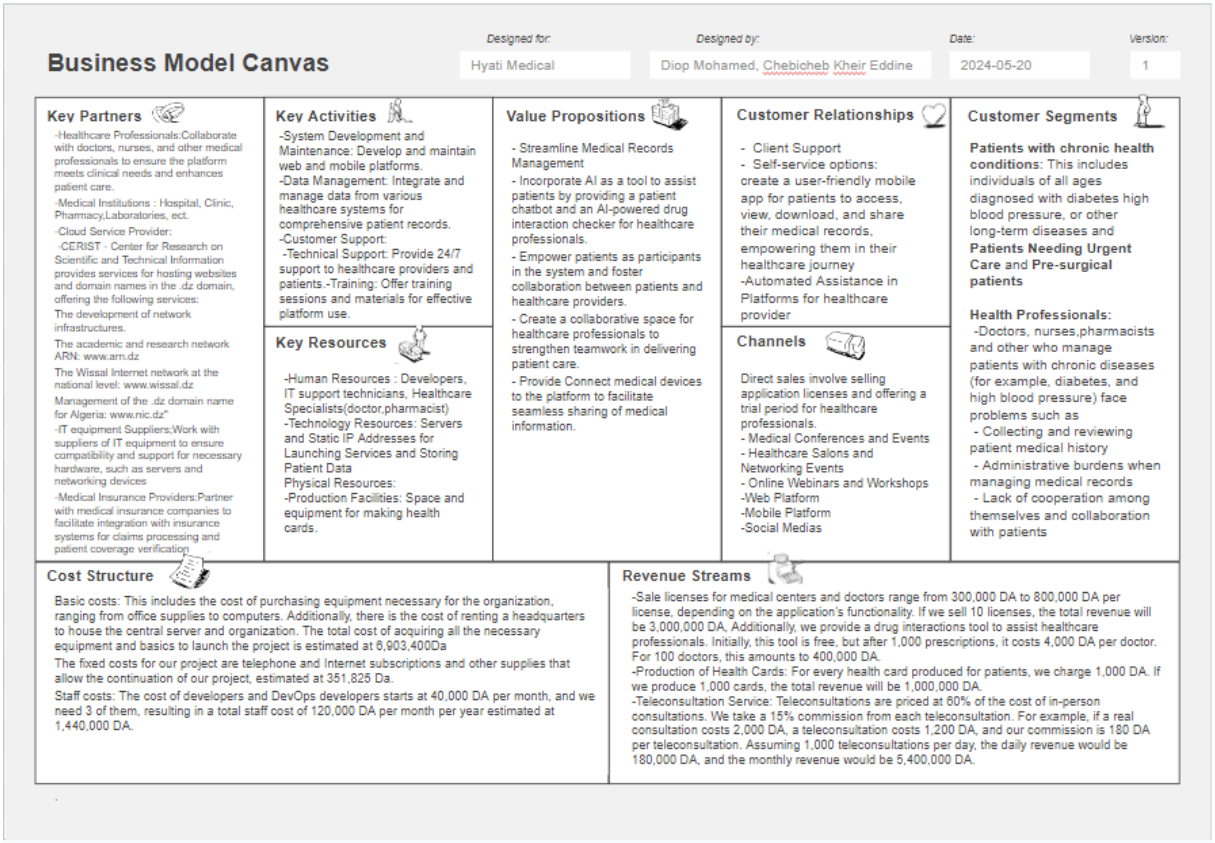


Figure 4.15: BMC.

Conclusion

In summary, this section presented the design of the system, both architecturally and visually. We outlined the type of architecture chosen, providing justifications for our choice, and described the resulting architecture. Additionally, we conducted a UX/UI design of the system to represent it from the end users' perspective and the presentation of the business model. This significantly strengthens the foundations and prerequisites for the implementation of the future system, which is the subject of the next chapter titled "Realization".

Chapter 5
Realization

Chapter 5

Realization

Introduction

This chapter details the practical implementation of the system design discussed in the previous chapters. It covers the technical and technological choices made, the development process, and the integration of various components. We will also present the fine-tuning techniques of the chosen AI model as well as the main interfaces and functionalities developed, highlighting the steps taken to ensure a seamless and efficient user experience. By the end of this chapter, readers will have a comprehensive understanding of how the theoretical design was translated into a functional and operational system.

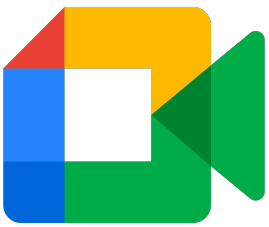
5.1 Technical and Technological Choices

In this section we will see the technologies used to ensure collaboration as well as the tools and development environments.

5.1.1 Collaboration and Design Technologies

These technologies have allowed us to collaborate effectively remotely while being supervised by our supervisor. They are among others :

5.1.1.1 Google Meet



A videoconferencing service developed by Google. It allows in particular to launch meetings or to join which was useful for us to debrief on the progress of the project.

5.1.1.2 Git/GitHub

It is a project version management platform allowing to follow its evolution and to know all the deployed versions. Its advantages are the collaboration on the same project of several collaborators and the management of changes as well as its integration into several development environments.

5.1.1.3 Overleaf

It is an online Latex editor that allows real-time collaboration. Despite its complexity due to the Latex language, it is powerful in terms of layout management once mastered. It also offers the possibility to preview the resulting PDF document. We used the free access, which limits the compilation time for large projects, to write our thesis in collaboration.

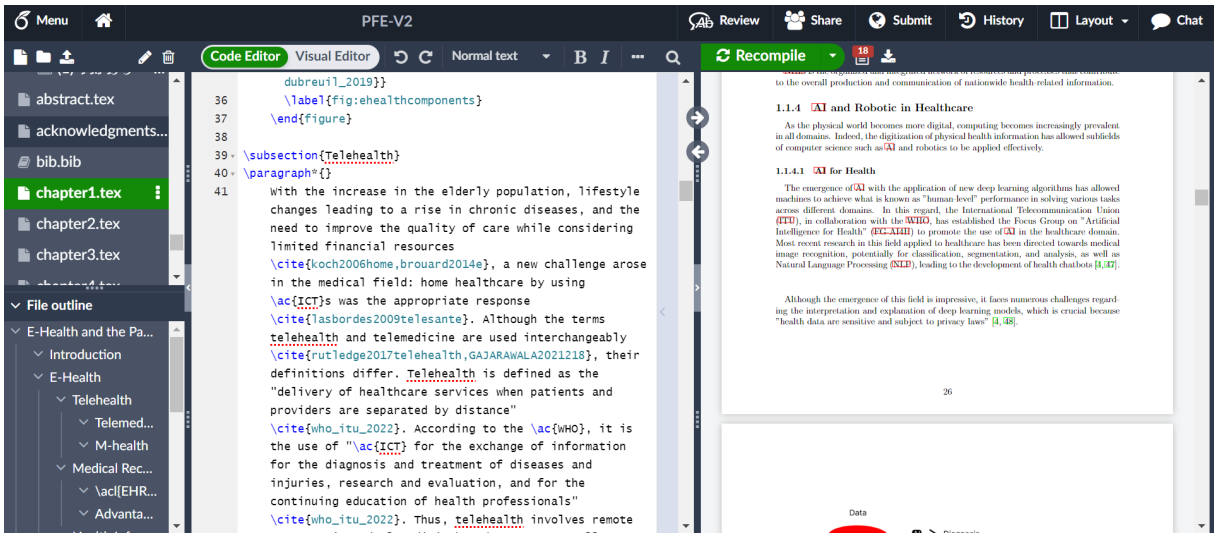


Figure 5.1: Overleaf Environment.

Figma

It is a collaborative web application for interface design, with additional offline features enabled by desktop applications for macOs and Windows. The feature set of Figma focuses on user interface and user experience design, with an emphasis on real-time collaboration [85], utilizing a variety of vector graphics editors and prototyping tools.

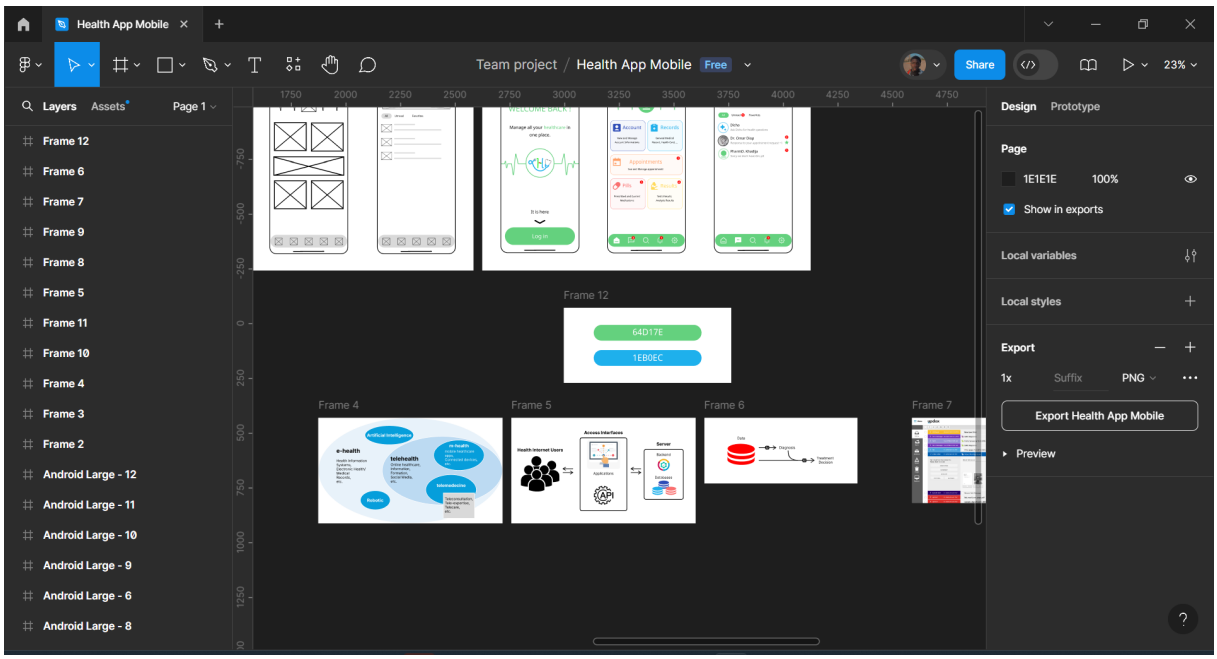


Figure 5.2: Figma Environment.

Draw.io

Draw.io is a robust technology stack designed for constructing diagramming applications. A key strength of draw.io lies in its comprehensive support for UML (Unified Modeling Language), a standardized method for visually representing software systems[86]. It offers the following features:

- **Effortless UML Diagramming:** With a drag-and-drop interface and pre-made UML shapes, draw.io enables quick and easy diagram creation.
- **Versatile UML Support:** Draw.io supports a variety of UML diagrams, including class diagrams and use case diagrams, among others.
- **Real-Time Collaboration:** An added advantage of draw.io is its real-time collaboration feature, allowing multiple users to work on the same UML diagram simultaneously.

5.1.2 Mobile development tools

Those are tools used specifically to implement the system at the mobile level. They are among others:

5.1.2.1 Android Studio

According to Wikipedia, "Android Studio is the official Integrated Development Environment (IDE) for Google's Android operating system, built on JetBrains' IntelliJ IDEA software and designed specifically for Android development". We chose it to allow the development of the mobile application under Android. It uses languages like

- Kotlin or Java for the backend;
- Extensible Markup Language (XML) or Kotlin for the front-end.

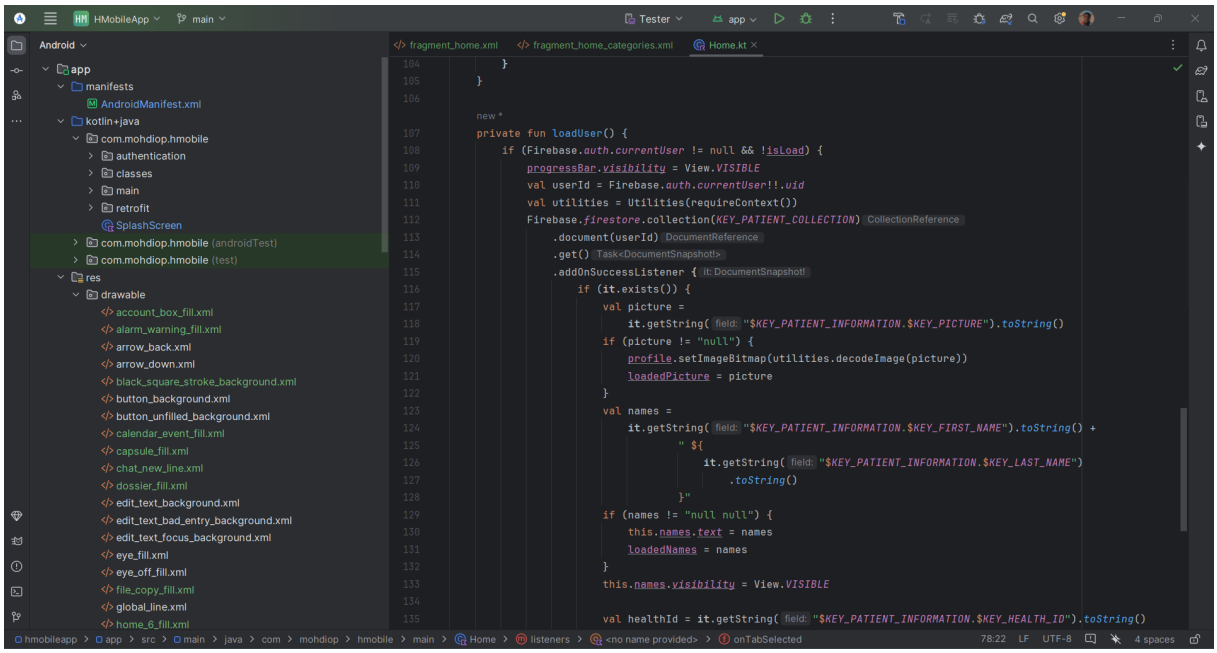


Figure 5.3: Android Studio Environment.

5.1.3 Web development technologies

These are the tools that allowed us to implement the web part of the system.

5.1.3.1 Front-end

Front-end development, also known as client-side development, is the practice of producing HTML, CSS, and JavaScript for a website or web application so that a user can see and interact with it directly we utilize the following frameworks:

5.1.3.2 Font Awesome

It is a font and icon toolkit based on CSS and Less. As of 2023, Font Awesome was used by 30% of sites that use third-party font scripts, placing Font Awesome in second place after Google Fonts[87]

Tailwind CSS Tailwind CSS is an open-source CSS framework. The main feature of this library is that, unlike other CSS frameworks like Bootstrap, it does not provide a series of predefined classes for elements such as buttons or tables. Instead, it creates a list of "utility" CSS classes that can be used to style each element by mixing and matching[88]

BootStrap Is a free and open-source CSS framework directed at responsive, mobile-first front-end web development. It contains HTML, CSS, and (optionally) JavaScript-based design templates for typography, forms, buttons, navigation, and other interface components [89].

Alpine.js It is a minimal JavaScript framework for adding JavaScript behavior to markups. It's designed to be lightweight and easy to use, with a syntax similar to Vue.js. Alpine.js allows you to have rich, interactive front-ends without the need for a build step or a full-blown JavaScript framework [90]

5.1.3.3 Back-End

Back-end development refers to server-side development, where the core computational logic resides. This universal concept applies to both web and mobile applications. It includes creating and maintaining the database, scripting, designing the application architecture, and implementing algorithms to ensure proper functionality[91]. The back end interacts indirectly with the front end to provide information and functionality[92], rather than directly contacting the user. We utilize the following languages and frameworks to complete the connection:

Laravel Laravel is a free and open-source PHP-based web framework for building high-end web applications [93]. It was created by Taylor Otwell and intended for the development of web applications following the model–view–controller (Model View Controller (MVC)) architectural pattern and based on Symfony. Some of the features of Laravel include a model packaging system with a dedicated dependency manager, different ways for accessing relational databases, utilities that aid in application deployment and maintenance, and its orientation toward syntactic sugar [93].

5.1.3.4 Visual Studio Code

Visual Studio Code is an open-source code editor developed by Supporting a huge number of languages thanks to extensions. He supports auto-completion, syntax highlighting, debugging, and git commands[94].

5.2 BioBERT Fine-tuning

As we have seen in the chapter "Literature Review", BioBERT is initially trained on a large medical corpus. To make it even more effective in specific tasks such as NER, RE, or QA, it needs to be fine-tuned as per the article [6]. The pre-trained model is available at `https://github.com/dmis-lab/biobert`,we conducted a fine-tuning process. Fine-tuning involves taking the pre-trained BioBERT model and training it further on task-specific datasets. This step is crucial for enhancing the model's performance in our targeted applications: Following the guidelines from the original BioBERT paper by Lee et al. (2019), we utilized this model as a base for our fine-tuning process

- **NER (Named Entity Recognition):** We fine-tuned BioBERT using annotated biomedical texts to accurately identify and classify entities such as diseases, medications, and anatomical terms.
- **RE (Relation Extraction):** For extracting relationships between entities, BioBERT was fine-tuned on datasets that describe interactions between medical terms.

- **QA (Question Answering):** We further trained BioBERT to answer domain-specific questions by providing it with a comprehensive set of biomedical questions and answers.

5.2.1 Dataset:

The pre-trained model is available at `https://github.com/dmis-lab/biobert` and it provides a pre-processed version of benchmark datasets for each task as follows:

- **Named Entity Recognition:** (17.3 MB), 8 datasets on biomedical named entity recognition.
- **Relation Extraction:** (2.5 MB), 2 datasets on biomedical relation extraction.
- **Question Answering:** (5.23 MB), 3 datasets on biomedical question answering task.

5.2.2 Implementation Steps

The first step in the implementation is to follow the repository steps that exist in the GitHub link `https://github.com/dmis-lab/biobert` to run the BioBERT model and evaluate it to match our business needs for detecting drug interactions and Question Answering, This is steps to starting run mode by

Data Preparation:

We collected and prepared task-specific datasets for NER, RE, and QA. This involved annotating text, structuring data, and splitting it into training and validation sets from repository

Model Training:

Using the pre-trained BioBERT model, we performed fine-tuning on our prepared datasets by running Named Entity Recognition (NER). The token-level evaluation result for the NCBI disease corpus will be like:

```
processed 24497 tokens with 960 phrases; found: 983 phrases; correct: 852.
 accuracy: 98.49%; precision: 86.67%; recall: 88.75%; FB1: 87.70
           MISC: precision: 86.67%; recall: 88.75%; FB1: 87.70 983
```

Validation Data

After training a pre-trained BioBERT model with Named Entity Recognition (NER) datasets, you got a result "BERT-BASE".

Table 5.1: Performance of the fine-tuned BioBERT model on the NER task

Entity Type	Precision	Recall	F1-Score	Support
PER	0.9677	0.9756	0.9716	1842
LOC	0.9671	0.9592	0.9631	1837
MISC	0.8872	0.9132	0.9001	922
ORG	0.9191	0.9314	0.9252	1341
Avg/Total	0.9440	0.9509	0.9474	5942

Additional Data

Here are additional results obtained from the model.

Table 5.2: Additional performance of the fine-tuned BioBERT model on the NER task

Entity Type	Precision	Recall	F1-Score	Support
ORG	0.8773	0.9037	0.8903	1661
PER	0.9646	0.9592	0.9619	1617
MISC	0.7691	0.8305	0.7986	702
LOC	0.9333	0.9305	0.9319	1668
Avg/Total	0.9053	0.9184	0.9117	5648

Model Evaluation:

After fine-tuning, we evaluated the model's performance in the validation dataset to ensure that it met the performance benchmarks for each task. This included measuring metrics such as NER, RE, QA task accuracy, recall, and F1 scores.

Model Deployment:

Once the model demonstrated satisfactory performance, we deployed it within our application framework. This step included integrating the model into our existing system and ensuring it could effective.

By fine-tuning BioBERT for our specific tasks, we have been able to significantly enhance its ability to identify and process biomedical information. This improved model now delivers outputs that are both more reliable and accurate, meeting the critical needs of our application.

5.3 Interfaces Presentation

In this section, we will cover the main interfaces of the system for the web and mobile application.

5.3.1 Web application Interfaces

Figure 5.4 represents the welcome page for healthcare professionals and the admin interfaces.

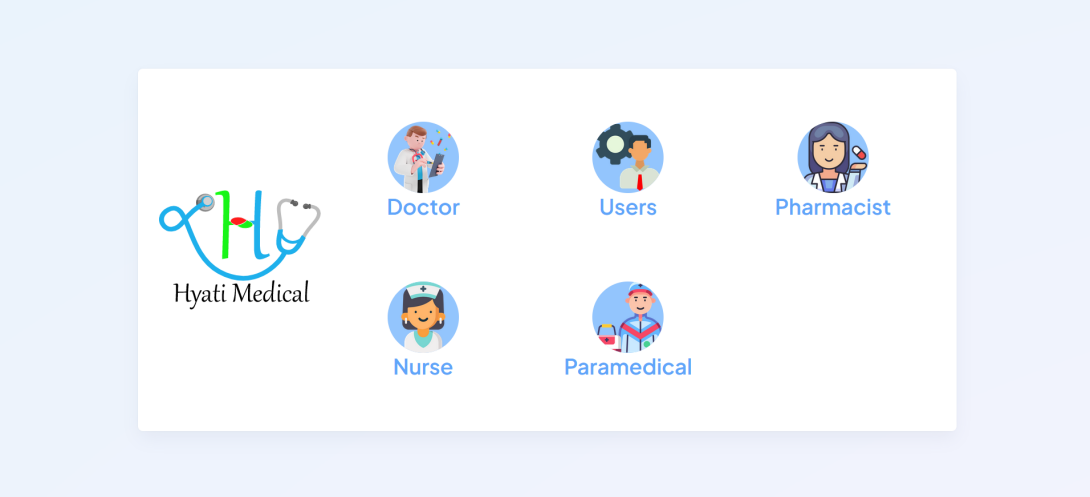


Figure 5.4: Web App Interface #1 : Welcome Page

Figure 5.5 represents login page interface.

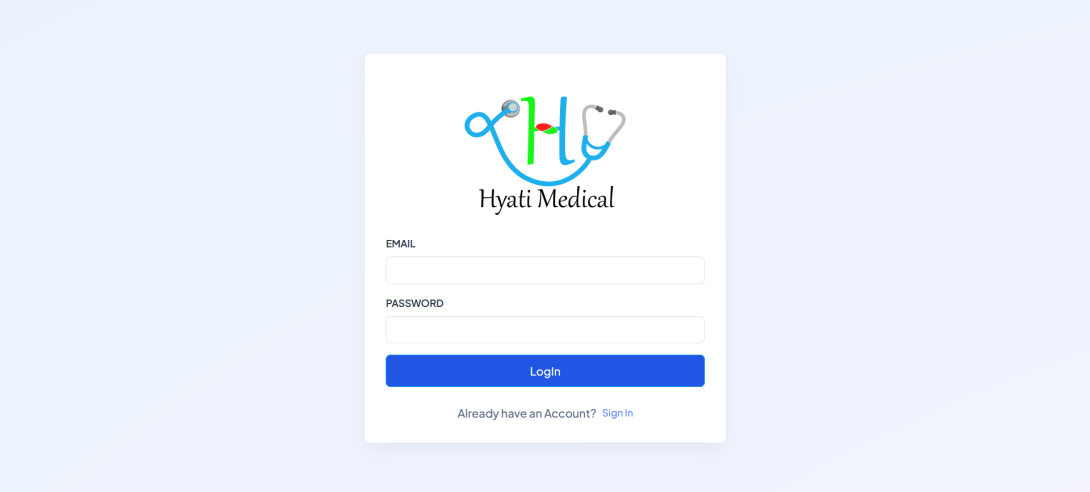


Figure 5.5: Web App Interface #2 : Login Page

Figure 5.6 represents the admin and super admin dashboard interface.

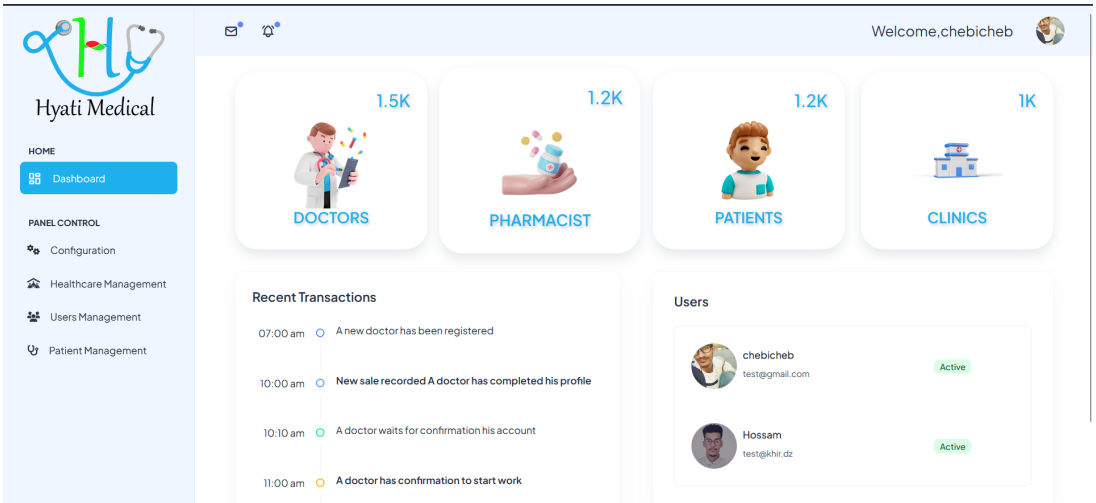


Figure 5.6: Web App Interface #3 : Administrators' Dashboard

Figure 5.7 represents the permissions and roles configuration in the platform.

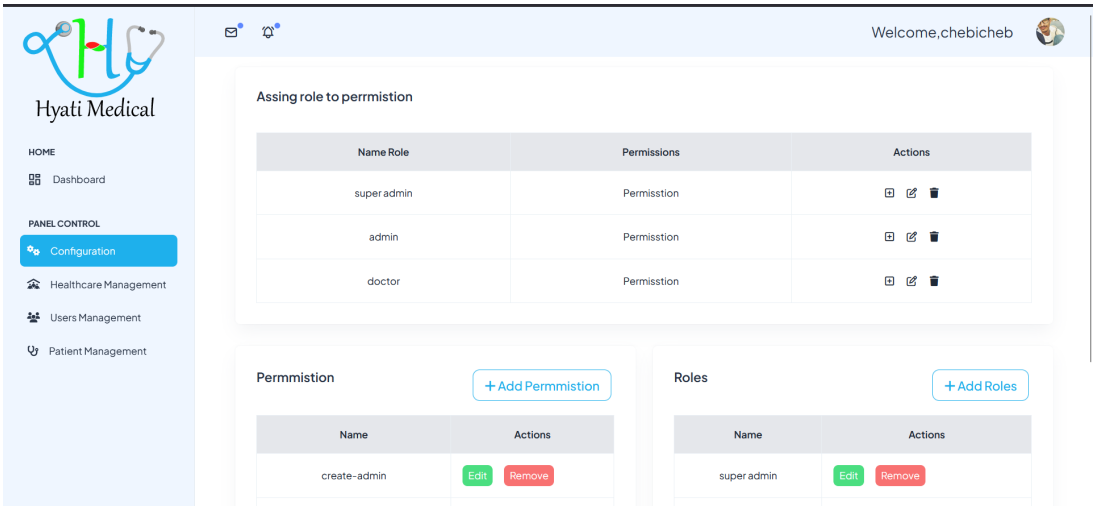


Figure 5.7: Web App Interface #4 : Permissions and Roles Configuration.

Figure 5.8 represents the permissions and roles synchronisation.

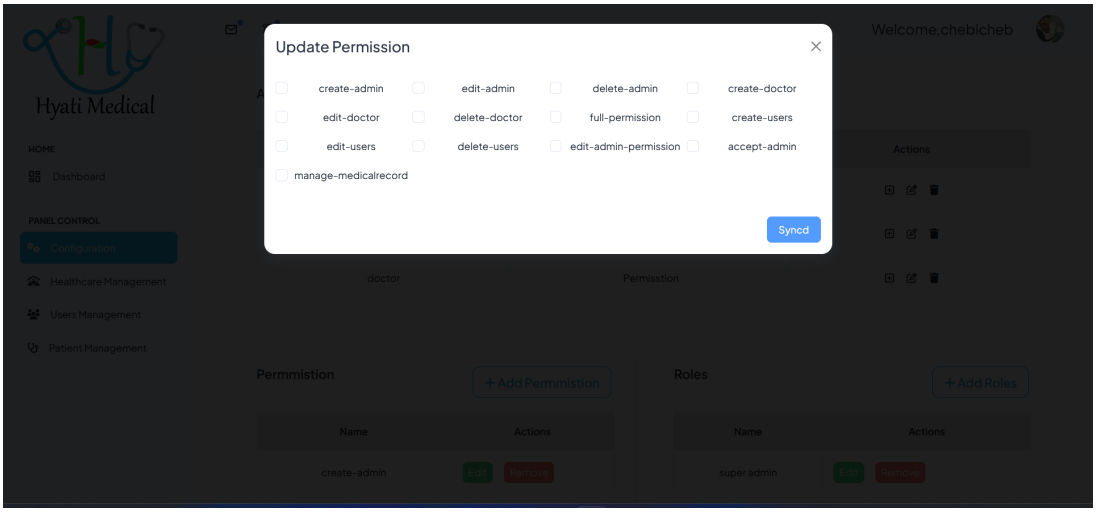


Figure 5.8: Web App Interface #5 : Permissions and Roles Synchronisation.

Figure 5.9 represents the healthcare management interface.

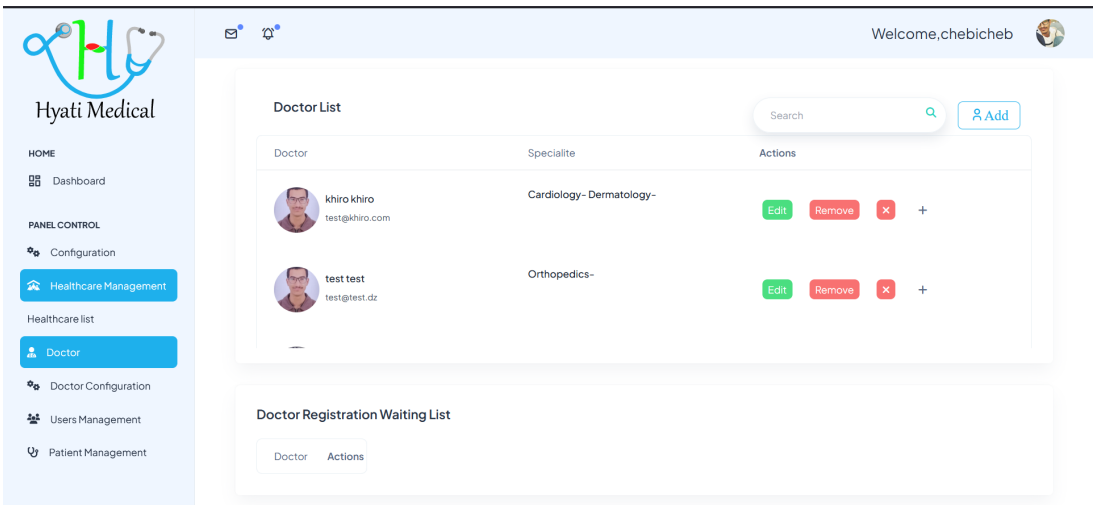


Figure 5.9: Web App Interface #6 : Healthcare Management.

Figure 5.10 represents the patient management interface.

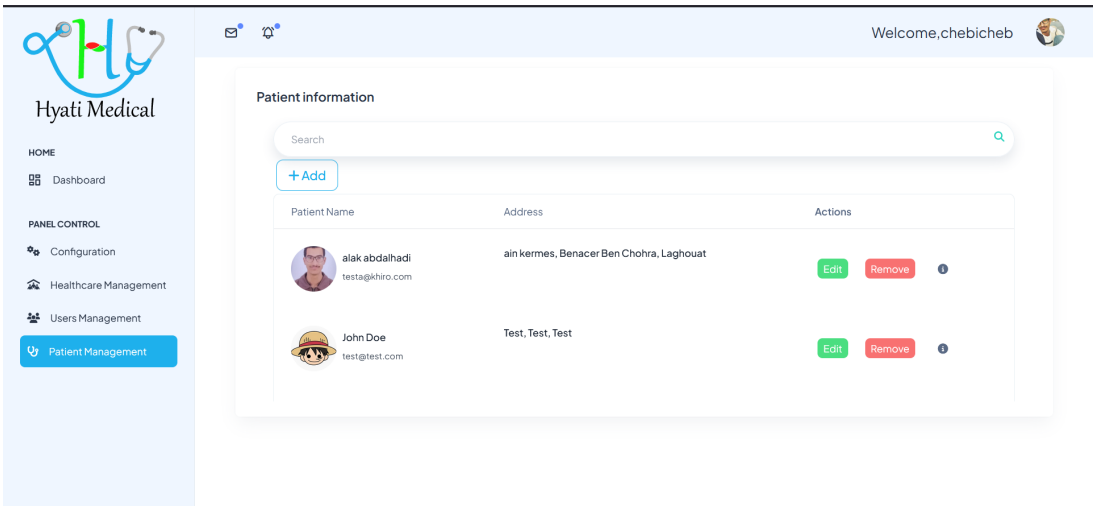


Figure 5.10: Web App Interface #7 : Patient Management

Figure 5.11 illustrates the Patient's Health Card Information.

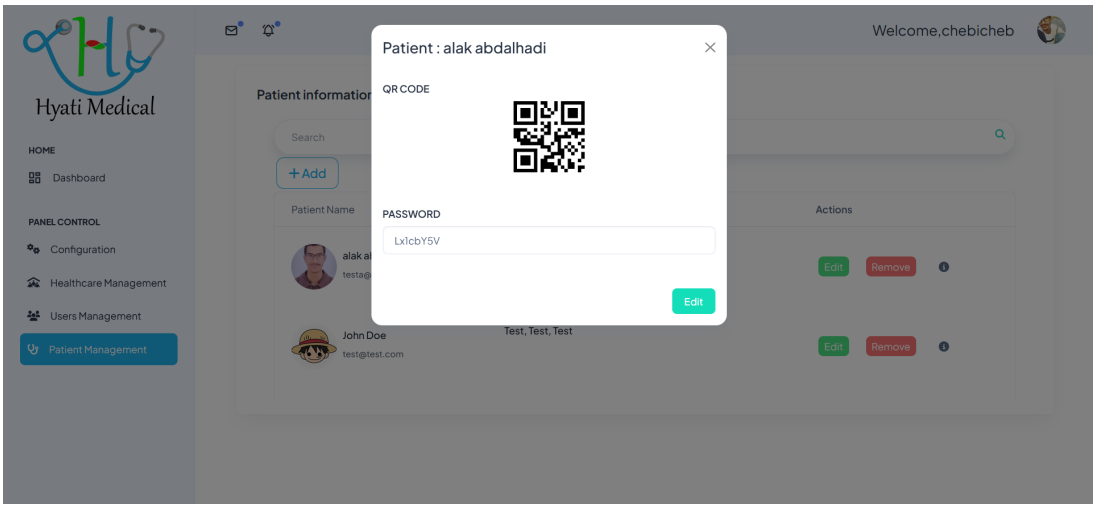


Figure 5.11: Web App Interface #8 : Patient's Health Card Information.

5.3.2 Mobile App Interfaces

The figure ?? illustrates the main welcome screen when the application is launched for the first time.

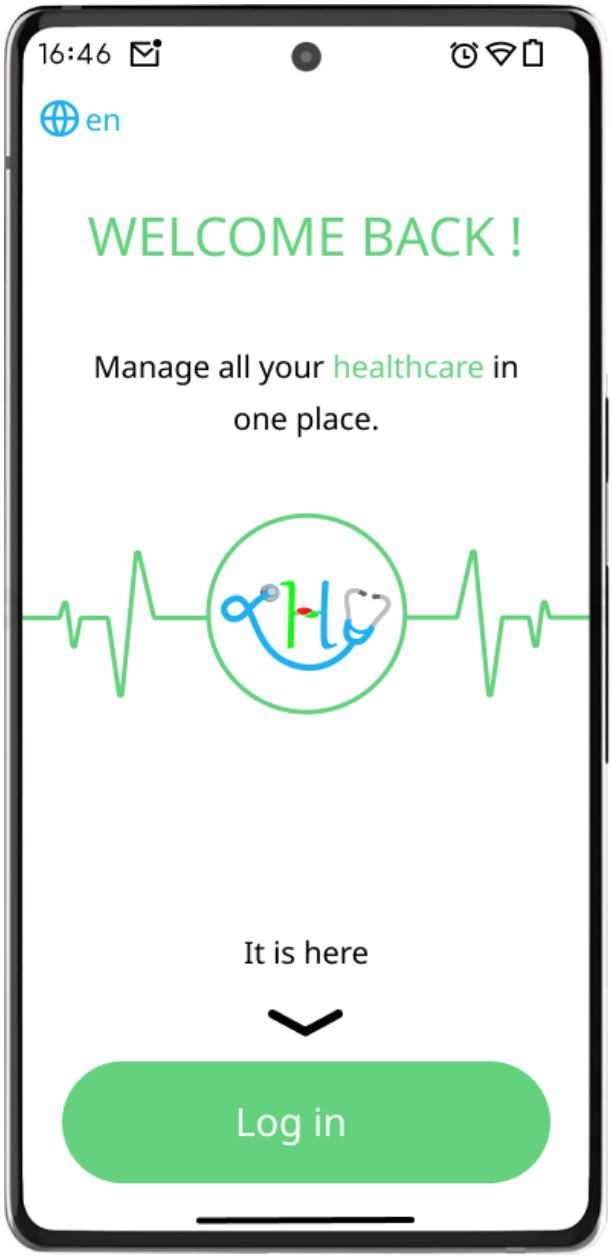


Figure 5.12: Mobile App Interface #1 : Welcome Page.

The figures 5.13 and 5.14 illustrate the login page in the mobile application where patients can log in using their login credentials or scan their medical card and provide the pin code

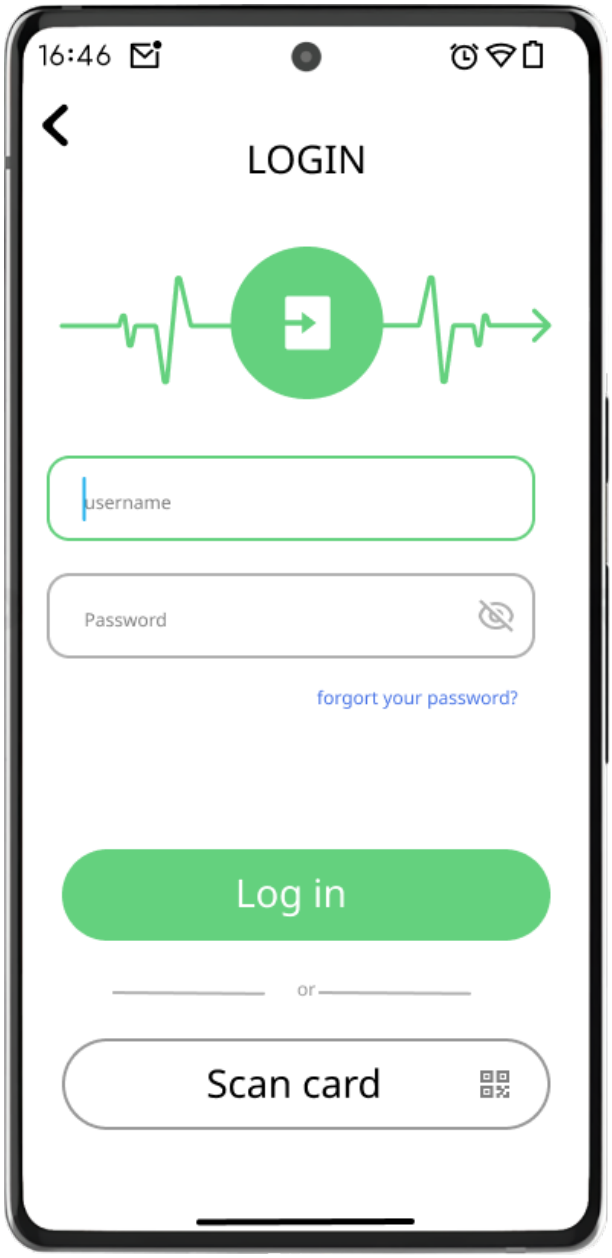


Figure 5.13: Mobile App Interface #2 : Connexion Page #1.

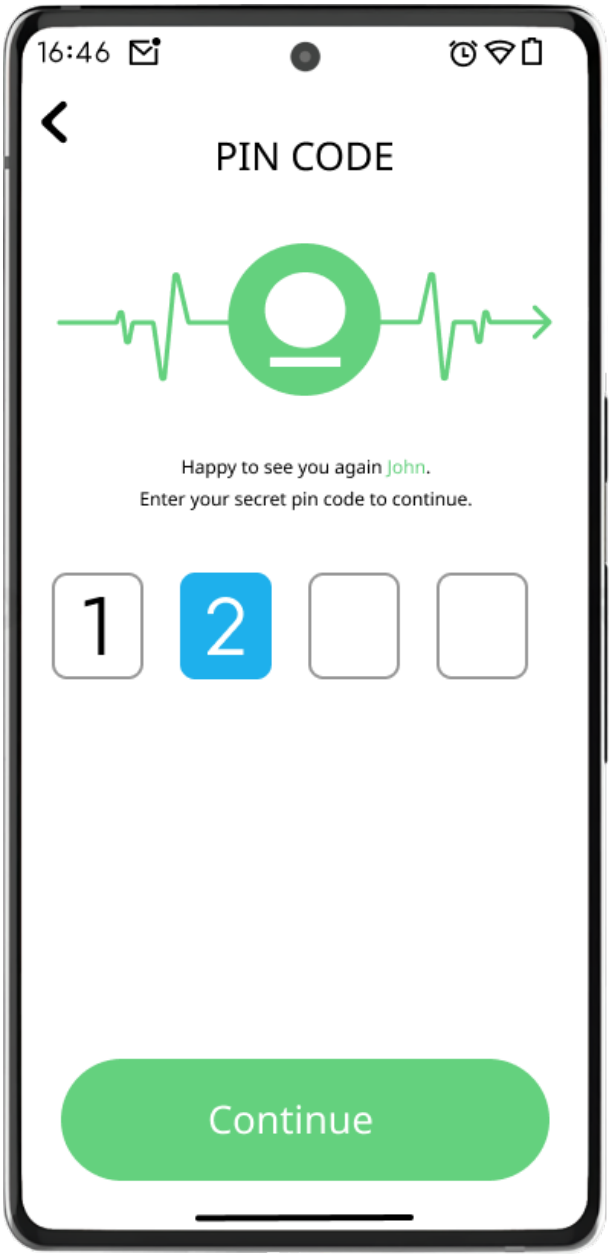


Figure 5.14: Mobile App Interface #3 : Connexion Page #2.

The figure 5.15 illustrates the patient's home screen. On this interface, they have the ability to navigate between the different interfaces: home, discussions, search, notifications, and settings. On the home screen, they can access and manage their account information, access and manage their medical record, manage appointments, manage taken medications, and view test and analysis results. They can also overview their medical ID and QR code (for search by healthcare professionals in case of forgetting or losing the card) and report a medical emergency for themselves or another person

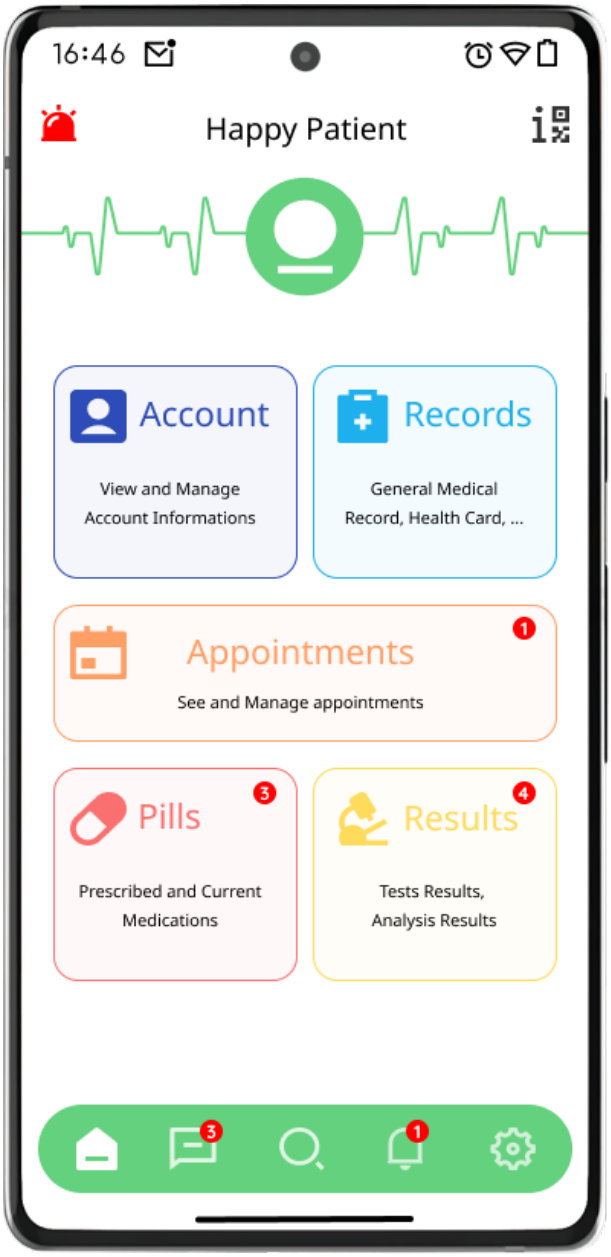


Figure 5.15: Mobile App Interface #4 : Home page.

The figure 5.16 illustrates the discussion interface where the patient can see the list of their discussions, start a new discussion with professionals, or ask for information from the Dicha chatbot

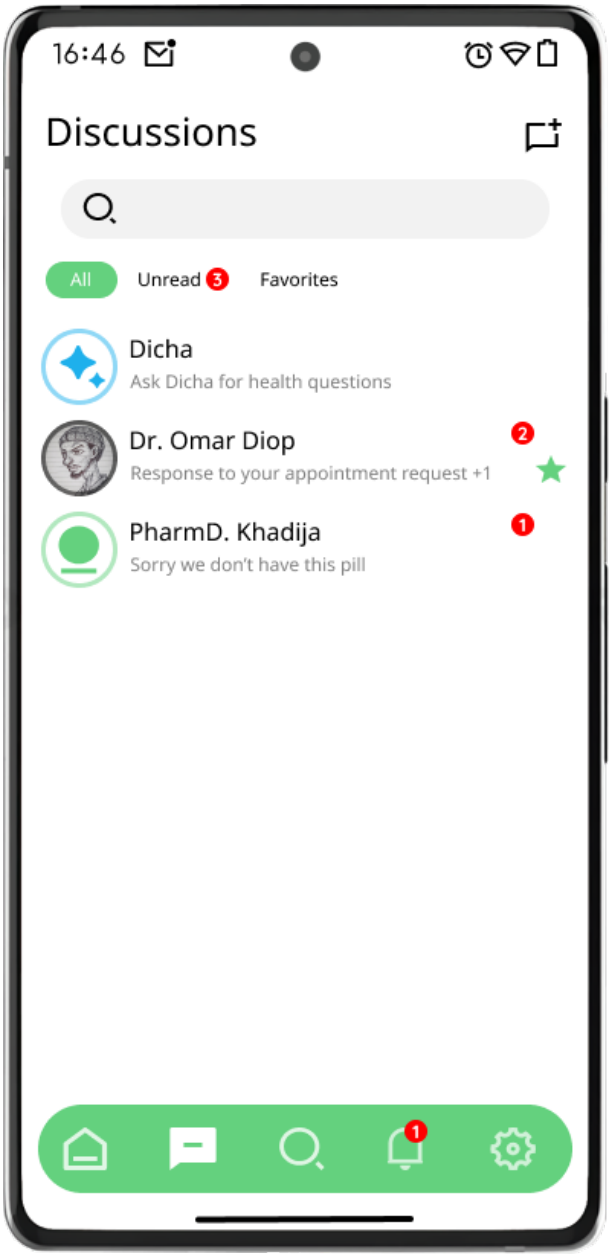


Figure 5.16: Mobile App Interface #5 : Discussion page.

Conclusion

In summary, in this chapter we have seen the different techniques and technologies used during the development of the project as well as the results obtained following the practical application of the theoretical frameworks discussed in the previous chapters. These results have been defined by two web and mobile platforms respectively for Health Professionals and Administrators, and Patients. We have seen the main interfaces from these platforms which give an overview of the final system.

Chapter 6
Conclusion

Chapter 6

General Conclusion

In conclusion, this thesis has addressed the need to advance the digitization of healthcare services in Algeria through the development of an innovative platform integrated into the Algerian NHIS. We have defined the objectives of this project, which are to address the challenges encountered in the digitization process, namely communication barriers, decentralization of healthcare services, patient empowerment, medical data management, care coordination, and integration of cutting-edge technologies such as AI.

To achieve these objectives, we first defined key concepts related to e-health and its impact on healthcare services and patients. Then, we conducted a state-of-the-art review to understand current advancements in this study context. This allowed us to identify the current needs of various stakeholders in relation to our objectives and to design these needs into a final system consisting of two mobile platforms for Patients and a web platform for Healthcare Professionals. The adoption of the Scrum methodology provided a flexible and efficient framework for project development, enabling effective communication, problem-solving, and alignment with organizational objectives.

In summary, this thesis represents a significant step towards addressing the challenges encountered in the digitization of healthcare services in Algeria. By developing an integrated platform that enhances patient engagement, facilitates communication among stakeholders, and leverages advanced technologies, we aim to contribute to the advancement of healthcare delivery and improve the quality of care for the Algerian population. Although the journey has been marked by various challenges and obstacles, the ideas and solutions proposed pave the way for future research, innovation, and continuous improvement in the field of digital health.

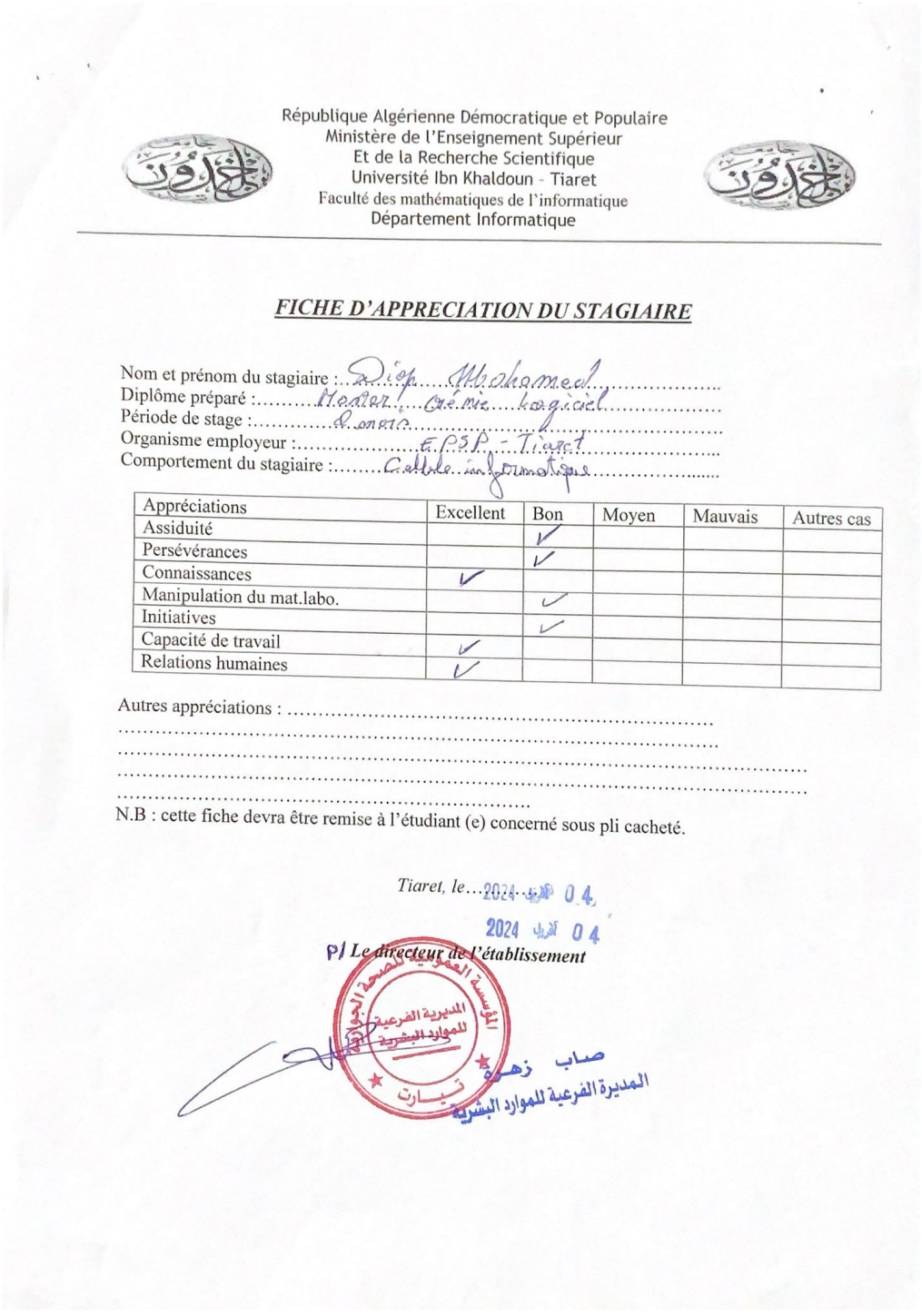
Perspectives

In order to improve this project, we thought about integrating certain features during its development, such as:

- **Geolocation** for emergency declaration services aimed at directing Patients to the nearest hospital center and optimized search for health professionals.
- The **development of a connected device** of the **watch** type to provide real-time information on the patient's condition.
- **Online medication purchase** with integration of **health insurance** services such as CNAS and CASNOS.

Appendix A

Internship Reports



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Université Ibn Khaldoun - Tiaret
Faculté des mathématiques de l'informatique
Département Informatique

FICHE D'APPRECIATION DU STAGIAIRE

Nom et prénom du stagiaire : Diop Mohamed
Diplôme préparé : Master Génie logiciel
Période de stage : 2 mois
Organisme employeur : EPSP - Tiaret
Comportement du stagiaire : Cellule informatique

Appréciations	Excellent	Bon	Moyen	Mauvais	Autres cas
Assiduité		✓			
Persévérances		✓			
Connaissances	✓				
Manipulation du mat.labo.		✓			
Initiatives		✓			
Capacité de travail	✓				
Relations humaines	✓				

Autres appréciations : .....
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N.B : cette fiche devra être remise à l'étudiant (e) concerné sous pli cacheté.

Tiaret, le 04 2024

P/ Le directeur de l'établissement

المديرية الفرعية للموارد البشرية
تيارت

صاب زهية
المديرية الفرعية للموارد البشرية

Figure A.1: Mohamed Diop's Internship report.

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Département Informatique

FICHE D'APPRECIATION DU STAGIAIRE

Nom et prénom du stagiaire : Chebicheb Kheireddine
Diplôme préparé : Master genie logiciel
Période de stage :. 15 jours
Organisme employeur : EPSP Ain Kermes
Comportement du stagiaire :

Appréciations	Excellent	Bon	Moyen	Mauvais	Autres cas
Assiduité	X				
Persévérances	X				
Connaissances	X				
Manipulation du mat.labo.					
Initiatives		X			
Capacité de travail	X				
Relations humaines		X			

Autres appréciations : ..... Très bien .....
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Ain kermes le.....

Le directeur de l'établissement

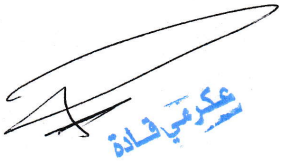
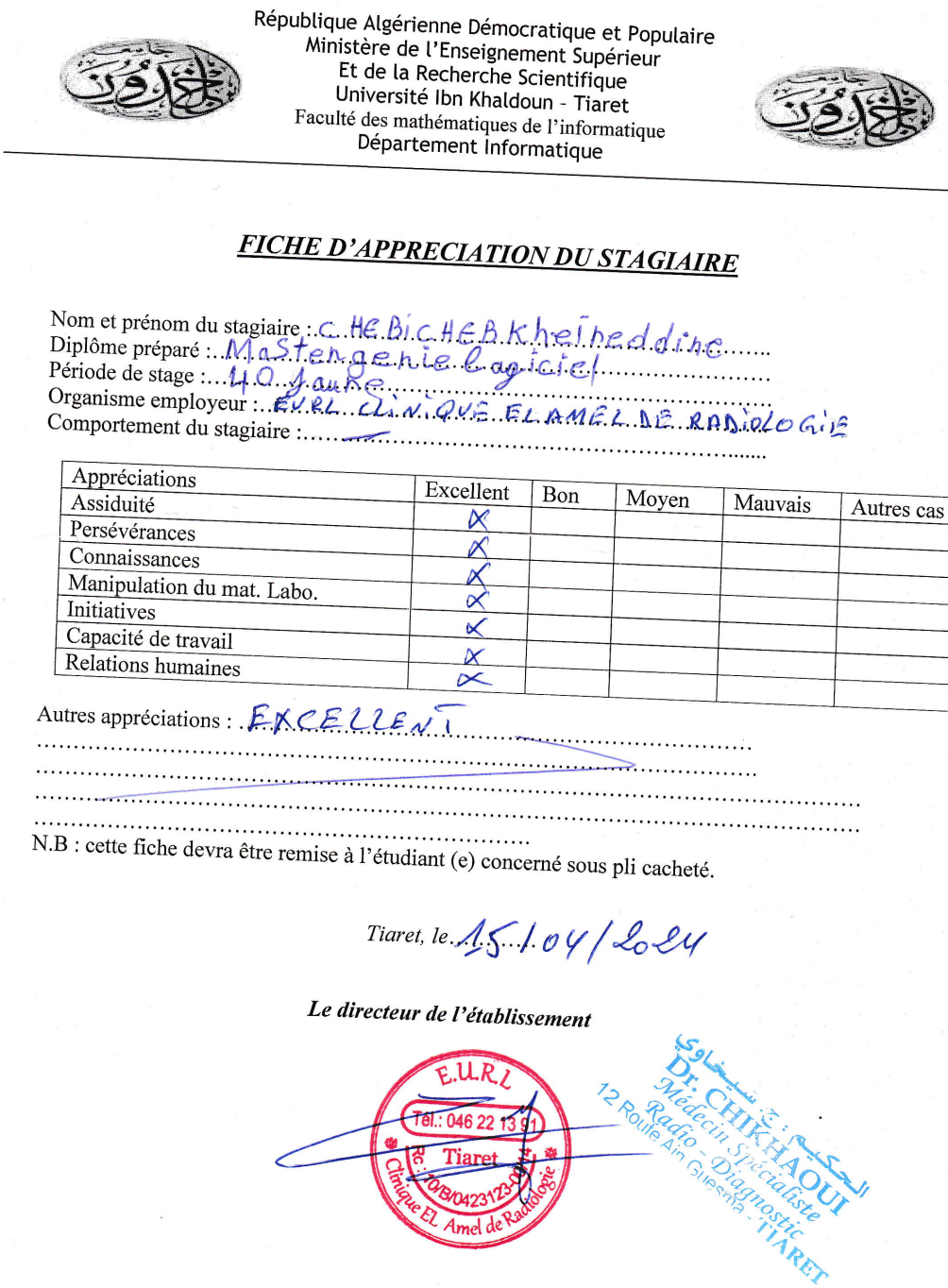


Figure A.2: Kheir Eddine Chebicheb's Internship report #1.



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Département Informatique

FICHE D'APPRECIATION DU STAGIAIRE

Nom et prénom du stagiaire : CHEBICHEB Kheireddine
Diplôme préparé : Master génie logiciel
Période de stage : 40 jours
Organisme employeur : EURL CLINIQUE EL AMEL DE RADIOLOGIE
Comportement du stagiaire : ✓

Appréciations	Excellent	Bon	Moyen	Mauvais	Autres cas
Assiduité	✗				
Persévérances	✗				
Connaissances	✗				
Manipulation du mat. Labo.	✗				
Initiatives	✗				
Capacité de travail	✗				
Relations humaines	✗				

Autres appréciations : EXCELLENT

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Tiaret, le 15/04/2024

Le directeur de l'établissement

E.U.R.L Tél.: 046 22 13 91 Tiaret N°: 20/B/042312300 Clinique EL Amel de Radiologie

Dr. CHIKHAOUI Médecin Spécialiste Radio - Diagnostic 12 Rouiba Ain Guesma - TIARET

Figure A.3: Kheir Eddine Chebicheb's Internship report #2.

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