T.C.

ALTINBAS UNIVERSITY

Institute of Graduate Studies

Electrical and Computer Engineering

ACCESS METHODS TO PATIENTS MEDİCAL RECORDS

YAZAN JABARI

Master of Science

Supervisor

Asst. Prof. Dr. Oguz KARAN

Istanbul, 2021

ACCESS METHODS TO PATIENTS MEDICAL RECORDS

by

YAZAN MOTAZ SHARIF JABARI

Electrical and Computer Engineering

Submitted to the Institute of Graduate Studies

in partial fulfillment of the requirements for the degree of

Master of Science

ALTINBAŞ UNIVERSITY

2021

The thesis titled "**ACCESS METHODS TO PATIENTS MEDICAL RECORDS**" prepared and presented by "Yazan Jabari" was accepted as a Master of Science Thesis in Electrical and Computer Engineering.

Asst. Prof. Dr. Oguz KARAN

Supervisor

Thesis Defense Jury Members:

Asst. Prof. Dr. Oguz KARAN	School of Engineering and Natural Sciences, Altinbas University	_____
Asst. Prof. Dr. Abdullahi Abdu IBRAHIM	School of Engineering and Natural Sciences, Altinbas University	_____
Asst. Prof.Dr. Zeynep ALTAN	Faculty of Engineering and ATrchitecture, Beykent University	_____

I certify that this thesis satisfies all the requirements as a thesis for the degree of Master of Science.

Approval Date of Institute of Graduate Studies: ____/____/____

I hereby declare that all information in this document has been obtained and presented in accordance with academic rules and ethical conduct. I also declare that, as required by these rules and conduct, I have fully cited and referenced all material and results that are not original to this work.

Yazan Motaz Sharif Jabari

Signature

ABSTRACT

ACCESS METHODS TO PATIENTS MEDICAL RECORDS

Author's Yazan Jabari,

M.Sc./PhD, Electrical and Computer Engineering, Altınbaş University,

Supervisor: Asst. Prof. Dr. Oguz KARAN

Date: 04/2021

Pages: (47)

Quick access to the medical record while maintaining confidentiality is one of the most important methods that must be followed in hospital emergency departments, taking into account that the information is correct and reliable. This research deals with ways to access the medical record while preserving the confidentiality of the information, knowing that there are many methods such as a user name and a password or via the health card. This paper proposes to exploit modern technology in the medical field and activate its use in this field, with a focus on identifying biometrics to access the health record with privacy policies. The study includes designing and creating a website, in terms of the technologies used, it contains PHP and C #, in addition to Arduino, and it also contains electronic components. In the first stage, the website and Arduino network are created with the fingerprint device, after which the device is tested to see if the system is operating at full capacity. The result of the general study system was a website to view the patient's file in emergencies with a fingerprint.

Keywords: Biometric, Medical record, Emergency cases, Health informatics (HI), QR code.

TABLE OF CONTENTS

Pages

LIST OF TABLES

Pages

LIST OF FIGURES

Pages

LIST OF ABBREVIATIONS

HI	:	Health Informatics
ML	:	Machine Learning
QR	:	Quick Response
EHR	:	Electronic Health Record

1. INTRODUCTION

The field of health informatics (HI) aims to provide a wide link between different ideas. The healthcare data set is usually incomplete and noisy; As a result, data reads from the dataset correlation traditionally fail in software engineering. Machine learning (ML) is a rapidly maturing branch of computer science because it can store data widely. Many ML tools can be used to analyze data and give knowledge that can improve the quality of work for both employees and doctors [1].

Electronic health records are electronic versions of health-care records for patients. An electronic health database captures, creates, and securely preserves health information. Health care providers have been slow to adopt electronic health records.

The benefits of an electronic health record include a gain in healthcare efficiencies, large gains in quality and safety, and lower healthcare costs for consumers. Electronic health record challenges include costly software packages, system security, patient confidentiality, and unknown future government regulations [2].

Specialist physicians identify pre-referral errors but struggle with whether and how to provide disclosure, even when clinical circumstances force disclosure. Education- or communication-based interventions that overcome barriers to disclosing pre-referral errors warrant development [3].

With the advent of information technology in the health industry, we have to keep records of the patient's health history to facilitate the delivery of high-quality, rapid health care, and to make the health record available before the start of care to treat the patient, and the use of electronic health records is more important in emergency situations, because they need immediate care To retrieve some records for the patient to avoid treating the patient by mistake [4], and it also helps to see the required data without the need to return to the source of these data as a former doctor or hospital who had previously diagnosed him, so the data is collected in one place for reference within specific powers [5].

In this paper, we will explore some methods of accessing the patient's medical files in emergency situations while ensuring the patient’s privacy, for example this is done by fingerprint or by QR code reader.

A fingerprint is considered the identity of a person, and among the characteristics it possesses are stability and lack of similarity, unless there is a serious accident that led to a deformation of the finger or the like [6].

1.1. THESIS OBJECTIVE

This research aims to exploit modern technology in the medical field and activate its use in this field, as it makes it easier for the doctor to obtain patient data quickly as well as to ensure that the patient is protected from side complications of a wrong ambulance operation, and also works to provide an easy and flexible mechanism for the doctor to obtain The data of the injured person when he is first treated, which saves time and effort, as he works to provide protection and confidentiality that guarantees the rights of the user, whether the patient or the medical staff, and at the same time saves the patient's data from loss.

1.2. FINGERPRINT SENSOR

The fingerprint sensor is an electronic device used to capture images of fingerprint patterns, the fingerprint scanner system contains functions for taking a user's fingerprint image and determining whether the fingerprint flow pattern of the captured image is the same as the fingerprint flow pattern found in the database. Then this sensor sent the fingerprint ID data through the serial communication. The fingerprint sensor is shown in Figure 1.1 [6].

Figure 1.1: Fingerprint Sensor [6]

1.3. ARDUINO UNO

Arduino Uno is a microcontroller board based on the ATMega 328. This microcontroller has 14 digital I/O (6 pins can be used as PWM output) and 6 analogue inputs, 16 MHz crystal oscillator, USB connection, power Jack, ICSP header, and reset button. This microcontroller operates at 5V

voltage which is used as a USB-to-serial converter for serial communication to the computer via USB port. The Arduino uno is shown in Figure 1.2 [6].

Figure 1.2: Arduino Uno [6]

1.4. LITERATURE REVIEW

The research problem is represented in the difficulty of keeping the patient's data completely in one place so that it is easy to refer to it when needed, especially in emergency situations that the patient may face on the one hand, and on the other hand.

The presence of incorrect, late or incomplete diagnostic errors, or the use of unnecessary or incorrect diagnostic tests at the wrong time, and the patient's privacy is also affected and the powers that are possible by some people are violated in some cases [3]. What if we could access the patient's record in a way that would make it easier for us to fully access his data without having to refer to the paper documents?

The literature on electronic health records emphasizes the importance of the information sharing function of electronic health records in improving health care outcomes. And a proposal to establish a lifelong health record system to track all health care information for individuals from birth to death to allow for the effective, consistent and comprehensive sharing of health information. According to the American Institute of Medicine, EHRs improve patient safety, support effective patient care and improve the efficiency of healthcare services [7]. All this indicates and confirms that it helps us to quickly find out the patient's health information, especially in emergency cases. What if we got to the patient's record just by placing his finger on the fingerprint scanner?

Web services such as Microsoft Health Vault and the previous Google Health provide a space to store medical information for any registered user. This type of service is effective in storing information, but it depends on the patient's credentials, for example the username and password [8], [13], but it may be forgotten. Patient this information.

Because of the conditions that lead to the deterioration of the patient's condition when his previous record is not viewed, and sometimes these problems cause the patient's death when the emergency department doctors do not specifically see his medical file if he suffers, for example, from a specific allergy or a specific chronic disease [3].

And from here we started thinking that we can access the patient's medical record by fingerprint in emergency cases [4], or by scanning the patient's special QR in normal cases.

For an emergency doctor, he checks a patient's fingerprint and fingerprints are unique identifiers for anyone. They provide an if-and-only-if (iff) relationship between a patient and a fingerprint. Once the fingerprint is matched on the system, the patient's medical record is reviewed and of course, the fingerprint must contain it.

Pre-register in the electronic health records database in order to find it, after which he will be able to work on adding the diagnosis to the patient record and adding the prescription to the patient record. Add a laboratory examination request, transfer the patient to another doctor, add a patient's medical report.

Also, for the patient, he will be able to review his medical record.

And for the administrator, he will log in to his account and create accounts for doctors, in addition to the possibility of performing maintenance operations on the site.

And on the security side, biometrics have proven a basic safety mechanism that identifies an individual's unique identity according to some physiological characteristics (fingerprint). Therefore, biometrics are more reliable and able to distinguish between an authorized person and an impostor, and traditional authentication systems rely on identity cards, tokens, or passwords that can be lost, broken, or stolen. On the other hand, biometric features cannot be lost or forgotten and most importantly, they are difficult to replicate, share or distribute. Moreover, the system has the presence of the authenticated person and for this reason it is difficult to forge [9].

Another way to store medical information is via a flash drive [10],The health key is a USB flash drive. Medical records are stored on it, however, and when the USB cable is inserted it automatically asks the user for its content. For this reason, the device is supposed to be inserted into the trusted doctors' computer only in order not to violate the privacy of the content, and it is difficult to update this information continuously. This causes fear because it may be used for personal purposes and this is a violation of the patient’s rights.

For non-functional requirements:

1. Ease of use: The application interface is easy to use for application users as there is no difficulty in performing operations within the system.
2. High efficiency and speed of performance: the efficiency of the system is evident from the speed of response taking.

   Consider that there are huge databases to which the application is connected.
3. Achieving safety for users: as the system works to save users' data by securing that information and not disclosing it.

2. USE CASE DIAGRAM

2.1. PATIENT

For the patient, he can register as a new user, fill in his personal information, and he can view his medical file as described in figure 2.1.

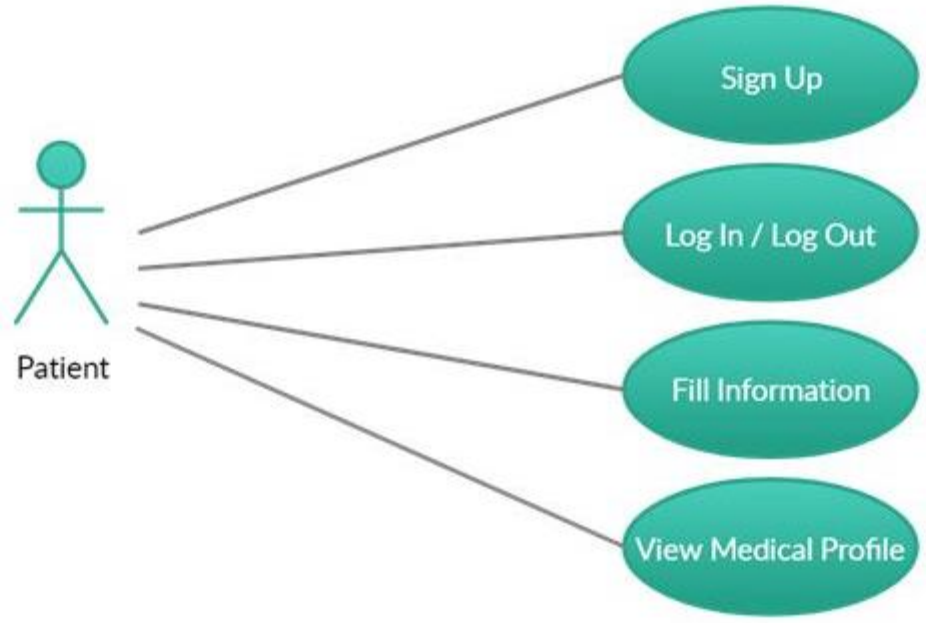

Figure 2.1: For Patient

2.2. ADMIN

As for the admin, he can create doctors' and laboratory accounts and modify the system in general as described in figure 2.2.

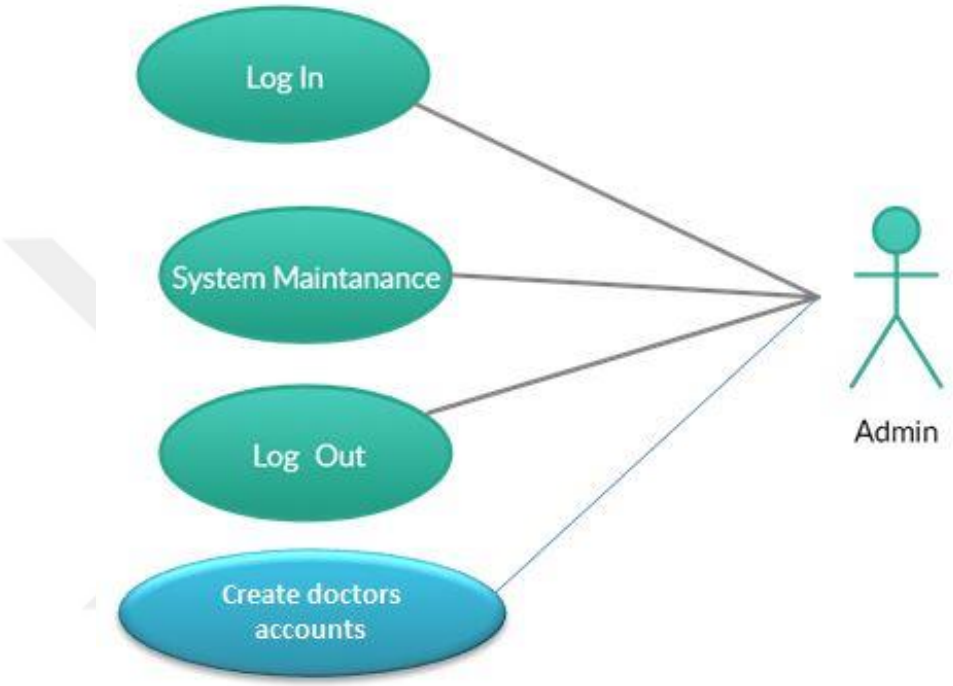

Figure 2.2: For Admin

2.3. DOCTOR

As for the doctor, he can log in to the site after that he can request a QR-Code from the patient to enter the patient's medical file, or he can enter with the patient's fingerprint or through the username and password. After entering, he can see the patient's medical file and add a diagnosis ، add A prescription, adding a referral disease, adding a medical report, and asking the laboratory for an examination as described in figure 2.3.

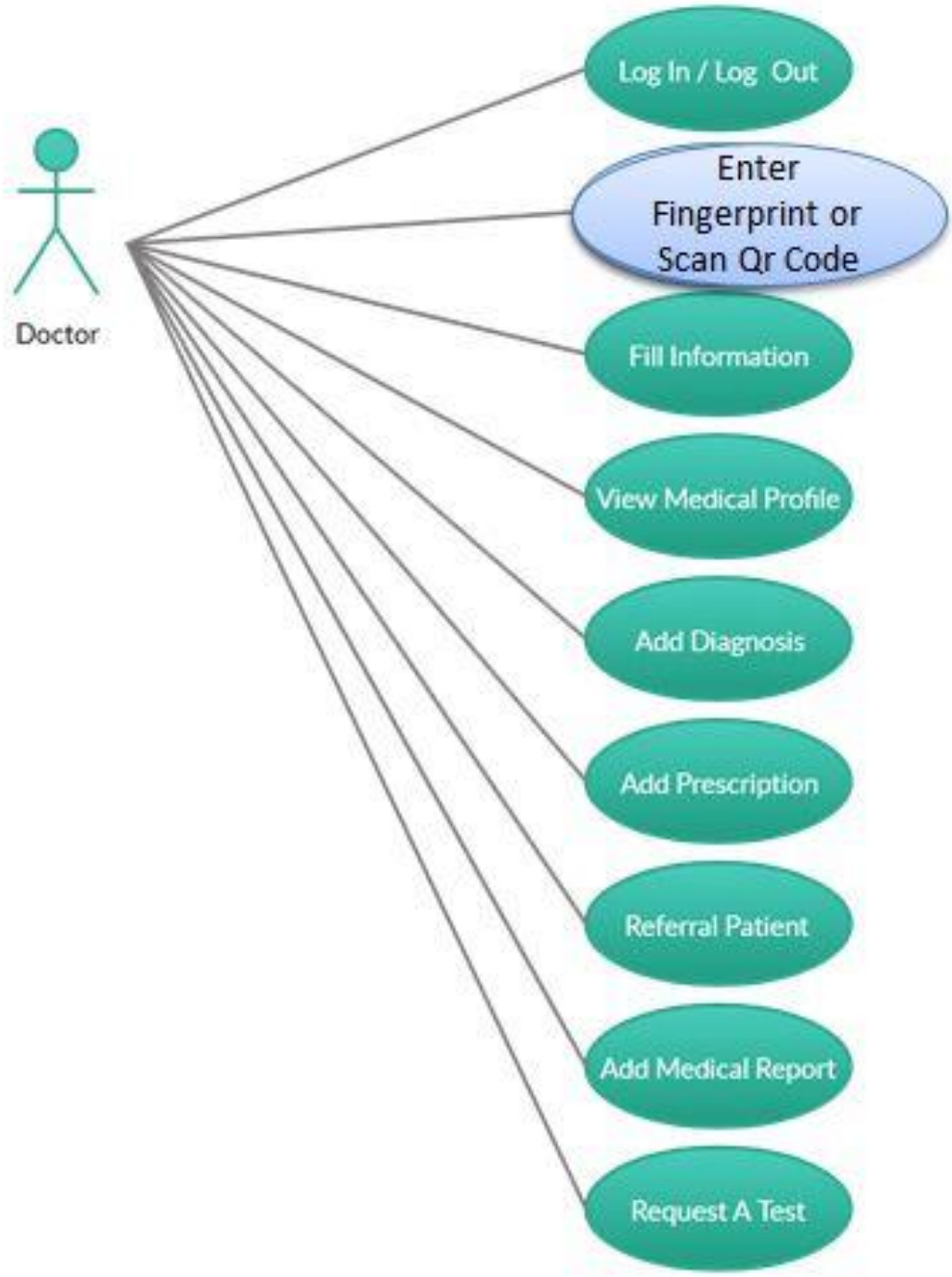

Figure 2.3: For Doctor

3. ER-DIAGRAM

The ER-Diagram it will explain the relationships between the users and the tables that were used, as detailed in figure 3.1.

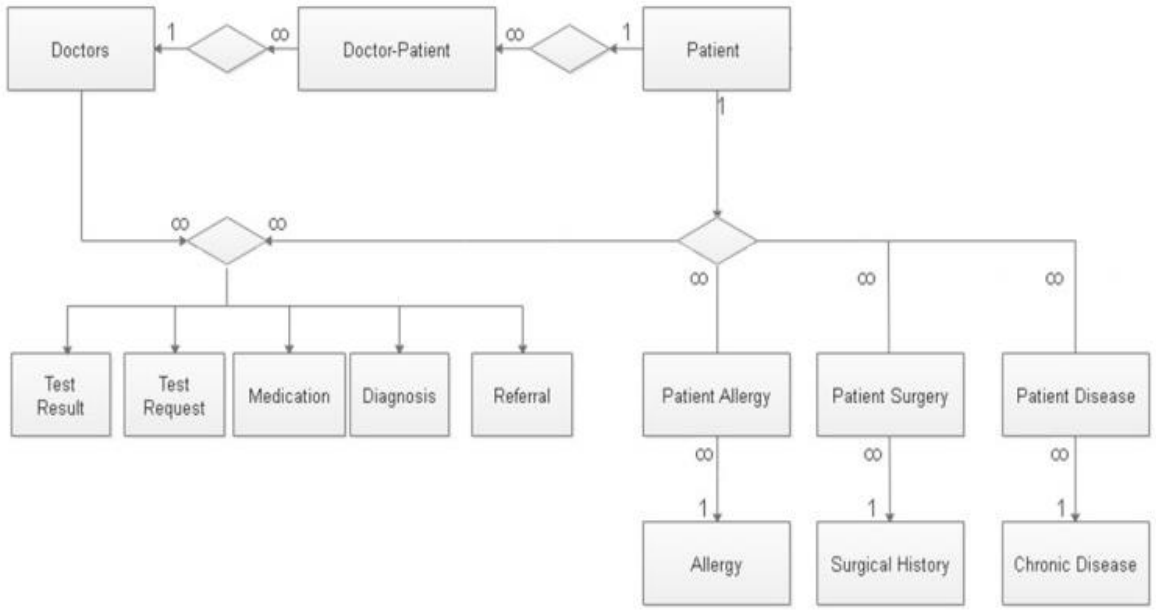

Figure 3.1: ER-Diagram

4. ACTIVITY DIAGRAM

4.1. DOCTOR LOGIN

It will explain to us how to sign in as a doctor as detailed in figure 4.1.

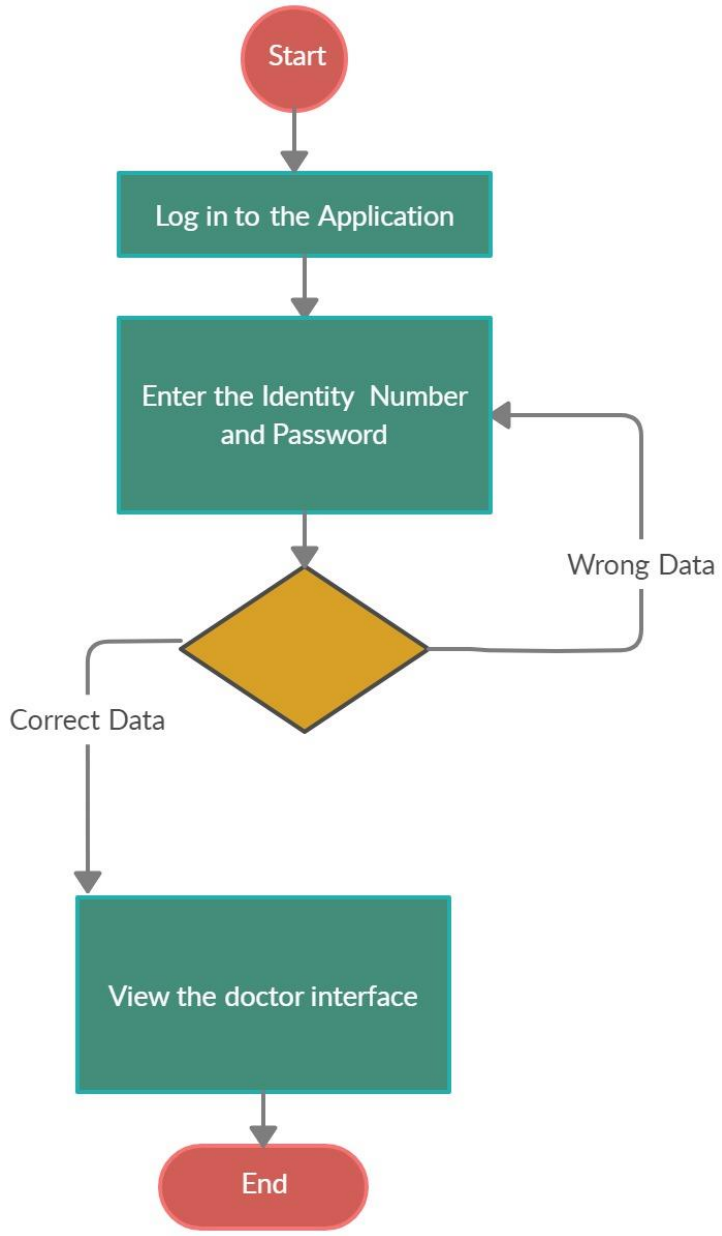

Figure 4.1: Doctor Login

4.2. PATIENT LOGIN

4.2.1. By finger print

There are several ways to enter the patient's file, and we will explain the way to enter by fingerprint, as shown in the figure 4.2.

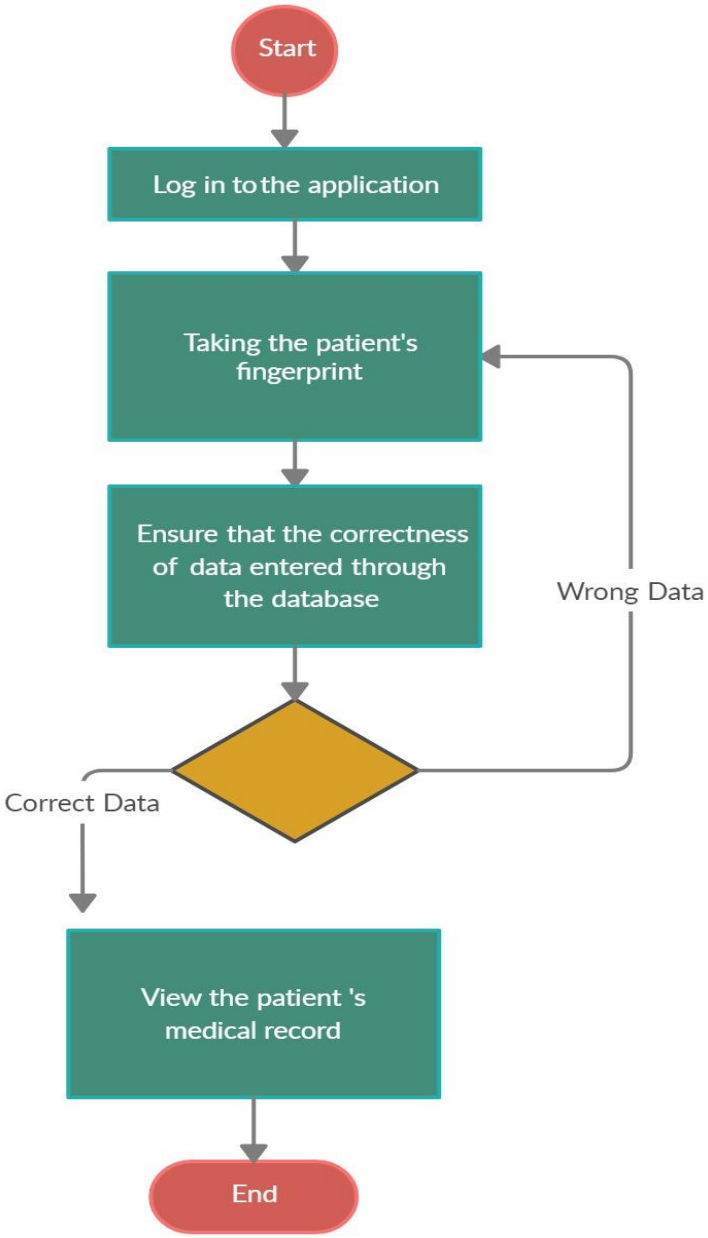

Figure 4.2: By Fingerprint

4.2.2. By QR code

We will explain how to enter via QR code as shown in the figure 4.3.

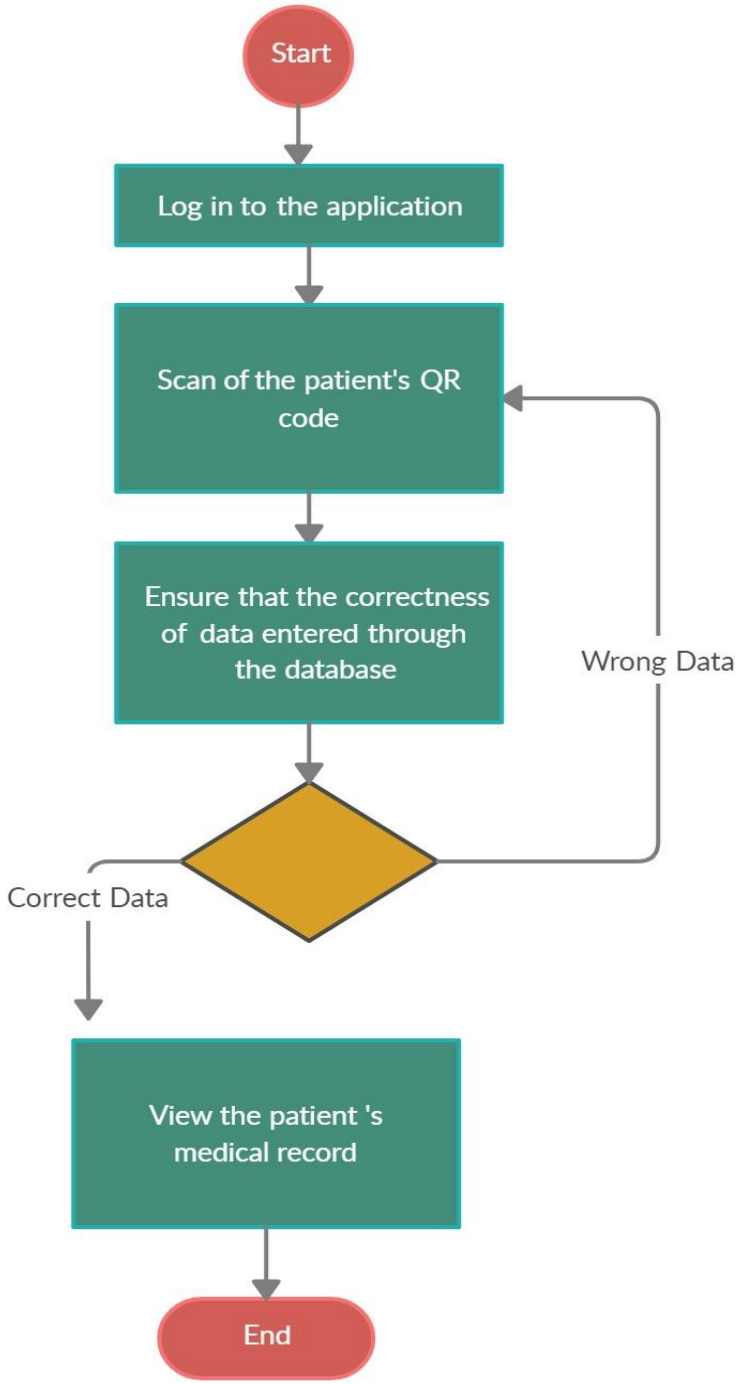

Figure 4.3: By QR Code

4.3. DOCTOR ACTIVITY

4.3.1. Access the patient's file through the doctor

And here we will explain how to access the patient's file through the doctor, as shown in the figure 4.4.

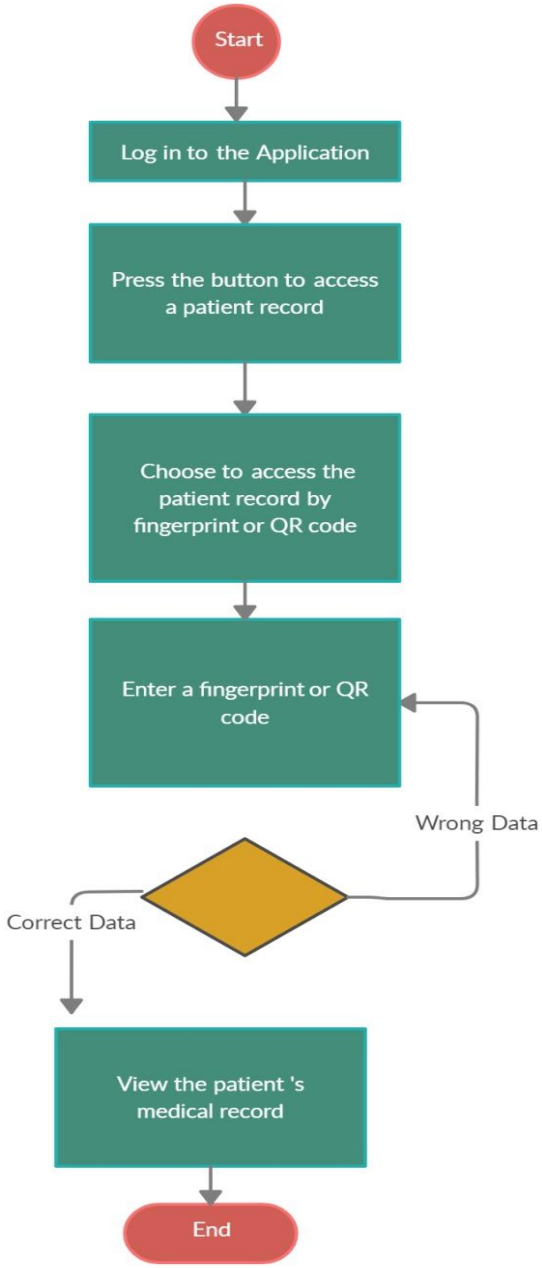

Figure 4.4: Access the patient's medical record By doctor

4.3.2. Action on Patient

Here is a description of the operations that the doctor performs in the patient's file, as shown in the figure 4.5.

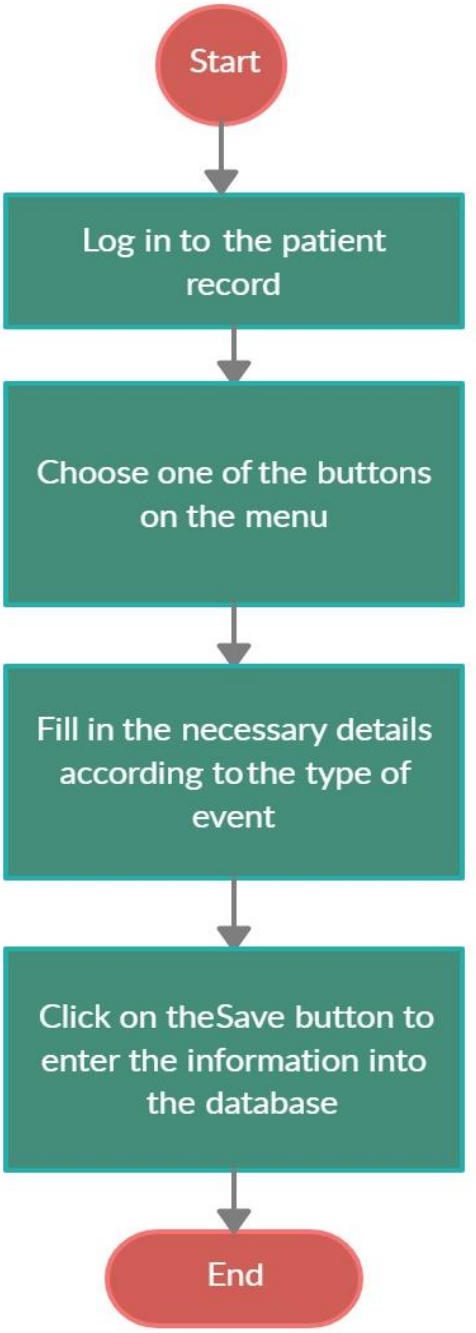

Figure 4.5: Make action on Patient

5. SEQUENCE DIAGRAM

5.1. DOCTOR LOGIN

A detailed explanation of the doctor login process is shown in the figure 5.1.

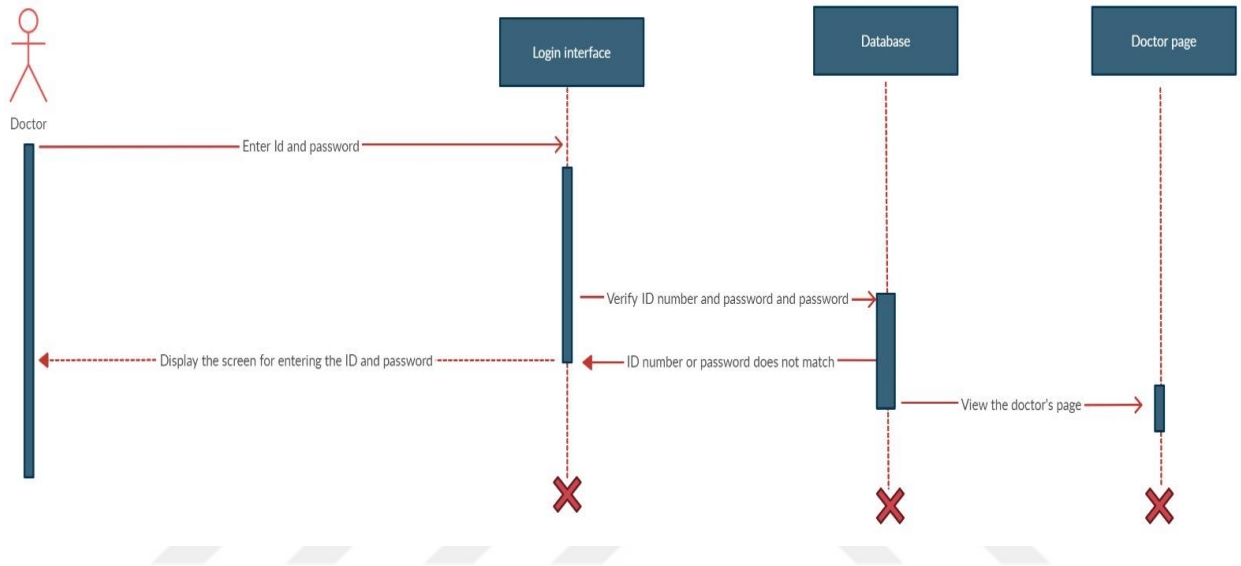

Figure 5.1: Doctor Login

5.2. PATIENT LOGIN

5.2.1. By finger print

A detailed explanation of the process of logging in to the patient by fingerprint, as shown in the figure 5.2.

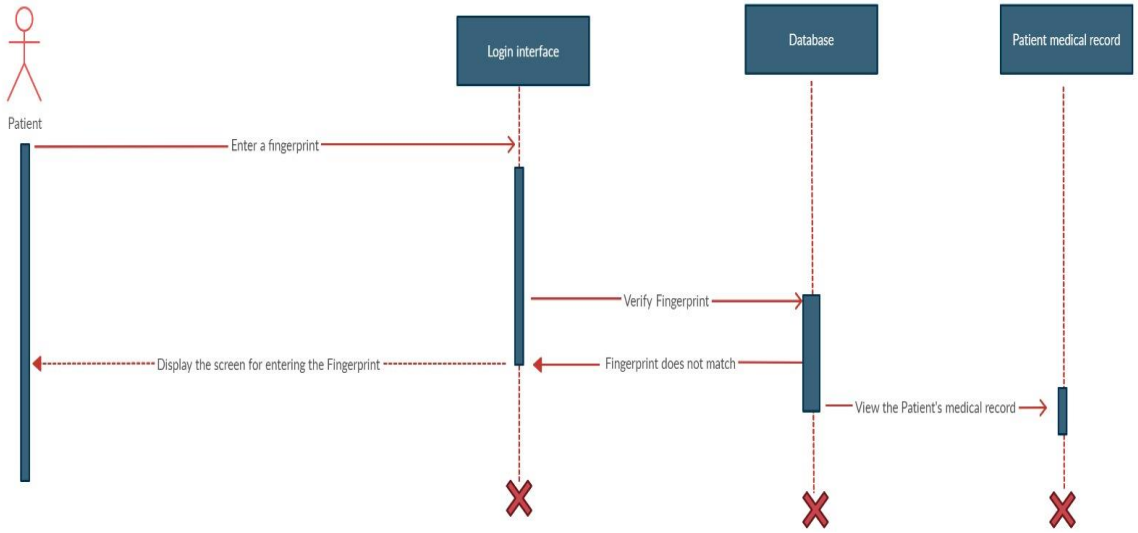

Figure 5.2: By Fingerprint

5.2.2. By QR Code

A detailed explanation of the patient login process by QR Code as shown in the figure 5.3.

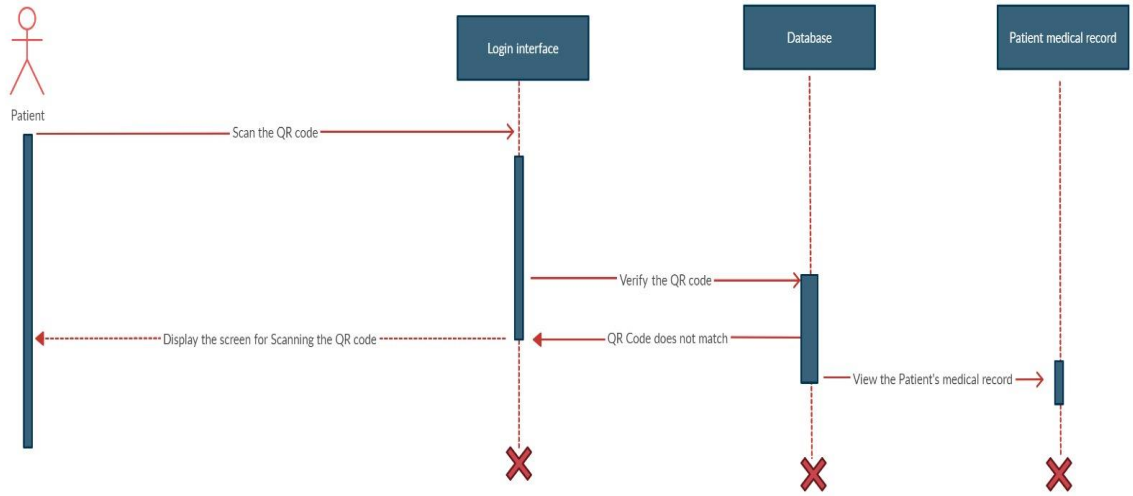

Figure 5.3: By QR Code

5.3. ACCESS THE PATIENT'S MEDICAL RECORD AS DOCTOR

5.3.1. By Finger print

A detailed explanation of the process of displaying a patient's medical record as a doctor by fingerprint as shown in the figure 5.4.

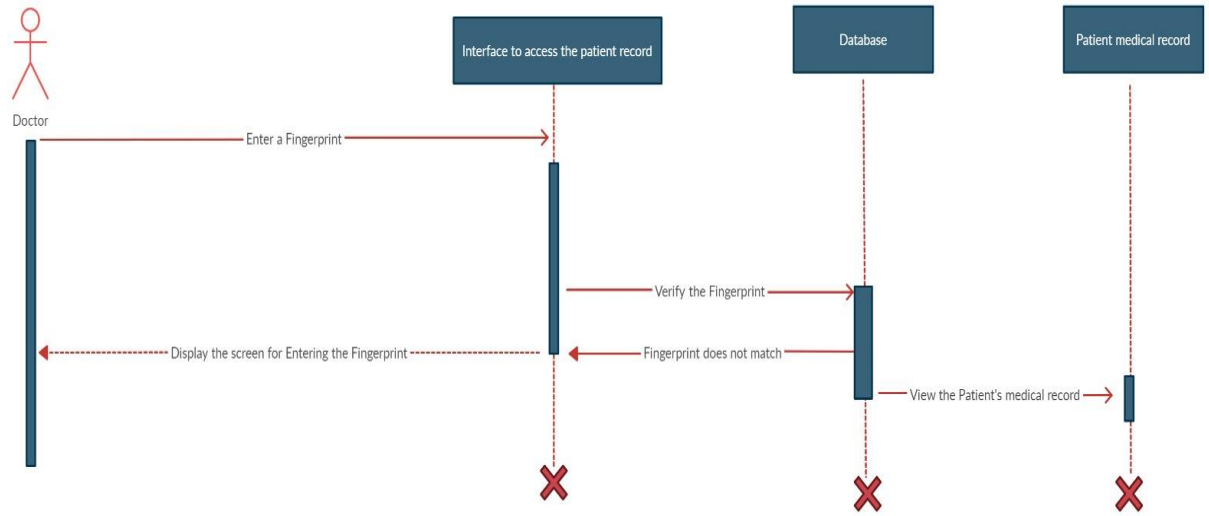

Figure 5.4: By Fingerprint

5.3.2. By QR Code

A detailed explanation of the process of displaying a patient's medical record as a doctor by QR Code as shown in the figure 5.5.

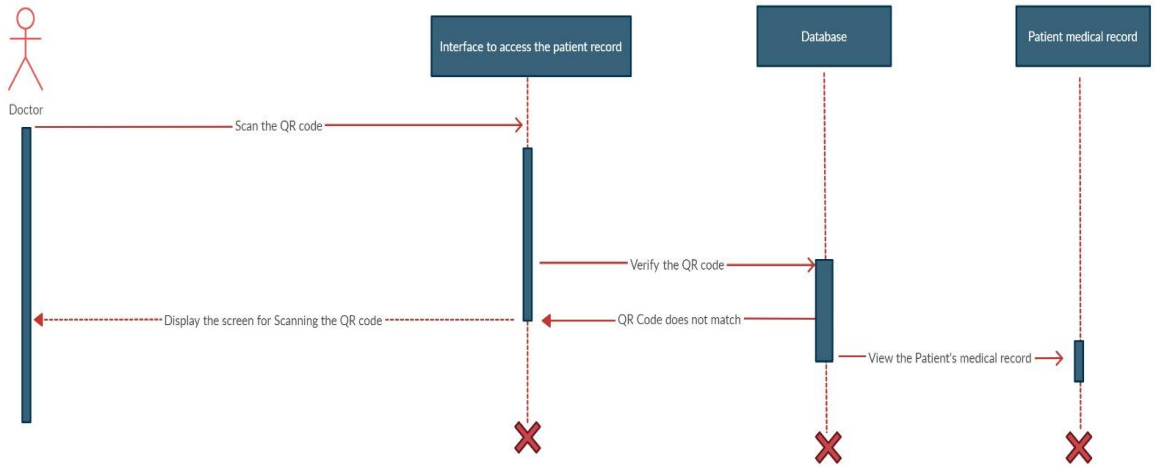

Figure 5.5: By QR Code

5.4. MAKE ACTION IN PATIENT MEDICAL RECORD

A detailed explanation of the functional operations performed by the doctor on the patient's medical record, as shown in the figure 5.6.

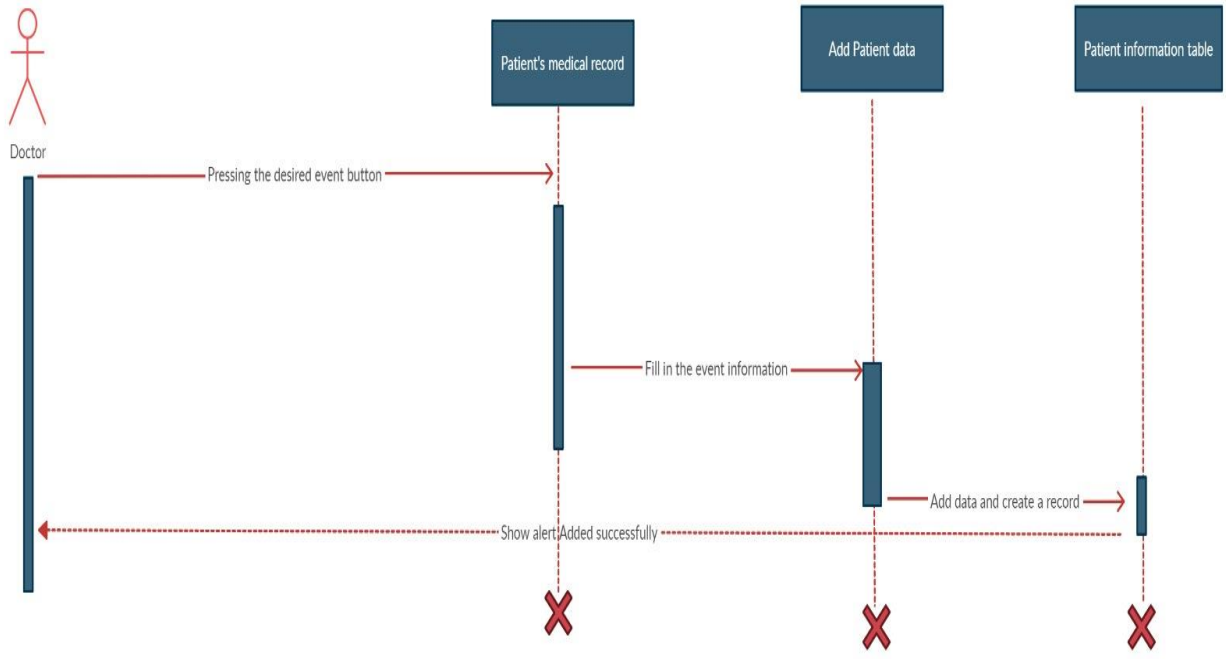

Figure 5.6: Make action in Patient medical record

6. CLASS DIAGRAM

The relationships between the tables that we have built are as shown in the figure 6.1.

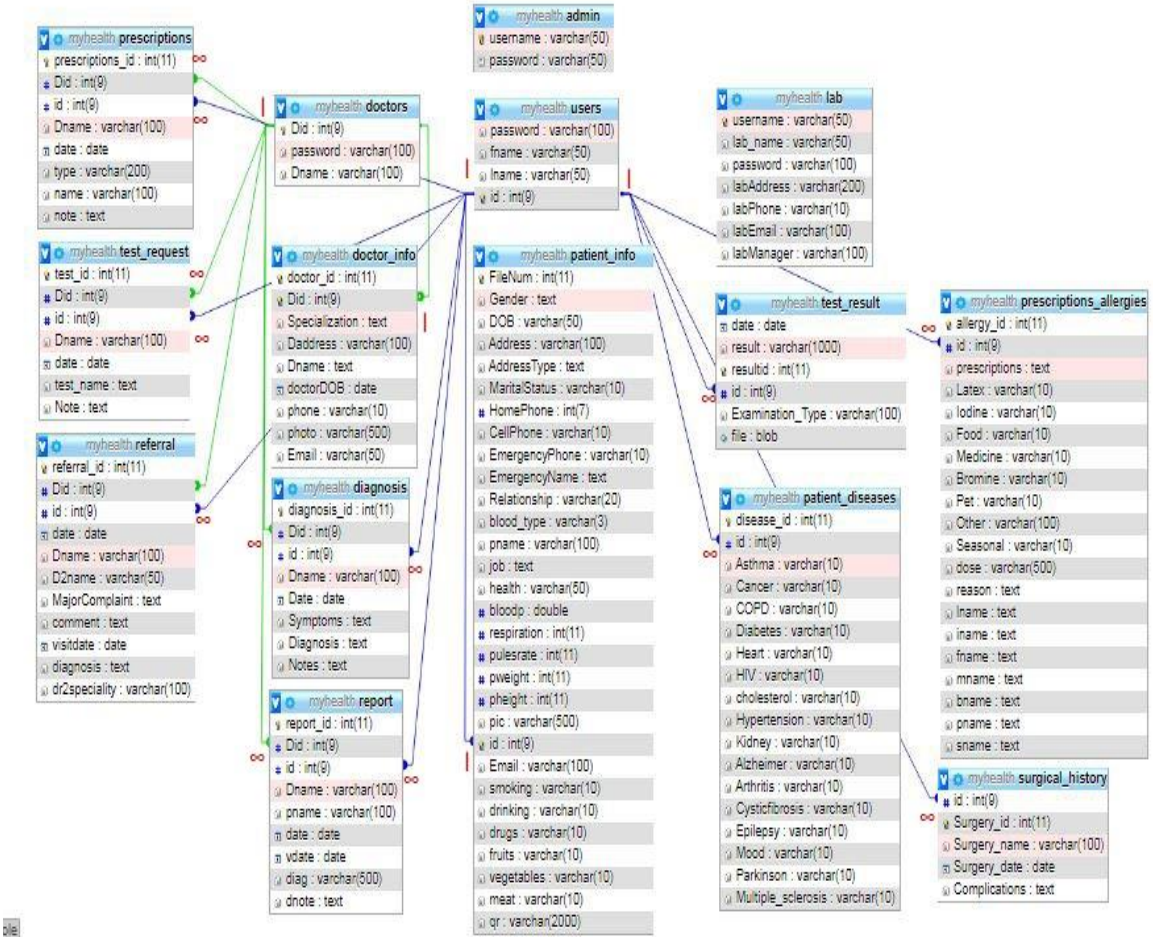

Figure 6.1: Class Diagram

7. METHODOLOGY

For the doctor, he must log in to the application via his ID number and password to access his own account to access the patient's medical record later. The fingerprint scanner is required in the emergency department so that the fingerprint is stored in the medical record and it is on the server so that when the patient's finger is placed on the fingerprint scanner, he compares the fingerprint to whoever has it, and then his electronic medical record is opened through a web page that is on the server and from here it is done View his medical data, does he suffer from allergies, chronic diseases, or the like? This method will be used in emergency cases, but in normal, non-intractable cases, the patient’s QR code will be scanned and thus access to his electronic medical record and the information required to be provided in the correct way later.

8. TECHNOLOGIES AND METHODS

The study includes the design and construction of a web site, in terms of the technologies used, it contains PHP and C#, in addition to the Arduino, and it also contains electronic components. In the first stage, the web site and the Arduino network are built with a fingerprint device, and later the device is tested to find out what If the system is fully functional.

8.1. DEVICE TESTING

Device testing aims to ensure that all stages of the research are successful. The test planning procedure can be seen in the table below

8.1.1. For emergency case:

Table 8.1: Emergency case

Stages of Testing	Objectives
The user places his finger on the fingerprint sensor.	The sensor detects the finger and adds its fingerprint to the system OR to detect the patient profile.
When the fingerprint is recorded, the pop up message It will indicate to place your finger on the fingerprint one more time	To see if the finger is already included in the database and direct the system to enter standby mode

8.1.2. For normal case:

Table 8.2: Normal case

Stages of Testing	Objectives
The user places his ID to register to the website.	The website creates the patient profile.
If the patient's Id already exists in the system, the error message will notice you.	To see if the patient id is already included in the database.
For the search case, The user places his ID or scan the QR code to preview his medical record.	The website shows to the doctor the patient's medical record.

8.2. FINGERPRINT USER TO BE USED ON FINGERPRINT SENSOR:

The doctor's account is entered, then pressed the button to add the finger and fill in the patient's ID number and password. When entering his account, to identify his fingerprint on the system, the sfg demo button is chosen. Then the program for identifying fingerprints will be accessed and the steps required to add the patient's fingerprint will be followed up. Later, the patient's fingerprint is added to the site through the C#, and it is added to the Database.

In the case of searching (in emergency situations), the doctor's account is entered and then pressed "via fingerprint," the site opens the C# program and asks the user to put his fingerprint and then displays the patient's medical record.

9. RESULTS AND DISCUSSIONS

The general study system is a website to view the patient's file in emergency cases by fingerprint stored in the database.

9.1. TESTING OF FINGERPRINT ACCESS TO MEDICAL RECORD

The fingerprint access test is considered successful when the patient’s record can be opened in an emergency situation, however the system is considered a failure if it is unable to open the medical file. Some factors that affect fingerprints such as hand condition, hygiene and finger moisture will affect the sensor reading results.

9.2. FINGERPRINT DETECTION TESTING

The fingerprint detection test aims to view the patient's medical file in an emergency situation, to know the success rate of fingerprints that have been entered into a database. The test is performed by affixing the user's fingerprint first and then continuing by affixing another person's fingerprint.

The method of placing the fingerprint will be tested using the sensor in different positions, and we will use one fingerprint to open the same record, but in different positions, i.e. we will rotate the same finger at five different angles. The fingerprint detector test results are shown in the table 9.1:

Table 9.1: Right Thumb Rotation Test Result for patient medical record

position	Result
1	Opened
2	Opened
3	Opened
4	Opened
5	Opened

The table above shows the results of the fingerprint detection test using the right thumb in 5 different positions for the same person. All positions were successful and we opened the user's medical record 5 times.

And to check the confidence level, we tested ten users consecutively to check that he could know the fingerprints of people and open for each user his own medical file, the results of the fingerprint detector test are shown in the table 9.2.

Table 9.2: Test result to open the medical file for each user

User	Result
1	Succeeded
2	Succeeded
3	Succeeded
4	Succeeded
5	Succeeded
6	Succeeded
7	Succeeded
8	Succeeded
9	Succeeded
10	Succeeded

The table (2) shows the results of the fingerprint detection test for 10 different people, respectively. And all the times were successful and we successfully opened the medical record for users.

Besides the level of confidence, a test is performed to determine the time required to read and open the medical record. The reading time is obtained from measuring the readings from the user. The results show that the reading ranges between 2 and 2.4 seconds are shown in the table 9.3.

Table 9.3: Time for opening the medical record

User	Time(s)
1	2
2	2.3
3	2.1
4	2
5	2.4
6	2.1
7	2.2
8	2.2
9	2.3
10	2.1

10.WEBSITE OPENING AND IMPLEMENTATION

The home page of the site includes three buttons so that each person chooses one of them according to his type, whether he is a doctor, patient or laboratory, and by pressing the button he can enter his own data to enter his personal page as shown in figure 10.1.

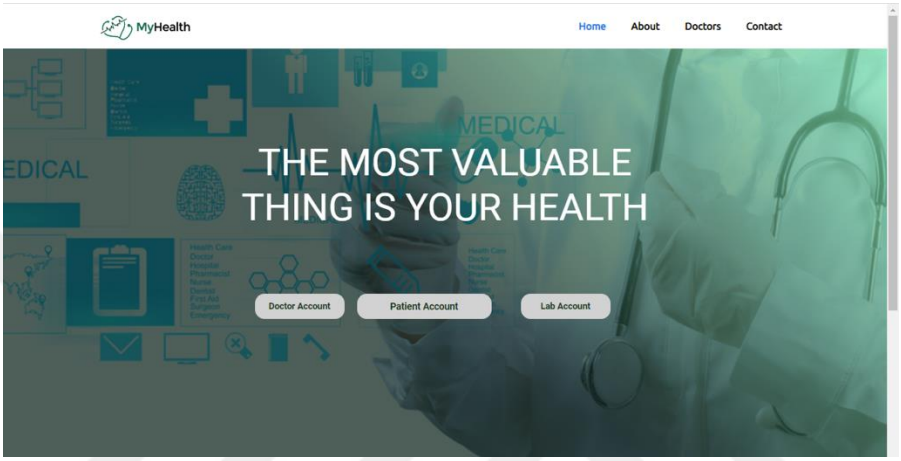

Figure 10.1: Home Page of website

Through this form, the doctor enters his ID number and password to enter his personal page as shown in figure 10.2

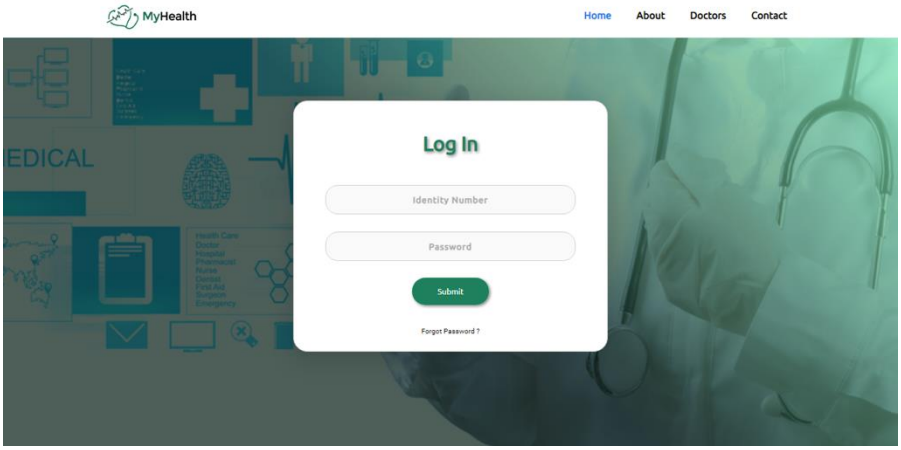

Figure 10.2: Doctor Login Form

After the doctor enters his data , he is entered into his personal page so that his personal information is displayed that he can edit through the edit information button as he can change the password of his account by way of the password change button, also this page includes two buttons, first button add a finger through which the fingerprint of the patient is added to database to be later searched

for it to reach it by any doctor, secondly the patient's record button is through Access to the patient's record either by fingerprint in an emergency cases or by scanning the QR code in normal cases or by entering the patient's ID number as shown in figure 10.3.

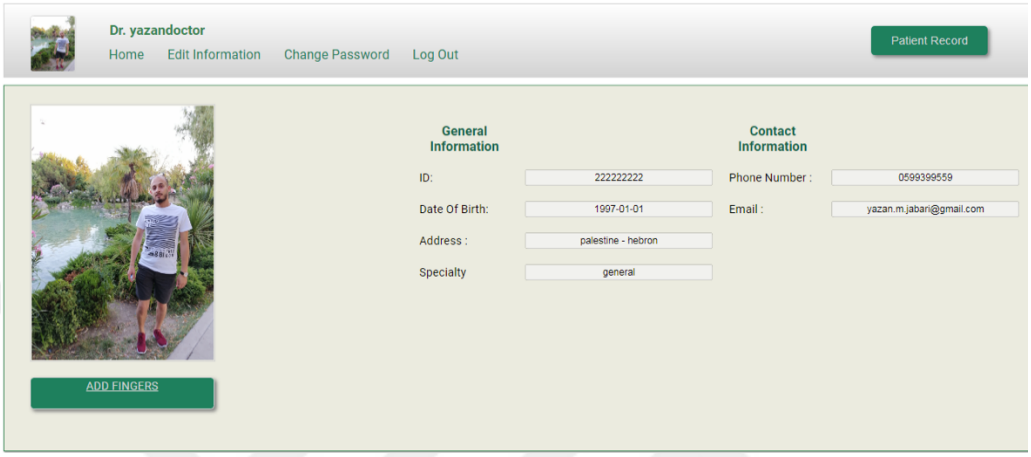

Figure 10.3: Doctor Home Page

When you press the finger-adding button, a page containing two buttons is reviewed, in case the patient's fingerprint is not known in database the sfg demo button is pressed to identify the patient's fingerprint so that he can then press the other button to scan the finger to find the patient's entry fingerprint as shown in figure 10.4.

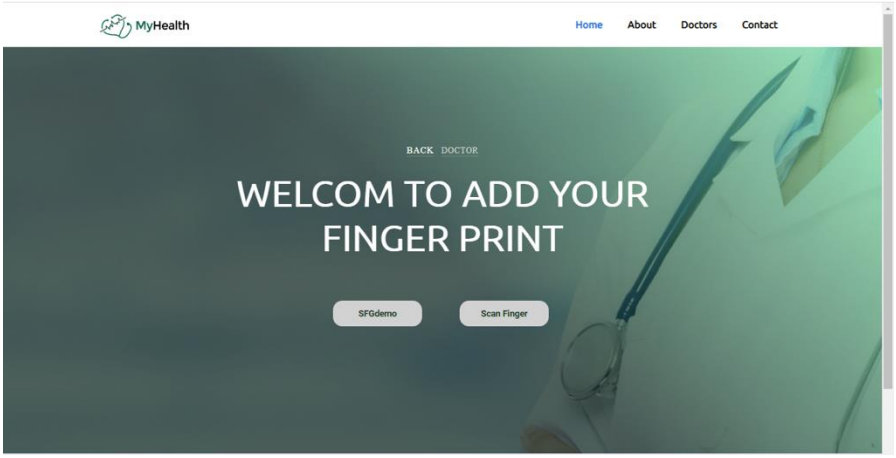

Figure 10.4: Add Finger Choices Page

When you press the SFG Demo button, the program is accessed through which the patient's fingerprint will be identified as shown in figure 10.5.

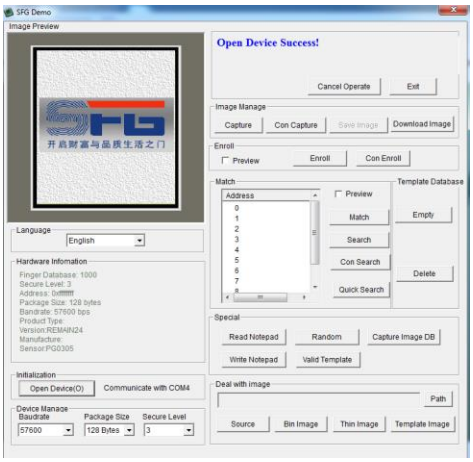

Figure 10.5: SFG Demo Interface

When you press the scan button is entered to the form enter the patient's data id number and password as shown in figure 10.6 to be displayed later a page containing all the patient's fingers to add all the fingerprints of the patient by adding each fingerprint in the place assigned to it as shown in figure 10.7 and then work a search for it in database to be confirmed added when pressing the scan button is entered into the application of the patient's data id number as shown in figure 10.8 to be displayed later a page containing all the patient's fingerprints to add all the fingerprints of the patient by He added to each fingerprint in the place assigned to her and then did a search for her in database to be confirmed.

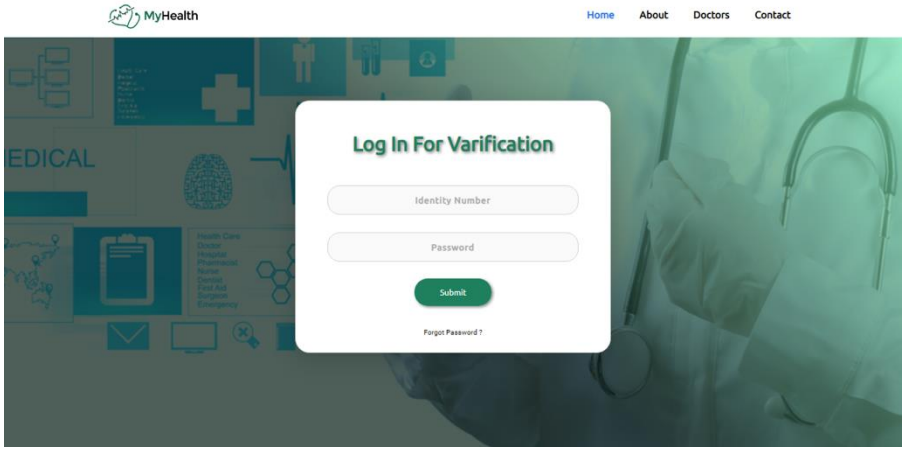

Figure 10.6: login Verification page

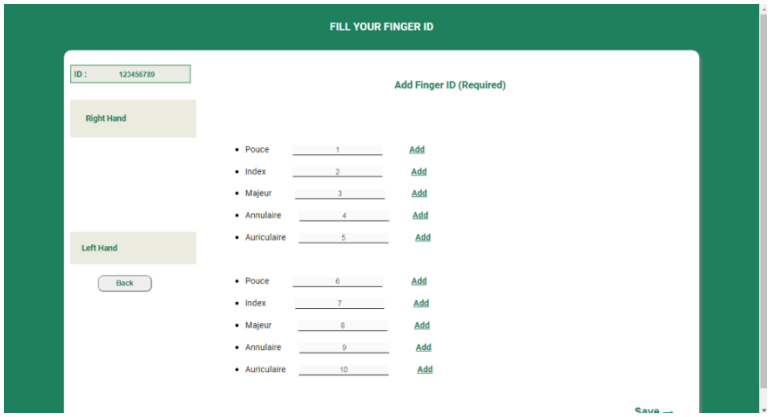

Figure 10.7: Add Finger page

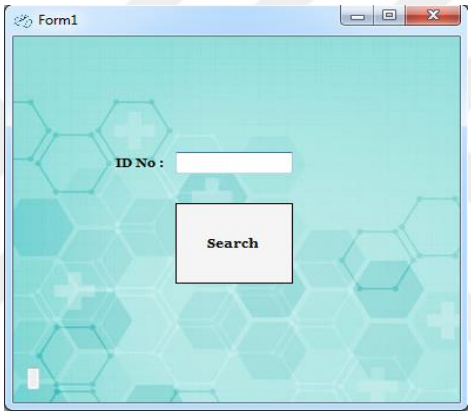

Figure 10.8: C# interface for adding to Data base

Through the doctor's page, the patient's medical record can be accessed through the patient's record button, which includes a drop-down list of three ways to access the patient's medical record, so that the patient's record can be accessed either via patient fingerprint or via QR Code scanning or via entering the patient's ID number as shown in figure 10.9. If he chooses to access the patient's record via the fingerprint in emergency cases, a page containing a button (scan) can be accessed to ask for the finger to be pressed on the fingerprint reader and when placing the finger is accessed the patient's required record as shown in figure 10.10.

If the doctor chooses to enter through the patient's QR code, the QR scanner is accessed, and the patient's code is cleared and then moved to the patient's requested page.

If access to the patient's record is chosen via patient's ID number, the patient's ID number will be entered to enter the patient's ID number and the patient's id number will be accessed after the desired patient's record is accessed.

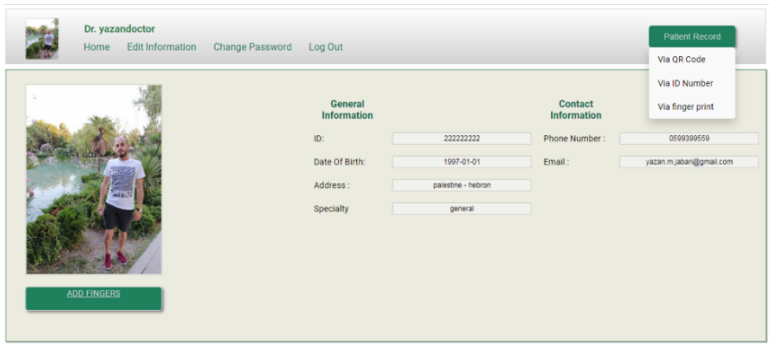

Figure 10.9: A drop-down list of three ways

Figure 10.10: C# interface for Scanning

if the user is a patient, the patient account button must be pressed, and a drop-down menu appears containing two buttons, either create a new account by sign up button if the patient does not have an account before, or make a login for his account that he previously created as shown in figure 10.11.

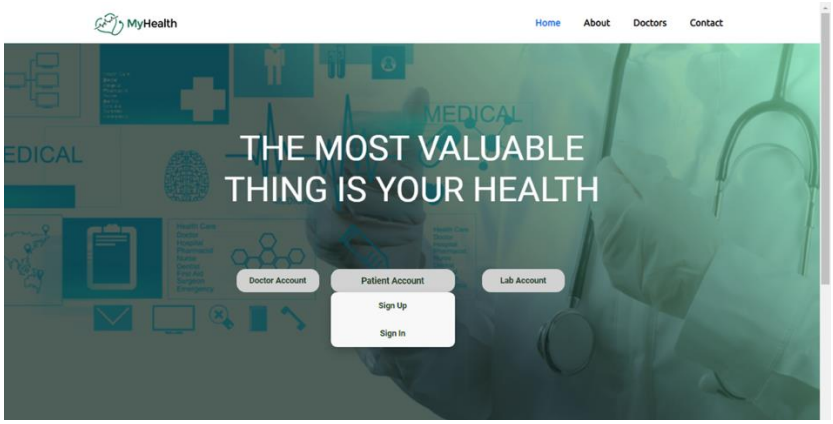

Figure 10.11: Patient Drop-Down menu

if he wants to create a new account, he chooses the sign up button, and a special form appears for filling in the patient's data, such as name, ID number and password as shown in figure 10.12, and then an account is created and moved to his personal page so that he can review his medical record and fill in his personal information with the ability to change his password as shown in figure 10.13:

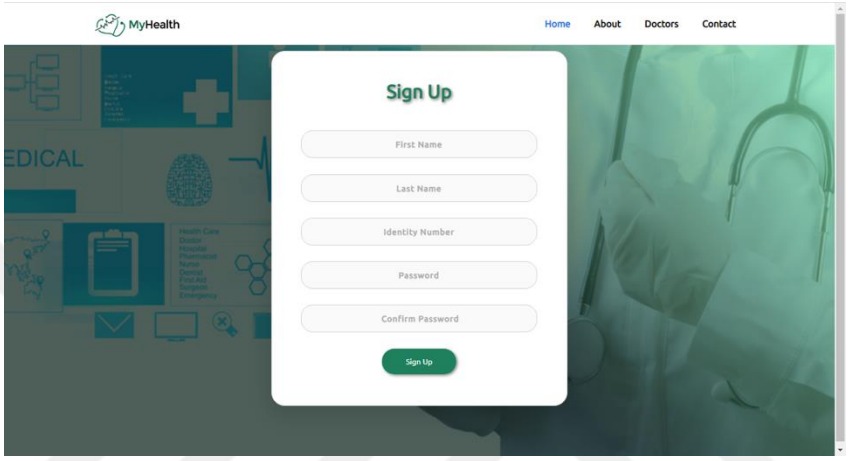

Figure 10.12: Patient Sign Up Page

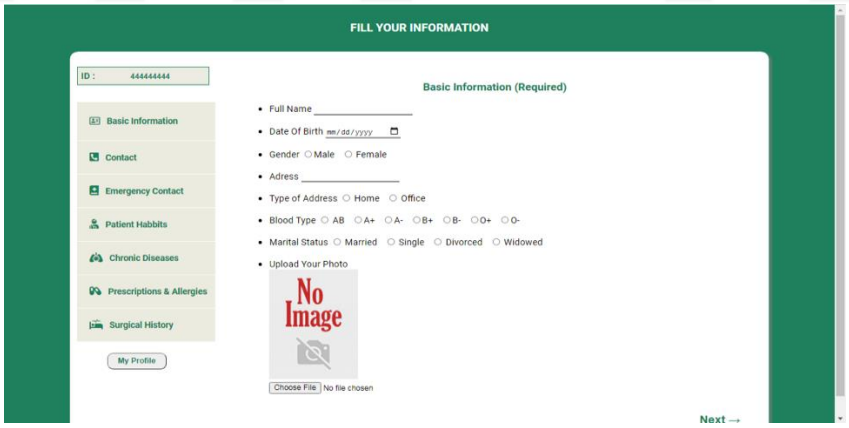

Figure 10.13: Patient fill information Page

and if the patient wants to enter his account that was previously created, he presses the log in button, and the form of filling in the patient's ID number and password appears as shown in figure 10.14, and then access to his personal account is done so that he reviews his personal information with the possibility of modification and also review his medical record as shown in figure 10.15.

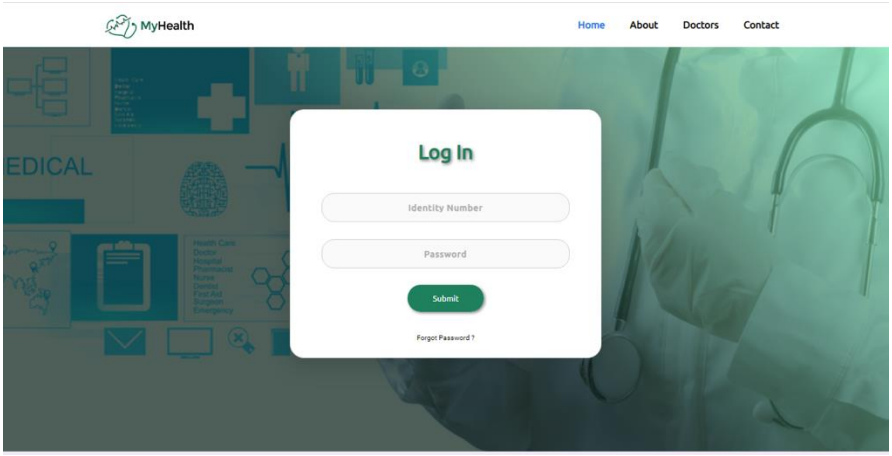

Figure 10.13: Patient Sign in Page

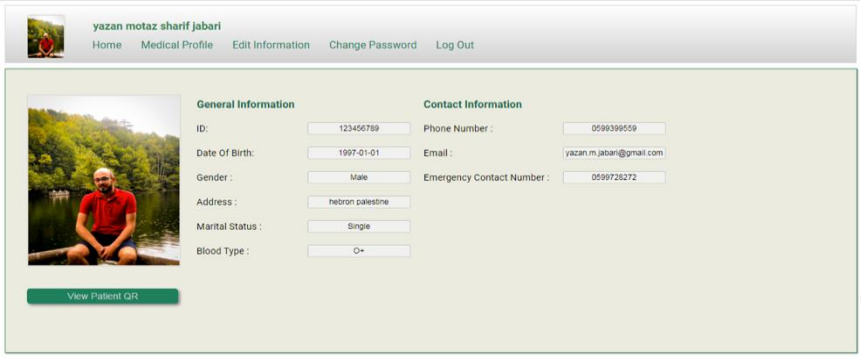

Figure 10.14: Patient Home Page

If the user is a laboratory, then the laboratory account button must be pressed, then the Sign in page for laboratory appears as shown in figure 10.15.

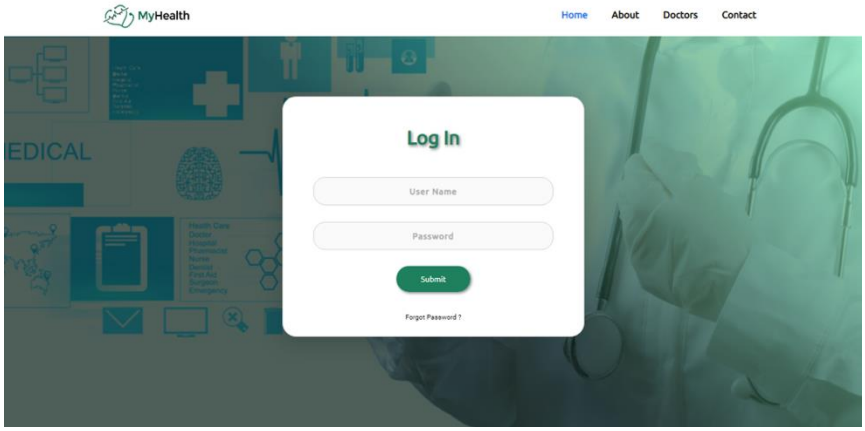

Figure 10.15: Patient Sign in Page

And after entering the laboratory page, private information appears in the laboratory, and if the laboratory wants to view the required tests for a patient, he must press the "Add Examination" button so that we have a page for entering the patient's ID number as shown in figure 10.16.

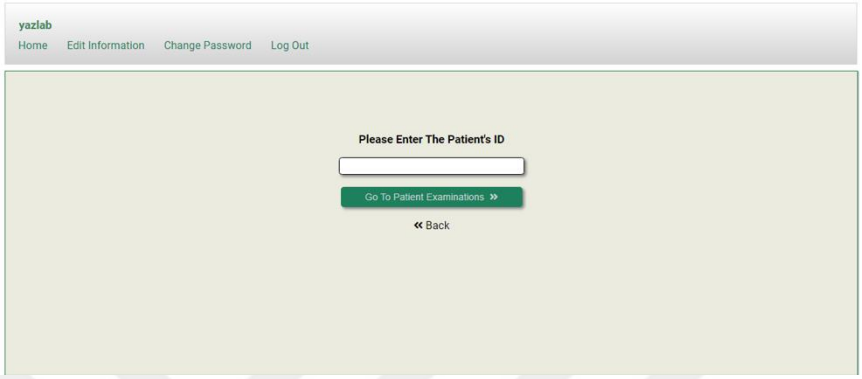

Figure 10.16: Patient's ID Page

and after that he can view the tests Required and enter the result of these checks as shown in figure 10.17.

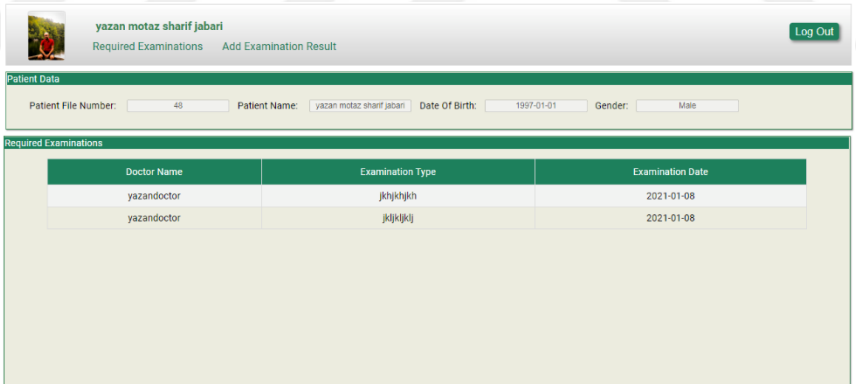

Figure 10.17: Patient Required Examinations

11.THESIS CONTRIBUTION

This thesis will be useful in the technological and medical fields, in addition to restoring control over the emergency department in hospitals, avoiding potential medical errors and reducing and controlling the number of deaths resulting from medical errors. In previous studies, when going to the emergency department, the doctor makes a lengthy examination of the patient, which is wasted Time, and in other cases, quick medical procedures can be taken without doing tests. It also helps expatriates who may be exposed to emergency medical conditions to refer to their medical records and view their data in a way that makes it easier for them to take the necessary medical measures for their condition, which saves time and effort for the patient and the doctor. In the meantime, by taking the patient's fingerprint in emergency cases, or by scanning his QR code in normal cases.

12.CONCLUSION

In previous studies, we found the smart card that is used to access the medical file [11] and we found that the smart card in emergency situations is useless because it is possible for the patient to lose it. Therefore, our study provides strong evidence that a fingerprint can facilitate quick access to patient data in Emergency cases. Therefore, doctors and patients are likely to benefit from this feature. In other previous studies, Bluetooth was used in connections [12], but using Bluetooth in emergency situations is not considered a reliable process because Bluetooth waves are easy to jam, so we used a USB wired connection. .

With the Corona crisis that we are going through at the present time, access to the medical file has become an important matter. Therefore, the electronic health record and the technologies associated with it are vital and necessary tools in support of disease outbreak management that must be used to its fullest potential [13].

The COVID-19 pandemic requires multiple data-sharing strategies. And with the IT infrastructure, it could be useful in solving this crisis [14].

The studies reviewed specific health information technology practices for outbreak management in China and discussed the critical issues that must be taken into account when using health information technology [15].

The workflow ensures that doctors can view the medical record on time.

For policymakers, our study helps reconcile previous conflicting findings about the benefits of a fingerprint by focusing on developing its use to improve care. Given the significant public investment in EHRs and the continued focus on developing ways to access patient medical records, it is likely that future policies - which ensure that the use of fingerprints are well integrated into physicians' workflows - will be key to ensuring that the benefits continue.

REFERENCES

[1] M. Moreb, T. A. Mohammed, and O. Bayat, "A novel software engineering approach toward using machine learning for improving the efficiency of health systems," *IEEE Access*, vol. 8, pp. 23169–23178, 2020, doi: 10.1109/ACCESS.2020.2970178.

[2] B. Melis, "Electronic health records," *Surg. Prod.*, vol. 30, no. 10, p. 34, 2011, doi: 10.19030/ajhs.v3i3.7139.

[3] L. A. Dossett *et al.*, "Specialist Physicians' Attitudes and Practice Patterns Regarding Disclosure of Pre-referral Medical Errors," *Ann. Surg.*, vol. 267, no. 6, pp. 1077–1083, 2018, doi: 10.1097/SLA.0000000000002427.

[4] I. A. Ogbodo, "Exploring Access to EHR by Emergency Patients Using Multimodal Biometrics," *Int. J. Latest Technol. Eng. Manag. Appl. Sci.*, vol. IX, no. IV, 2020.

[5] J. Everson, K. E. Kocher, and J. Adler-Milstein, "Health information exchange associated with improved emergency department care through faster accessing of patient information from outside organizations," *J. Am. Med. Informatics Assoc.*, vol. 24, no. e1, pp. e103–e110, 2017, doi: 10.1093/jamia/ocw116.

[6] F. Hidayanti, F. Rahmah, and A. Wiryawan, "Design of motorcycle security system with fingerprint sensor using arduino uno microcontroller," *Int. J. Adv. Sci. Technol.*, vol. 29, no. 5, pp. 4374–4391, 2020.

[7] M. Z. Ercan and M. Lane, "Evaluation of NoSQL databases for EHR systems," *Proc. 25th Australas. Conf. Inf. Syst. ACIS 2014*, 2014.

[8] Microsoft, "Dijital Sağlık Teknolojisi – e-Sağlık Bilgi Yönetimi | Microsoft." https://www.microsoft.com/tr-tr/industry/health?rtc=1 (accessed May 08, 2021).

[9] S. Jahan, M. Chowdhury, and R. Islam, "Robust fingerprint verification for enhancing security in healthcare system," *Int. Conf. Image Vis. Comput. New Zeal.*, vol. 2017-Decem, pp. 1–5, 2018, doi: 10.1109/IVCNZ.2017.8402502.

[10] healthcentral, "Migraine Signs, Symptoms, Causes, Triggers, and Treatments."

https://www.healthcentral.com/condition/migraines (accessed May 08, 2021).

[11] A. T. S. Chan, "Web-enabled smart card for ubiquitous access of patient's medical record," *Comput. Networks*, vol. 31, no. 11, pp. 1591–1598, 1999, doi: 10.1016/S1389-1286(99)00056-0.

[12] J. R. Díaz-Palacios, V. J. Romo-Aledo, and A. H. Chinaei, "Biometric access control for e-health records in pre-hospital care," *ACM Int. Conf. Proceeding Ser.*, pp. 169–173, 2013, doi: 10.1145/2457317.2457345.

[13] J. J. Reeves *et al.*, "Rapid response to COVID-19: Health informatics support for outbreak management in an academic health system," *J. Am. Med. Informatics Assoc.*, vol. 27, no. 6, pp. 853–859, 2020, doi: 10.1093/jamia/ocaa037.

[14] A. Dagliati, A. Malovini, V. Tibollo, and R. Bellazzi, "Health informatics and EHR to support clinical research in the COVID-19 pandemic: an overview," *Brief. Bioinform.*, vol. 00, no. August 2020, pp. 1–11, 2021, doi: 10.1093/bib/bbaa418.

[15] Q. Ye, J. Zhou, and H. Wu, "Using information technology to manage the COVID-19 Pandemic: Development of a technical framework based on practical experience in China," *JMIR Med. Informatics*, vol. 8, no. 6, 2020, doi: 10.2196/19515.