VIETNAM NATIONAL UNIVERSITY, HO CHI MINH CITYUNIVERSITY OF TECHNOLOGY
FACULTY OF COMPUTER SCIENCE AND ENGINEERING

DATABASE SYSTEM (CO2014)

Assignment 2

HOSPITAL MANAGEMENT SYSTEM

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HO CHI MINH CITY, DECEMBER 2024

Contents

1 Member list & Workload

No.	Fullname	Student ID	Task	Contribution
1	Tran Tri Dung	2252133	Define user groupsand permissions, define app architecture, Do functions, procedures, triggers and assertions, define detailed specifications	100%
2	Nguyen le Duy khang	2252303	Frontend development, normalize schema to BCNF, create data for application	100%
3	Huynh Ngoc Khoa	2211591	Backend development, indexing, Do functions, procedures, triggers and assertions, define detailed specifications	100%

2 Triggers

2.1 Prevent Patient Deletion

- Purpose: Prevent the deletion of a patient who has existing appointments.

```
CREATE TRIGGER PreventPatientDeletion
BEFORE DELETE ON Patient
FOR EACH ROW
BEGIN
    DECLARE appointment_count INT;
    SELECT COUNT(*) INTO appointment_count
    FROM Appointment
    WHERE ID_Patient = OLD.ID_Patient;

    IF appointment_count > 0 THEN
        SIGNAL SQLSTATE '45000'
        SET MESSAGE_TEXT = 'Cannot delete patient with existing
appointments.';
    END IF;
END;
```

2.2 After Appointment Insert

- Purpose: Automatically create an invoice when a new appointment is added.

```
CREATE TRIGGER AfterAppointmentInsert
AFTER INSERT ON Appointment
FOR EACH ROW
BEGIN
    INSERT INTO Invoice (ID_Patient, Amount, IssueDate)
    VALUES (NEW.ID_Patient, 100.00, CURDATE());
END;
```

2.3 Trg_insert_user

- Purpose: Automatically insert a new user into the Doctor or Patient table based on their role.

```
CREATE OR REPLACE TRIGGER trg_insert_user
AFTER INSERT ON Users
FOR EACH ROW
BEGIN
    IF UPPER(:NEW.role) = 'DOCTOR' THEN
        INSERT INTO Doctor (ID, Speciality)
        VALUES (:NEW.id, NULL);
    ELSIF UPPER(:NEW.role) = 'PATIENT' THEN
        INSERT INTO Patient (ID)
        VALUES (:NEW.id);
```

```
    END IF;
END;
/
```

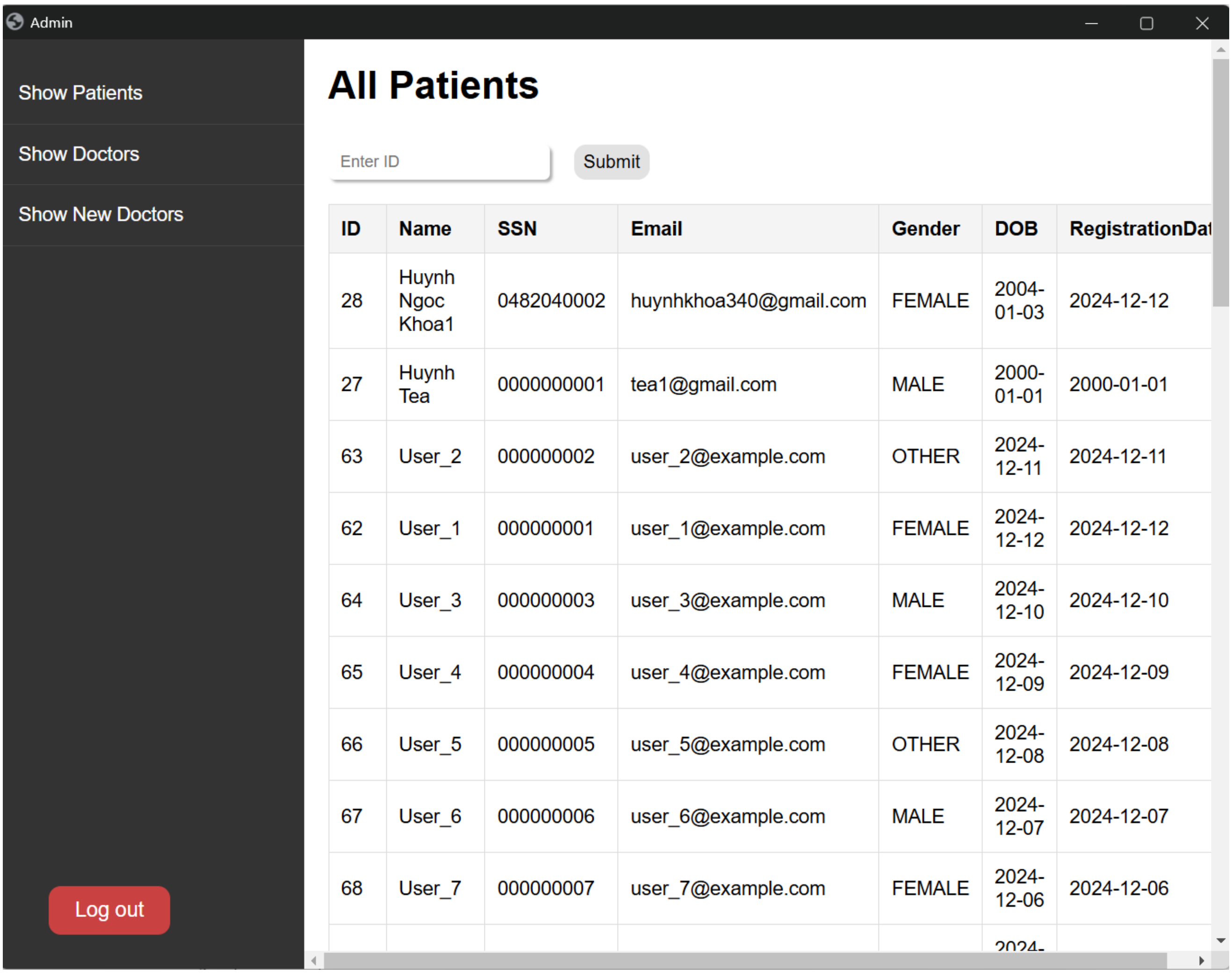
2.4 Trg_update_doctor_speciality

- Purpose: Automatically update a doctor's specialty based on the information added to the Doctor_Assigned table.

```
CREATE OR REPLACE TRIGGER trg_update_doctor_speciality
AFTER INSERT ON Doctor_Assigned
FOR EACH ROW
DECLARE
    dept_speciality VARCHAR2(100);
    current_speciality VARCHAR2(4000);
BEGIN
    SELECT Speciality INTO dept_speciality
    FROM Department
    WHERE ID = :NEW.Department_ID;
    SELECT Speciality INTO current_speciality
    FROM Doctor
    WHERE ID = :NEW.Doctor_ID;

    IF current_speciality IS NULL THEN
        UPDATE Doctor
        SET Speciality = dept_speciality
        WHERE ID = :NEW.Doctor_ID;
    ELSIF INSTR(current_speciality, dept_speciality) = 0 THEN
        UPDATE Doctor
        SET Speciality = current_speciality || ', ' || dept_speciality
        WHERE ID = :NEW.Doctor_ID;
    END IF;
END;
/
```

Display the number of patient and doctors before proceeding


Admin
Show Patients
Show Doctors
Show New Doctors
Log out
All Patients
Enter ID
Submit
ID Name SSN Email Gender DOB RegistrationDat
28 Huynh Ngoc Khoa1 0482040002 huynhkhoa340@gmail.com FEMALE 2004-01-03 2024-12-12
27 Huynh Tea 0000000001 tea1@gmail.com MALE 2000-01-01 2000-01-01
63 User_2 000000002 user_2@example.com OTHER 2024-12-11 2024-12-11
62 User_1 000000001 user_1@example.com FEMALE 2024-12-12 2024-12-12
64 User_3 000000003 user_3@example.com MALE 2024-12-10 2024-12-10
65 User_4 000000004 user_4@example.com FEMALE 2024-12-09 2024-12-09
66 User_5 000000005 user_5@example.com OTHER 2024-12-08 2024-12-08
67 User_6 000000006 user_6@example.com MALE 2024-12-07 2024-12-07
68 User_7 000000007 user_7@example.com FEMALE 2024-12-06 2024-12-06

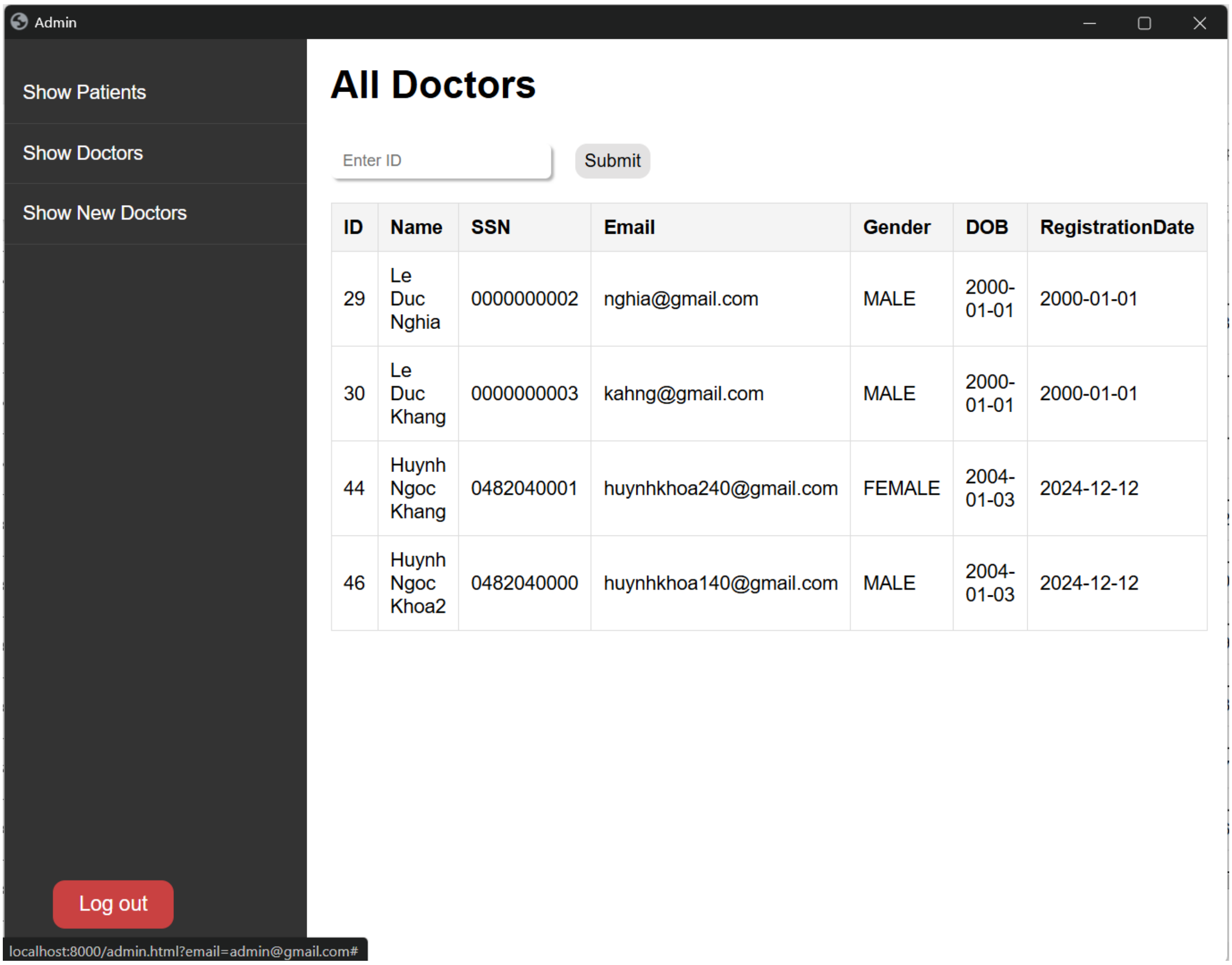


Figure 1 & 2: The number of patient and doctor on a date 13/12/2024

Try adding a patient that already has existing email

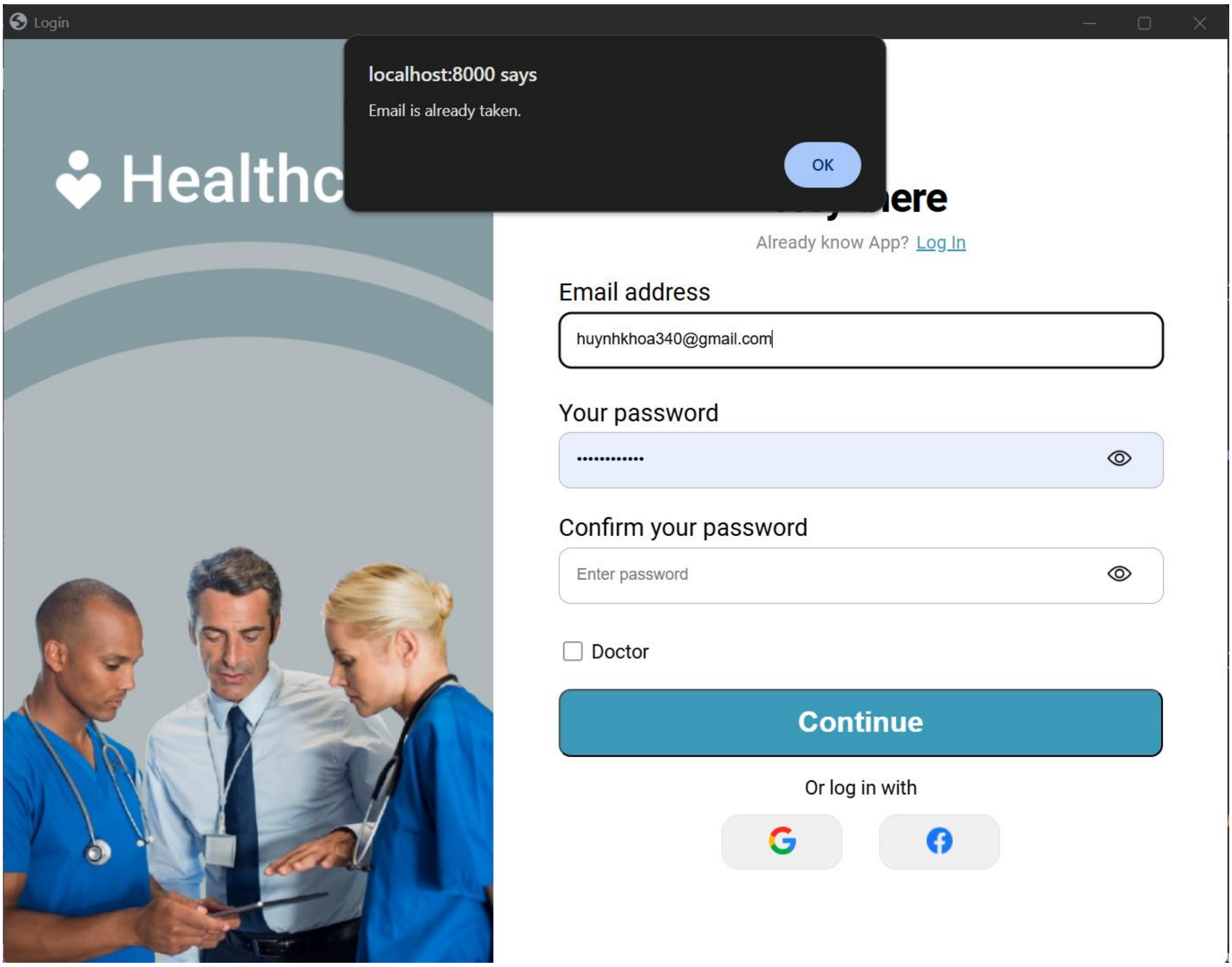


Figure 3: Error when registering account that have existing email

Add a patient to database

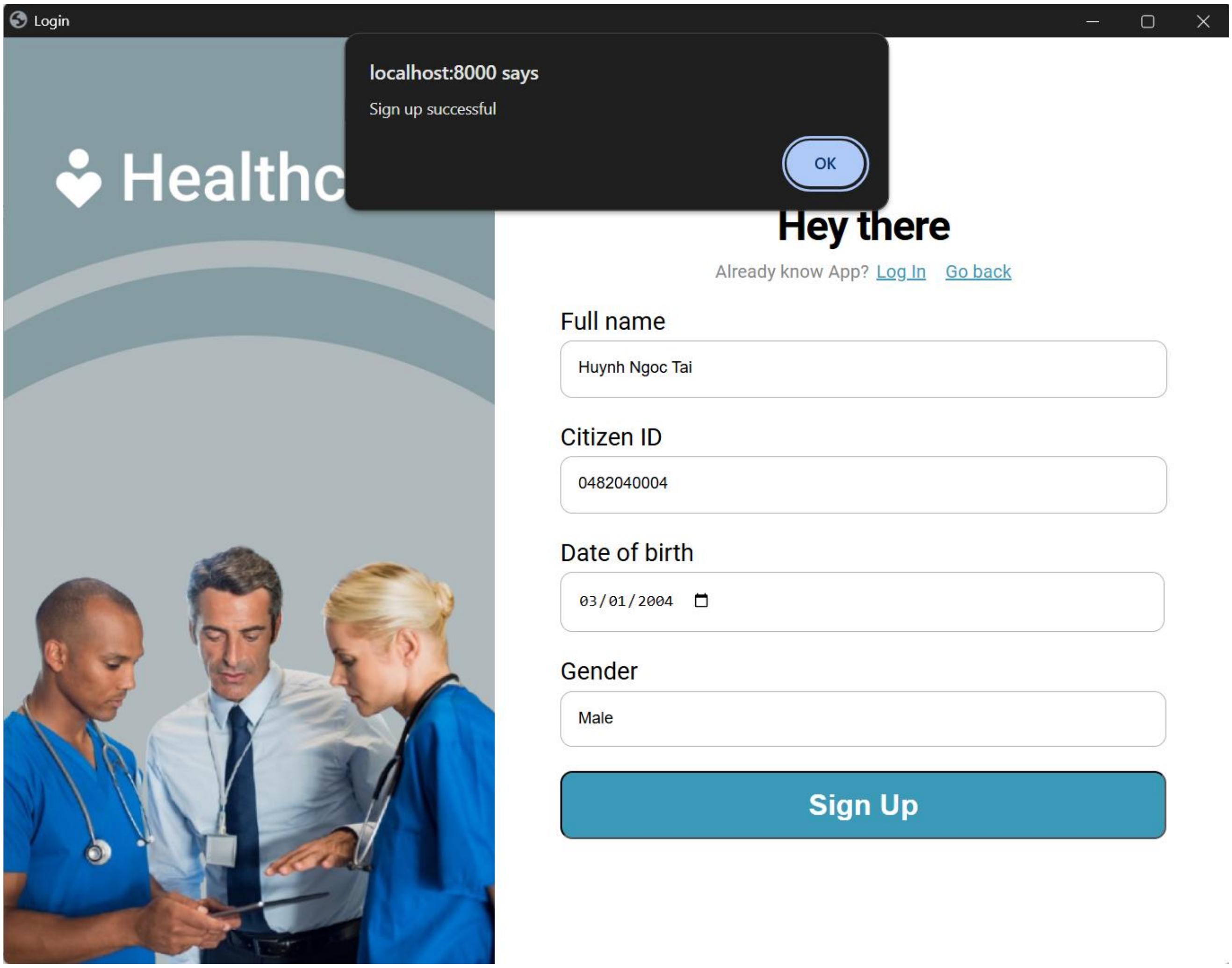


Figure 4: Adding new patient to database

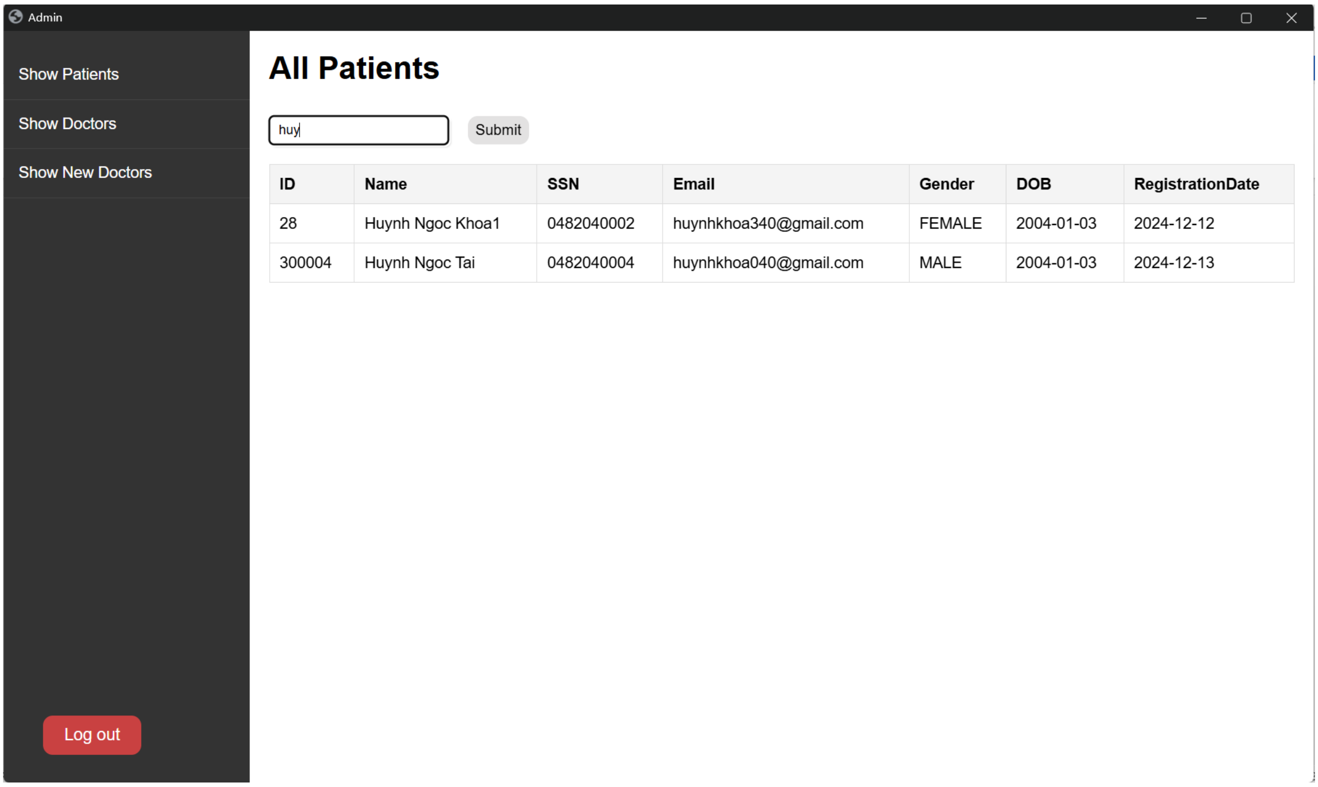


Figure 5: Patient is add to database that is showed by admin account

2.4.2 Check_email()

- Ensure that email is not registered in database

```
@eel.expose
def check_email(email):
    conn = connect_db()
    if conn:
        try:
            cursor = conn.cursor()
            query = """
            SELECT COUNT(*) from users where email = :email
            """
            print(email)
            cursor.execute(query, (email,))
            res = cursor.fetchone()
```

```python
            print(res[0])
            if res:
                return res[0]
            else:
                return 0
        except oracledb.DatabaseError as e:
            print("Error during retrieve:", e)
            return str(e)
        finally:
            cursor.close()
            conn.close()
    else:
        return "Failed to connect to Oracle"
```

2.4.3 Booking appointment based on department:

- Patient choose the department suitable for their demands and the system will choose the doctor have the free time suitable to patient.

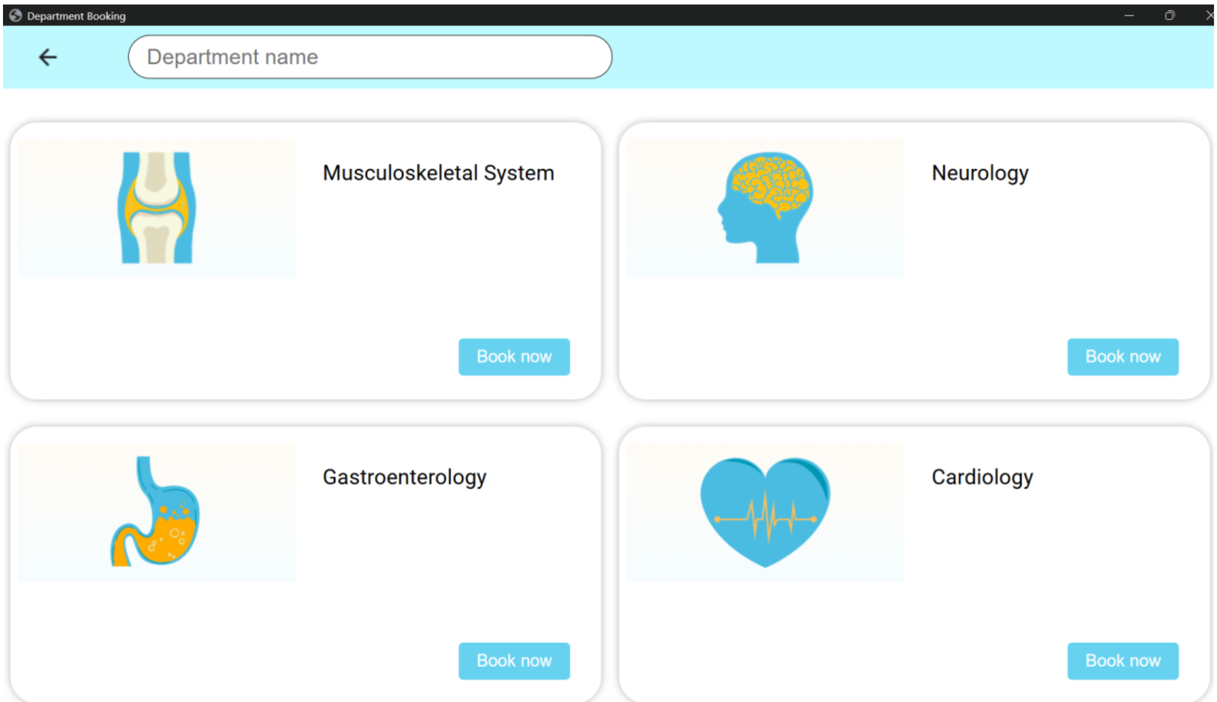


Figure 6: Finding department

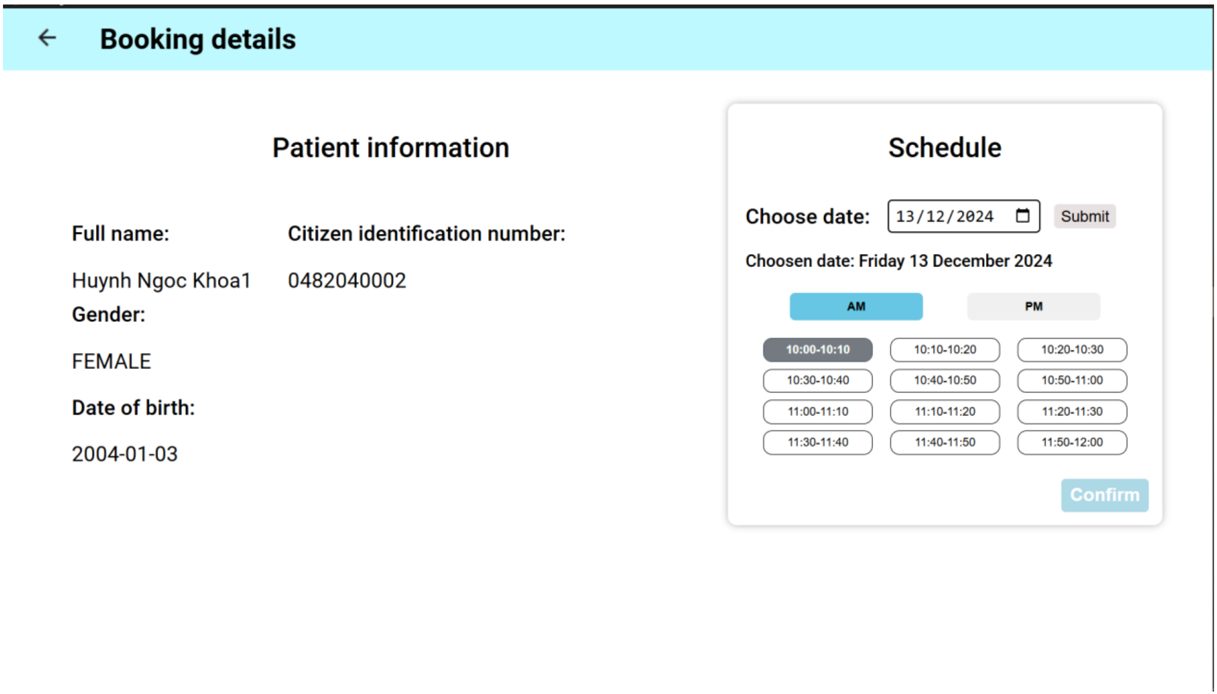


Figure 7: Choosing date

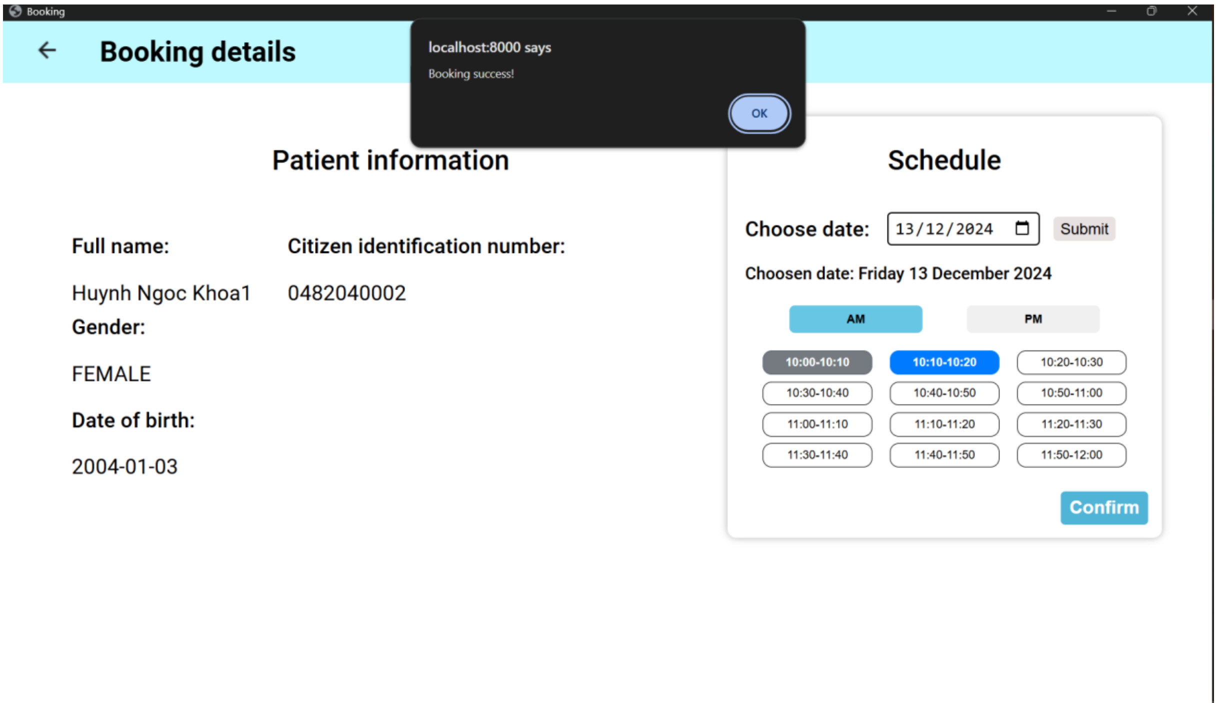


Figure 8: Confirm booking success

2.4.4 Booking appointment based on doctor

- Retrieve to the database to get the free time of the doctor in that day, after that show to the patient time that doctor is free

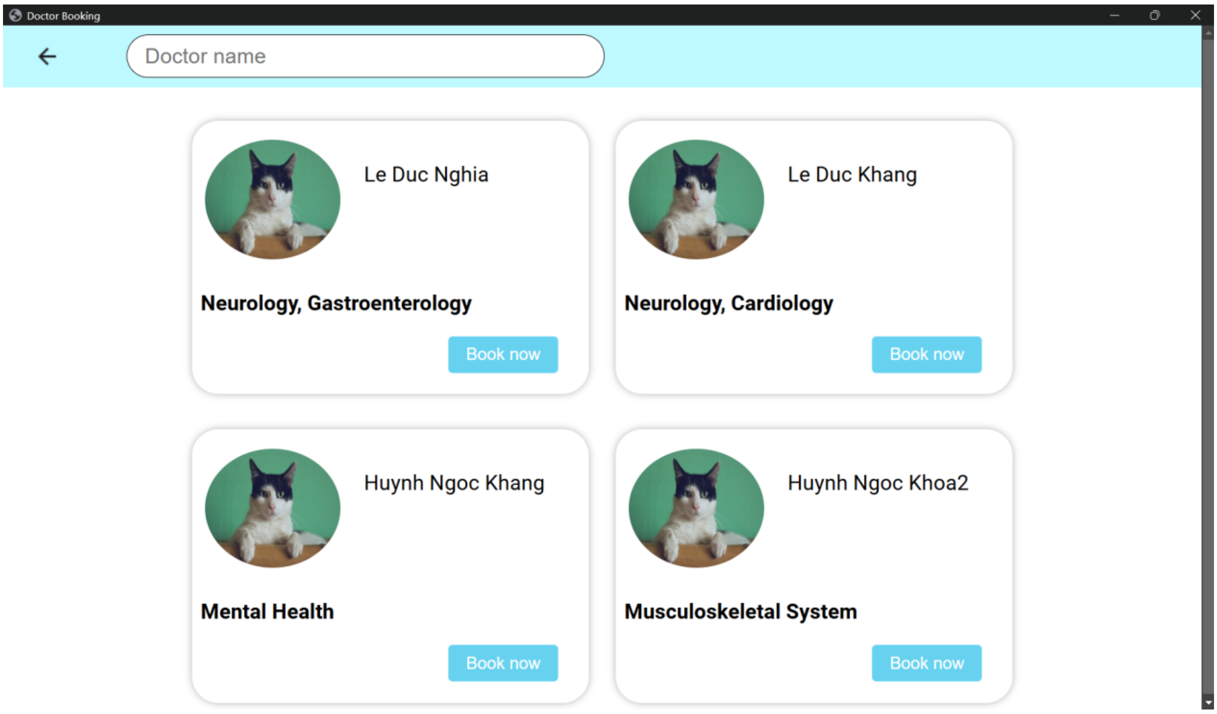


Figure 9: Choosing doctor

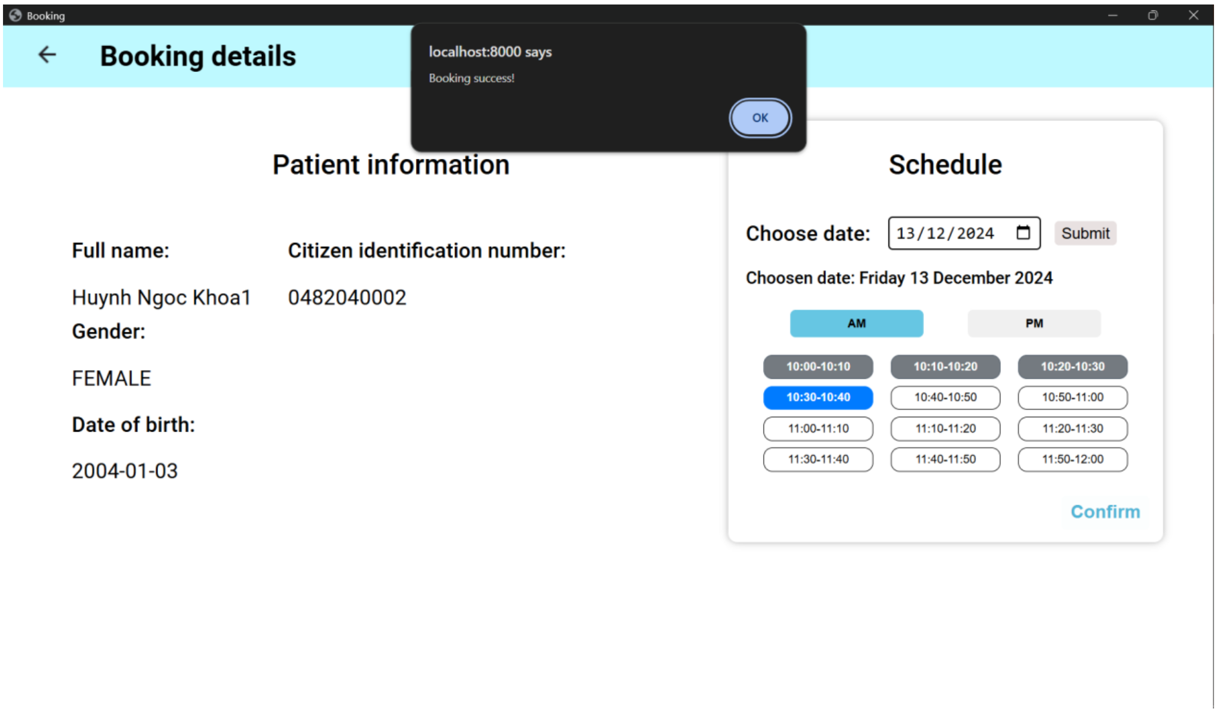


Figure 10: Confirm notification that success

2.4.5 Update Information of Patient:

- Ensure that patients and doctors can only change the attributes that not is ssn, email or id

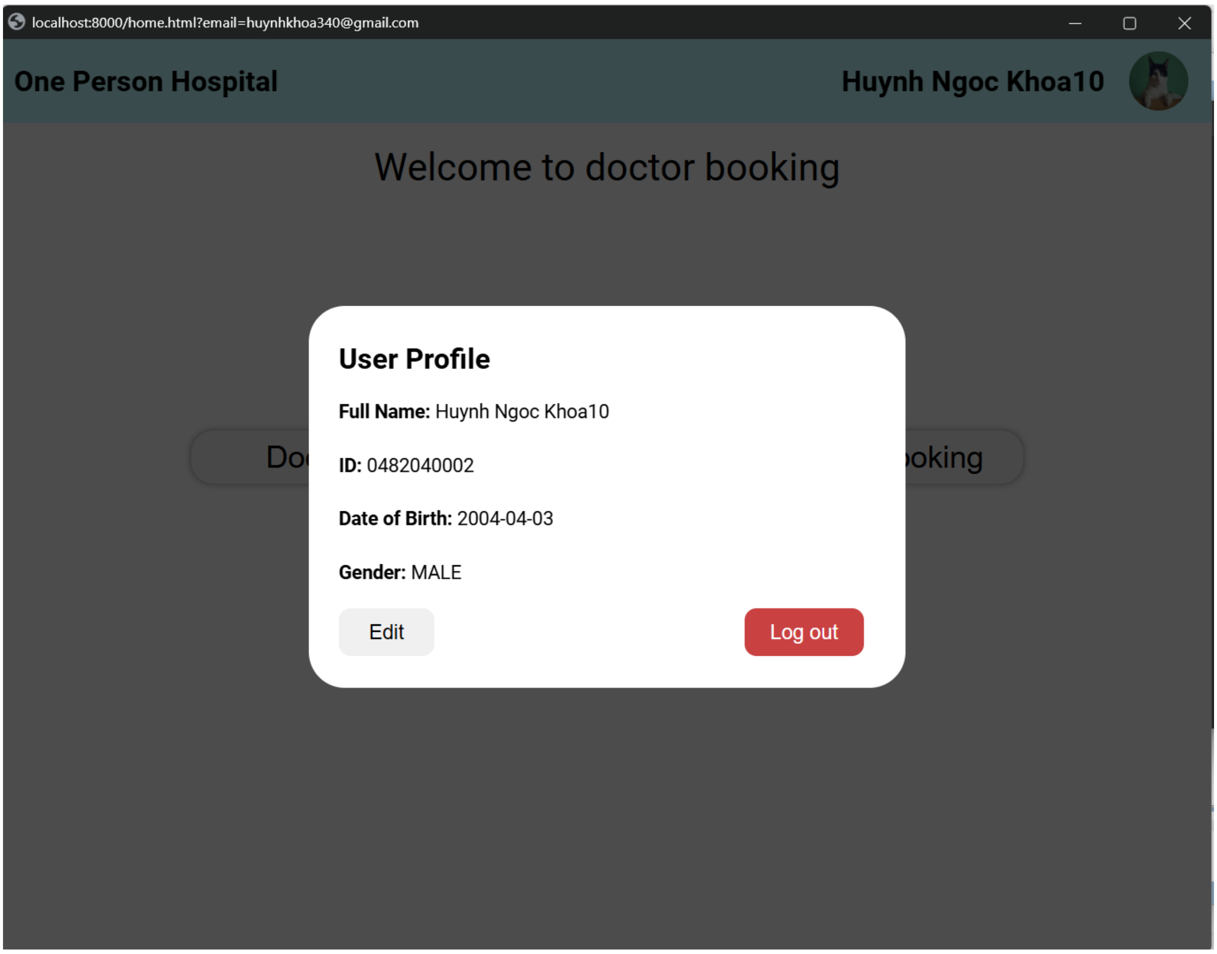


Figure 11: Editing profile

2.4.6 Showing booking calendar of doctor in the future:

- Ensure that the booking calendar always show the future day, and cannot change the report in the past

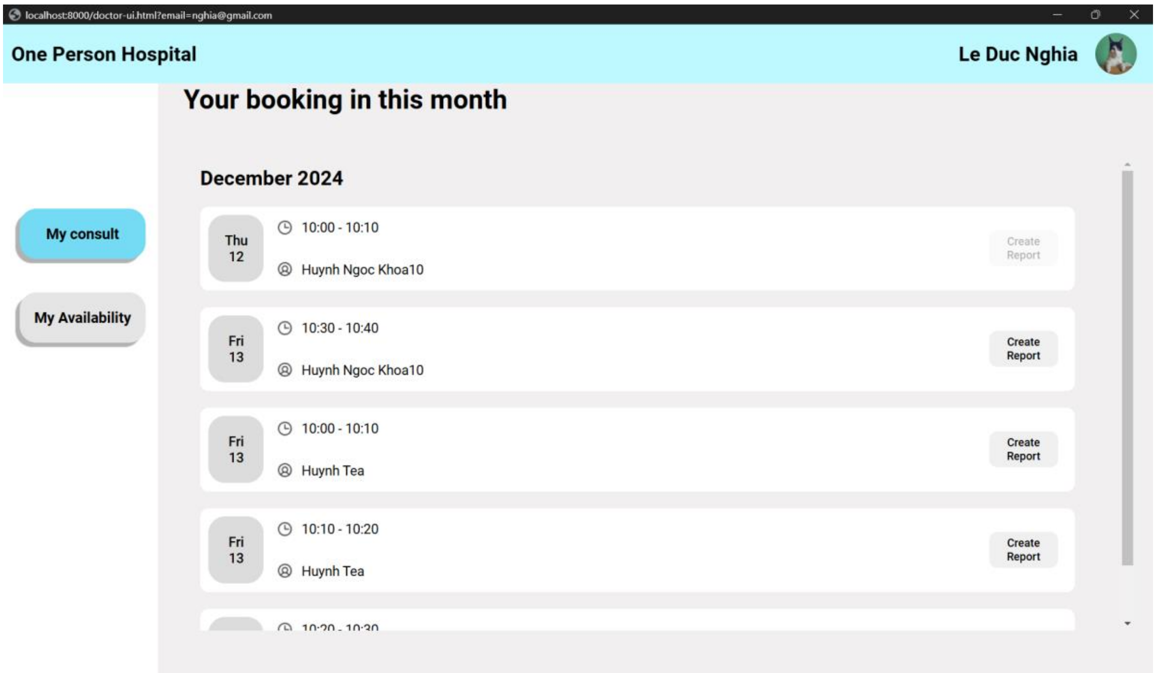


Figure 12: Doctor ui show booked appointment

3 User Groups and Set Application-level Permissions

User Group	Application-level Permissions
Admin	Manage entire system
Doctor	Handle patient records. They can see the list of all patients, all doctors, all departments,their personal information and appointments.
Patient	Access personal health information, personal information. They can see list of doctors, departments, their own appointments and can book an appointment.

Table 1: User Groups and Application-level Permissions

```
CREATE TABLE Department (
    ID INT PRIMARY KEY,
    Speciality VARCHAR(100)
);

CREATE Table Users (
    id          INT PRIMARY KEY,
    name        VARCHAR(100) NOT NULL,
```

```
    SSN         VARCHAR(10) NOT NULL UNIQUE,
    email       VARCHAR(40) NOT NULL,
    password    VARCHAR(20) NOT NULL,
    gender VARCHAR(10) not null check (gender in ('MALE', 'FEMALE',
'OTHER')),
    DOB DATE,
    role        VARCHAR(20) not null check (role in ('ADMIN','DOCTOR',
'PATIENT')),
    registrationDate DATE
);

CREATE TABLE Doctor (
    ID INT PRIMARY KEY,
    Speciality VARCHAR(100),
    CONSTRAINT  fk_doctor_id    FOREIGN KEY (ID)
    REFERENCES Users(id)
    ON DELETE CASCADE DEFERRABLE
);

CREATE TABLE Doctor_Assigned (
    Doctor_ID INT NOT NULL,
    Department_ID INT NOT NULL,
    PRIMARY KEY (Doctor_ID, Department_ID),
    CONSTRAINT fk_doc_dep_doctor FOREIGN KEY (Doctor_ID)
        REFERENCES Doctor(ID) ON DELETE CASCADE DEFERRABLE,
    CONSTRAINT fk_doc_dep_department FOREIGN KEY (Department_ID)
        REFERENCES Department(ID) ON DELETE CASCADE DEFERRABLE
);

CREATE TABLE Room (
    ID INT PRIMARY KEY,
    Capacity INT,
    Room_type VARCHAR(10) not null check (Room_type in ('NORMAL',
'DELUXE', 'PRIVATE')),
```

```
    price DECIMAL(10, 2)
);

CREATE TABLE Patient (
    ID INT PRIMARY KEY,
);

CREATE TABLE Patient_admission (
    Patient_ID INT,
    Room_ID INT,
    Date_start DATE,
    Date_end DATE,
    CONSTRAINT fk_patient_admission_pa_id FOREIGN KEY (Patient_ID)
        REFERENCES Patient(ID) ON DELETE SET NULL DEFERRABLE,
    CONSTRAINT fk_patient_admission_room_id FOREIGN KEY (Room_ID)
        REFERENCES Room(ID) ON DELETE SET NULL DEFERRABLE
);

CREATE TABLE Appointment (
    ID INT,
    Date_regis DATE,
    Time_regis TIMESTAMP,
    Patient_id INT,
    Doctor_id INT,
    PRIMARY KEY(ID, Patient_id, Doctor_id),
    CONSTRAINT  fk_app_pa_ssn   FOREIGN KEY (Patient_id)
    REFERENCES Patient(ID)
    ON DELETE SET NULL DEFERRABLE,
    CONSTRAINT  fk_app_doc_ssn  FOREIGN KEY (Doctor_id)
    REFERENCES Doctor(ID)
    ON DELETE SET NULL DEFERRABLE
);
```

```sql
CREATE TABLE Treatment (
    ID INT,
    Patient_id INT,
    Doctor_id INT,
    Date_prescripted DATE,
    Diagnosis VARCHAR(100),
    Invoice INT,
    Feedback VARCHAR(200),
    CONSTRAINT  fk_treat_doc    FOREIGN KEY (Doctor_id)
    REFERENCES Doctor(ID)
    ON DELETE SET NULL DEFERRABLE,
    CONSTRAINT  fk_treat_pa FOREIGN KEY (Patient_id)
    REFERENCES Patient(ID)
    ON DELETE SET NULL DEFERRABLE
);
CREATE Table Dosage_Treament (
    ID INT,
    Patient_id INT,
    Doctor_id INT,
    Medical_name VARCHAR(10),
    Medical_dosage VARCHAR(10),
    CONSTRAINT  fk_do_treat_doc FOREIGN KEY (Doctor_id)
    REFERENCES Doctor(ID)
    ON DELETE SET NULL DEFERRABLE,
    CONSTRAINT  fk_do_treat_pa  FOREIGN KEY (Patient_id)
    REFERENCES Patient(ID)
    ON DELETE SET NULL DEFERRABLE
);

CREATE TABLE Medical_Report (
    ID INT,
    Diagnosis VARCHAR(100),
    Patient_id INT,
```

```
    PRIMARY KEY(ID, Patient_id),
    CONSTRAINT  fk_med_pa_id    FOREIGN KEY (Patient_id)
    REFERENCES Patient(ID)
    ON DELETE SET NULL DEFERRABLE
);
```

4 Application Architecture

4.1 Presentation Layer (UI Layer):

The frontend layer where we interact with users (patients, doctors, admins). Here we are using technologies like Python, Oracle, HTML, CSS, JavaScript.

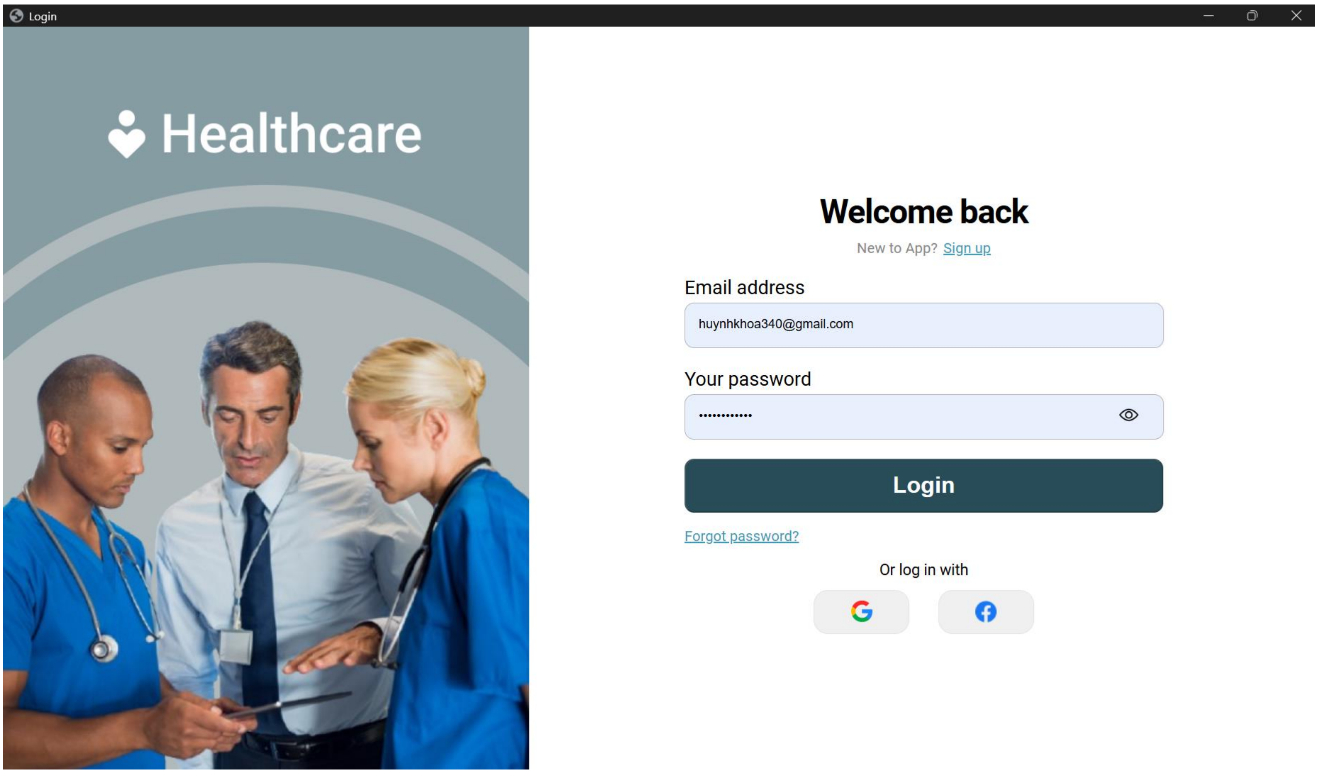


Figure 13: Presentation Layer

4.2 Application Layer:

The backend layer where we made logics of the system, navigations. Here we mainly use EEL which has Model View Templates architecture. Model represents the data that we want to present, which is from the database. View represents the request handler that returns the relevant templates and content. Template represents the HTML file (layout of the application).

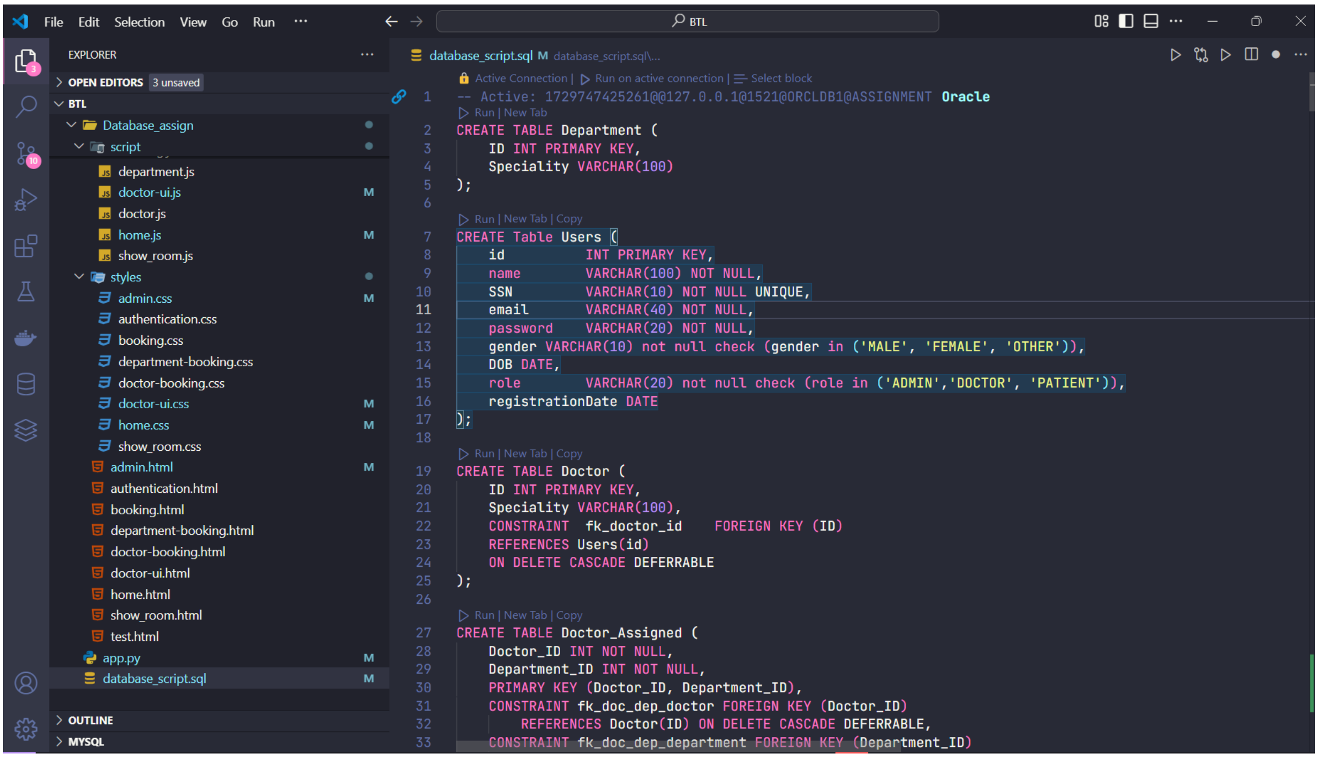


Figure 14: Application Layer

4.3 Database Layer:

The layer where data is stored and triggers are created. We used Docker and VScode here for our application.

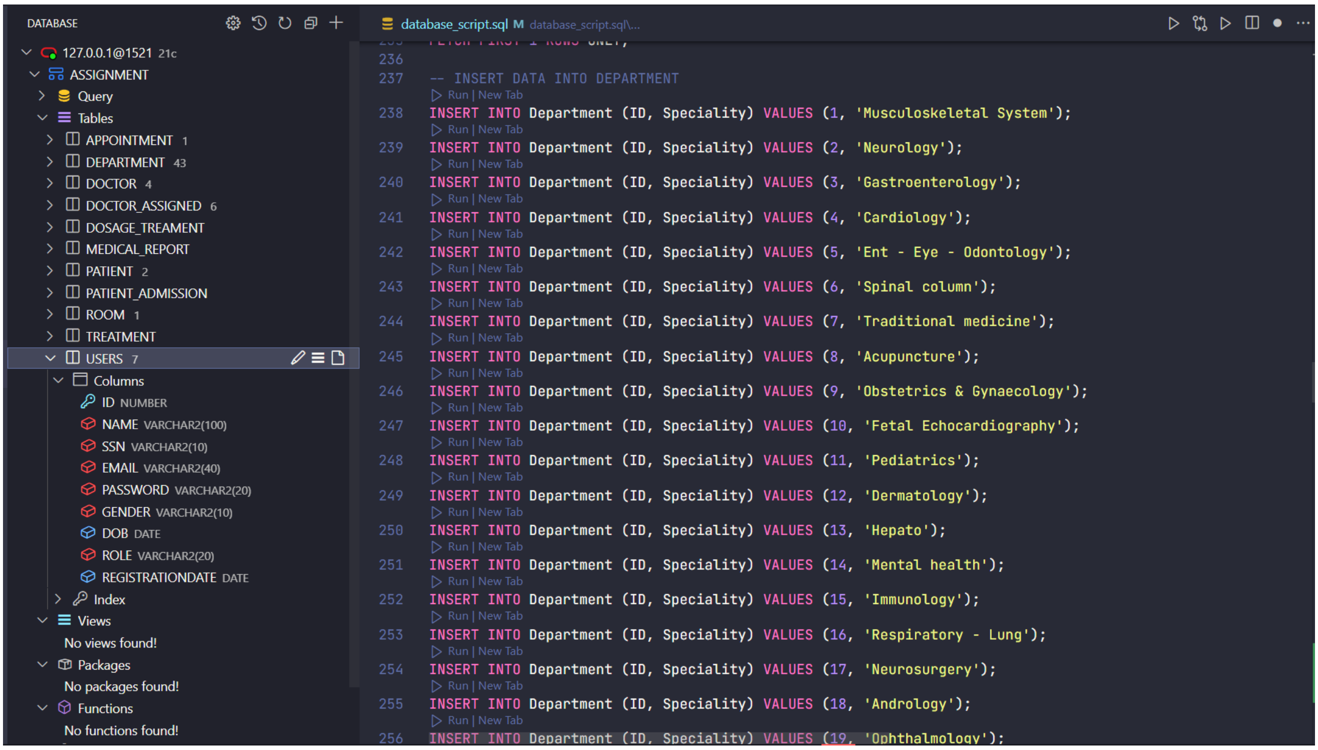


Figure 15: Database Layer

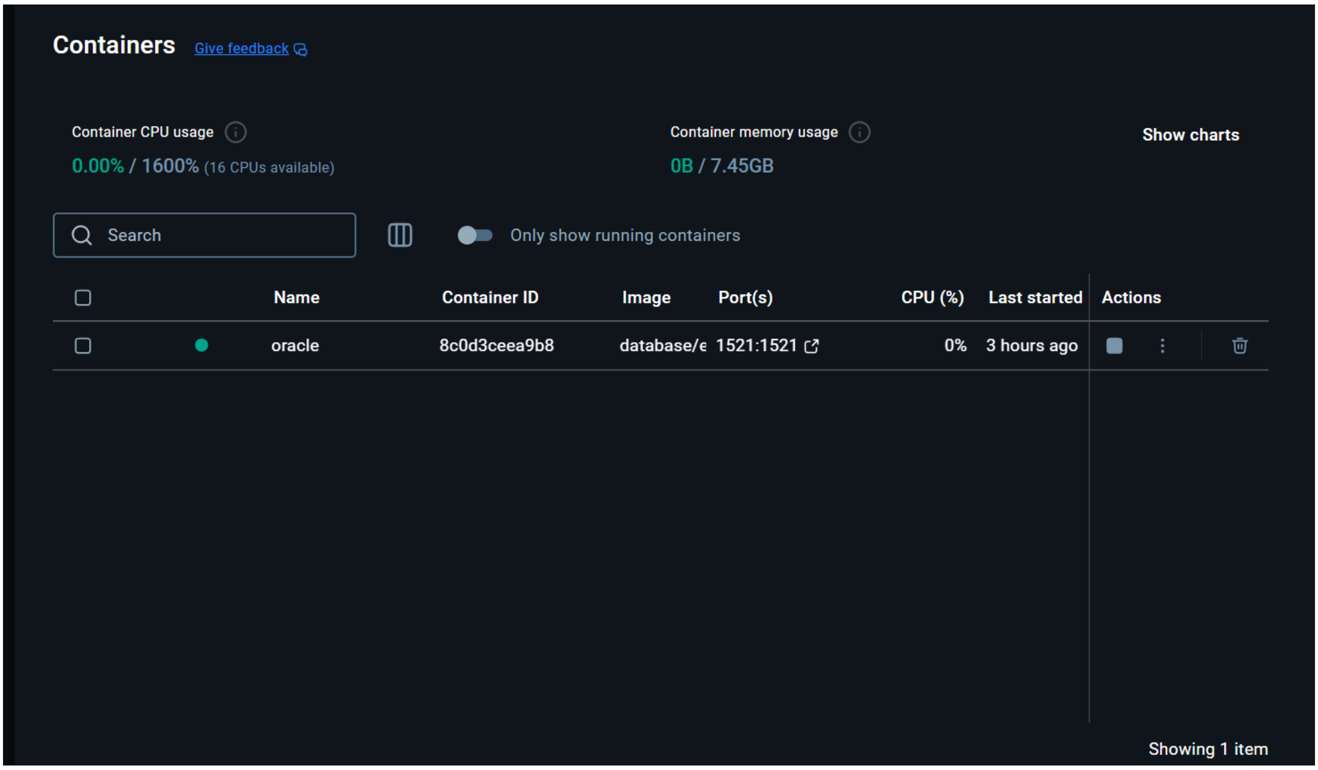


Figure 16: Docker server

5 Application Specifications

Hospital Management System (HMS) is a comprehensive application designed to manage hospi- tal operations, including doctors, patient care, appointments and rooms. It ensures seamless interaction among various roles while maintaining data security and role-based access.

5.1 Key Modules

- **Patient Management:** Handles patient registration, health records, and personal detailsin a secure manner.
- **Department Management:** Allows administrators to manage hospital departments,including assigning heads and monitoring departmental activities.
- **Doctor Management:** Enables administrators to manage doctor profiles, while facilitating the assignment of doctors to departments.
- **Appointment Management:** Facilitates patient booking with preferred doctors for up-coming appointments.
- **Room Management:** Manages room assignments, tracks patient occupancy, and ensures efficient use of hospital resources.
- **Medical Records:** Maintains detailed records of diagnoses, test results and treatmentsfor every patient.

5.2 Non-Functional Requirements

- **Security:** Implement user authentication and authorization to protect sensitive data.

- **Performance:** The application should handle up to 1000 concurrent users without significant performance degradation.
- **Usability:** The user interface should be intuitive and easy to navigate for all user types.
- **Scalability:** The system should be designed to accommodate future growth in user numbers and data volume.

5.3 Security and Compliance

- Implements secure authentication mechanisms.
- Ensures data privacy and compliance with healthcare regulations.

5.4 Deliverables

- Fully functioning HMS application.
- Documentation (user manual, API documentation).
- Test cases and test reports.
- Deployment scripts and configurations.

5.5 Technology Stack

The Hospital Management System (HMS) will be developed using the following technologies,ensuring a reliable and efficient system:

- **Programming Language:** Python
- **Framework:** EEL for python backend
- Eel bridges Python with web technologies, enabling Python code to handle business logic, database interactions, and computational tasks while delegating UI rendering to HTML, CSS, and JavaScript.
- Eel allows bi-directional communication between the Python backend and the JavaScript frontend.
- **Frontend:** HTML, CSS for creating a responsive and user-friendly interface
- HTML provides the structure of the UI, while JavaScript allows dynamic content rendering and real-time interaction.
- Adding JavaScript libraries (e.g., jQuery, Chart.js, or React) enhances functionality and responsiveness.
- **Database:** Vscode + docker to access oracle server for structured and scalable data management
- **Version Control:** Git for source code management and collaboration
- **Repository Hosting:** GitHub for centralized code storage and project management
- **Deployment:** Docker containers for consistency across development and production environments

5.6 System Design

The HMS application is designed using a layered architecture to enhance modularity and maintainability:

5.6.1 Frontend (Presentation Layer)

- Utilizes HTML, CSS, and EEL library to create interactive user interfaces.
- Offers role-based dashboards for administrators, doctors, and patients.
- Ensures cross-platform compatibility with responsive design.

5.6.2 Backend (Business Logic Layer)

- Developed using EEL, following the Model-View-Control (MVC) design pattern.
- Implements application logic, role-based access control, and session management.

5.6.3 Database Layer

- Uses Vscode with sqldeveloper to store and manage HMS data efficiently.
- Incorporates a well-structured schema with relationships, constraints, and optimized indexing.
- Utilizes EEL library in python to use cursor for database queries and transactions.

5.6.4 Version Control and Collaboration

- Employs Git for source code versioning, enabling effective tracking of changes and collaboration.
- Hosts the project repository on GitHub for centralized access and project management.
- Integrates GitHub Issues and Pull Requests for streamlined team workflows.

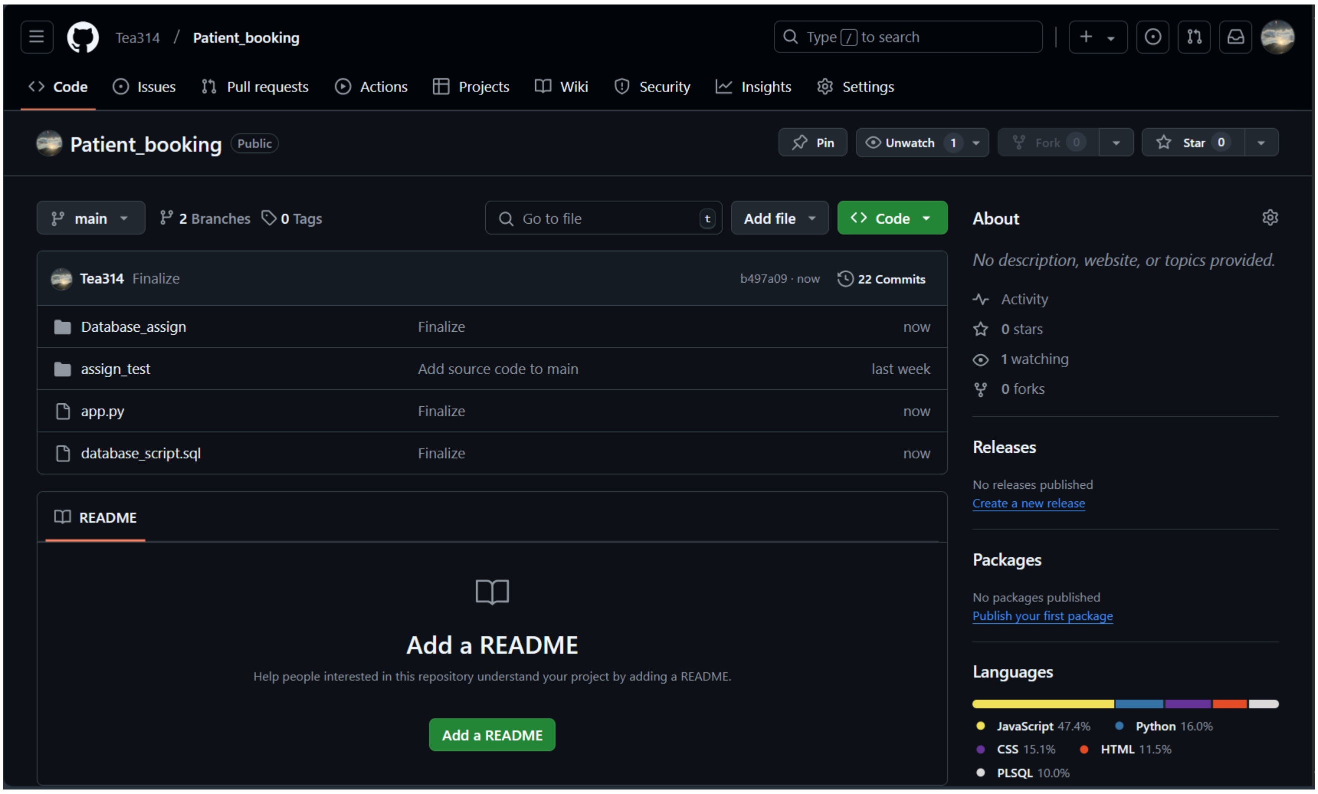


Figure 17: Project Github

5.7 Advantages of the Technology Stack

- **Python and Django:** Django's scalability and Python's simplicity accelerate development and maintenance.
- **HTML and CSS:** Enables interactive and responsive user interfaces.
- **Vscode with docker and sqldeveloper:** Ensures secure and efficient data storage and retrieval.
- **Git and GitHub:** Enhances collaboration, version control, and code review processes.

5.8 Development Workflow

The development process will follow an agile methodology, comprising the following stages:

1. Requirement Gathering and Prototyping
2. Database Design and Backend Development
3. Frontend Development and Integration
4. Version Control Management using Git and GitHub
5. Testing (Unit, Integration, and User Acceptance)
6. Deployment and Continuous Monitoring

6 BCNF normalization for the database schema

After thorough analysis of our relational schema, we have decided that they have met the requirement of BCNF. Below are the functional dendencies of all the relationships.

User(ID, Name, Gender, SSN, DOB, Role, Email, Password)

- ID -> {Name, Gender, SSN, DOB, Role, Email, Password}

Doctor(ID, Specialty)

- ID -> Specialty

Department(ID, Speciality)

- ID -> Specialty

Treatment(ID, Doc_ID, Paitent_ID, Date, Diagnosis)

- {ID, Doc_ID, Paitent_ID} -> {Date, Diagnosis)

Patient(ID)

Room(ID, Capacity, Room_type, Price)

- ID -> {Capacity, Room_type, Price}

Appointment(Doc_ID, Paitent_ID, App_ID, Date, Time)

- {Doc_ID, Paitent_ID, App_ID} -> {Date, Time}

Medical_Report(Paitent_ID, Med_ID, Diagnosis)

- {Patient_ID, Med_ID} -> Diagnosis

Doc_Assigned(Doc_ID, Dept_ID)

Dosage.Treatment(Doc_ID, Treat_ID, Paitent_ID, Medical_name, Medical_dosage)

- {Doc_ID, Treat_ID, Paitent_ID} -> {Medical_name, Medical_dosage}

Patient_Admission(Patient_ID, Room_ID, Date_start, Date_end, Total_price)

- {Patient_ID, Room_ID} -> {Date_start, Date_end, Total_price}

7 Compare Data between website and database wheninsert, delete or edit

7.1 Insert

First, I inserted a new patient into our system:

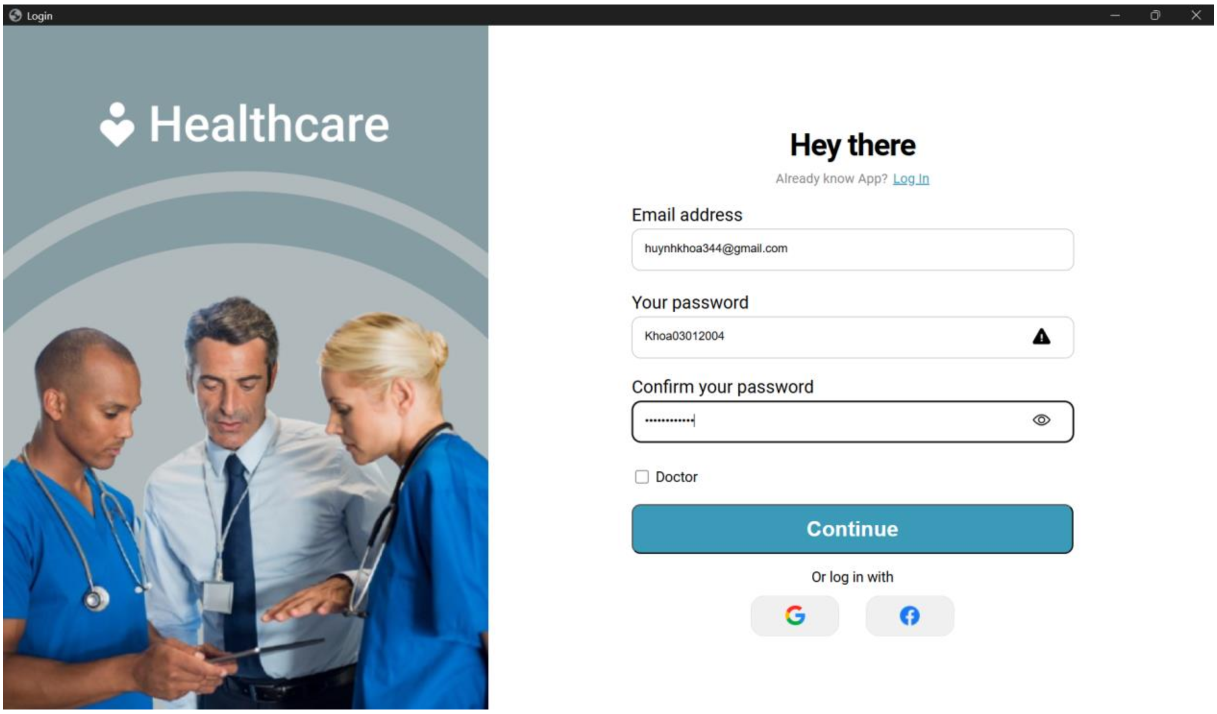


Figure 18: Register ui

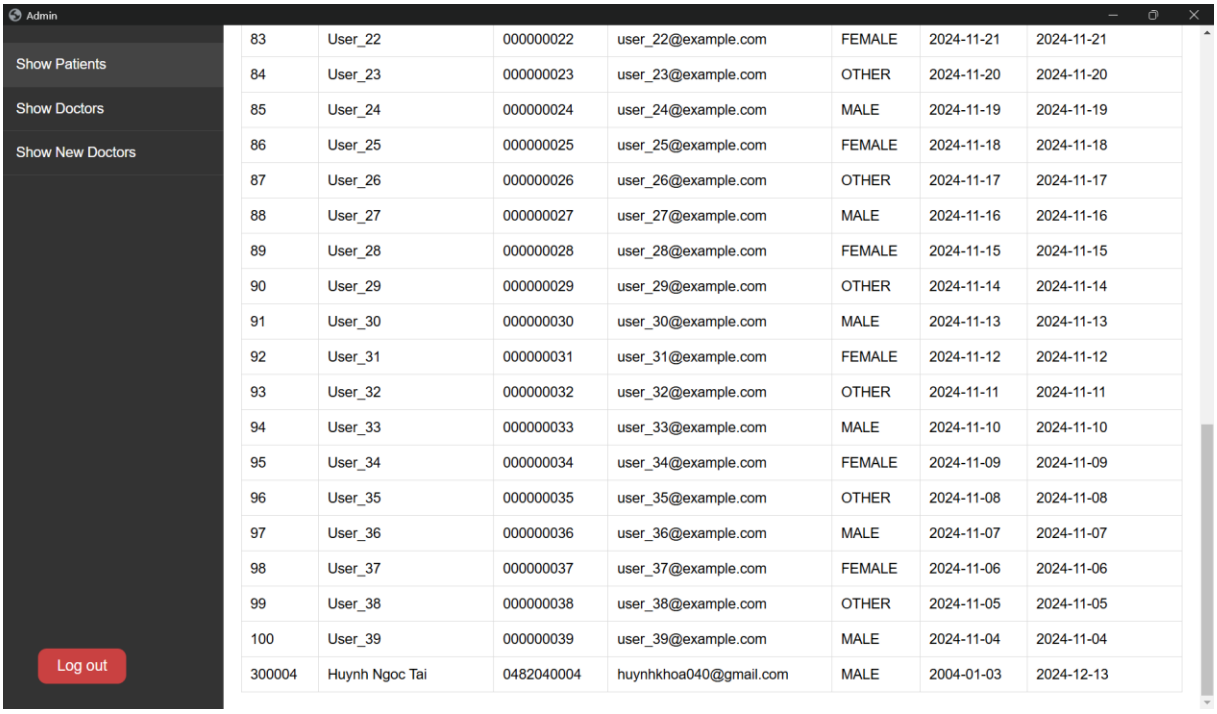


Figure 19: Result on website

Then, go to our database, we can check if there is a change in database:

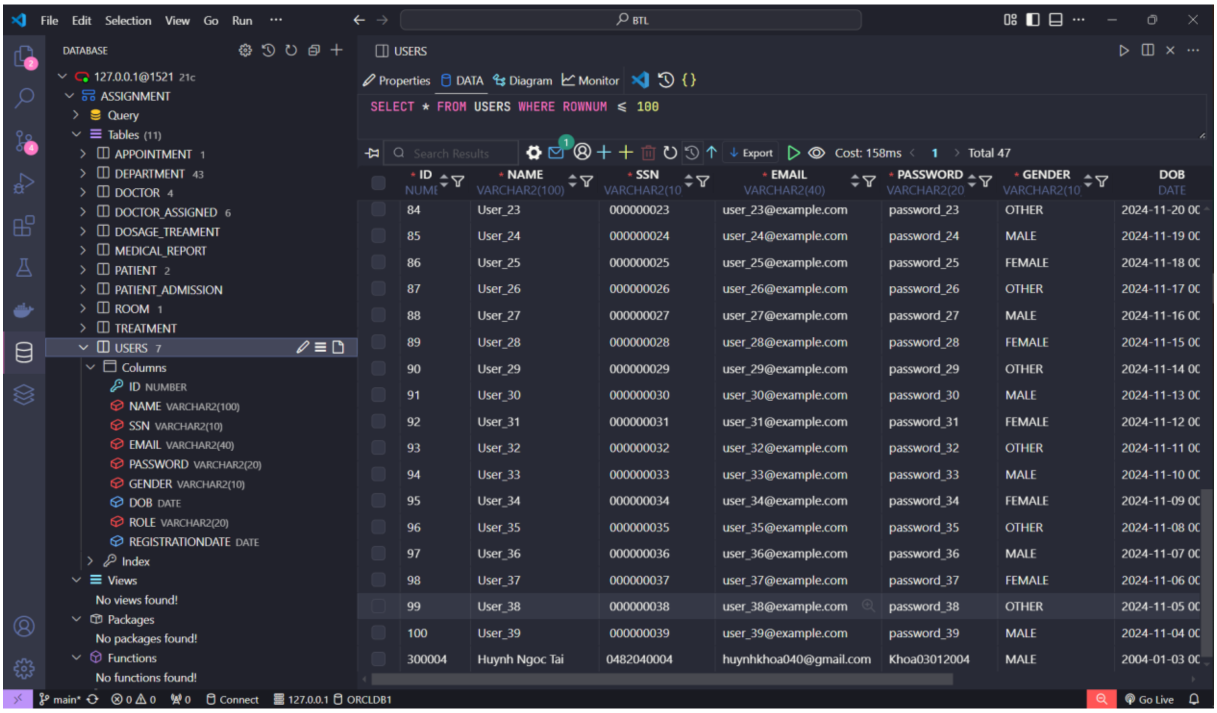


Figure 20: Result in database

We can conclude that the result when inserting on website can affect to the database.

7.2 Edit

Subsequently, when there are some mistakes when recording patient information, for instance inthis case, patient Khoa10 was born in 2000 not 2004, so I will fix it by editing on this website:

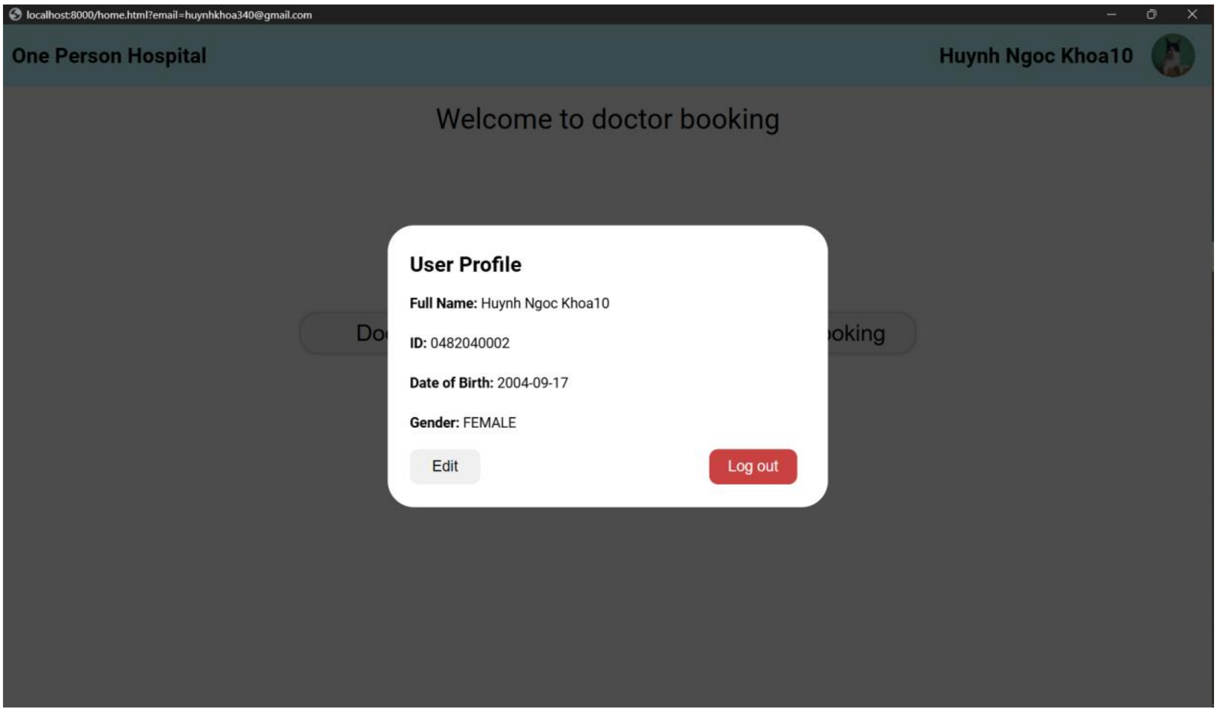


Figure 21: Edit patient information

Then this is the result on our website:

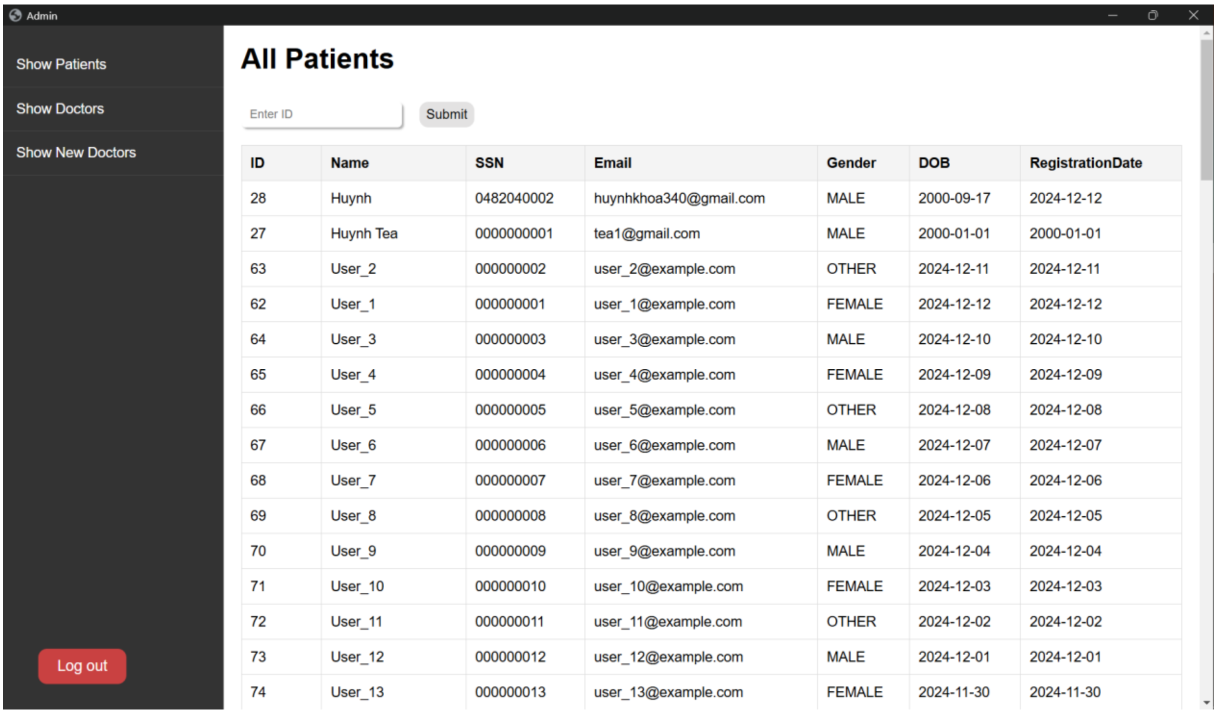


Figure 22: Result on admin

Go to the database, we can see:

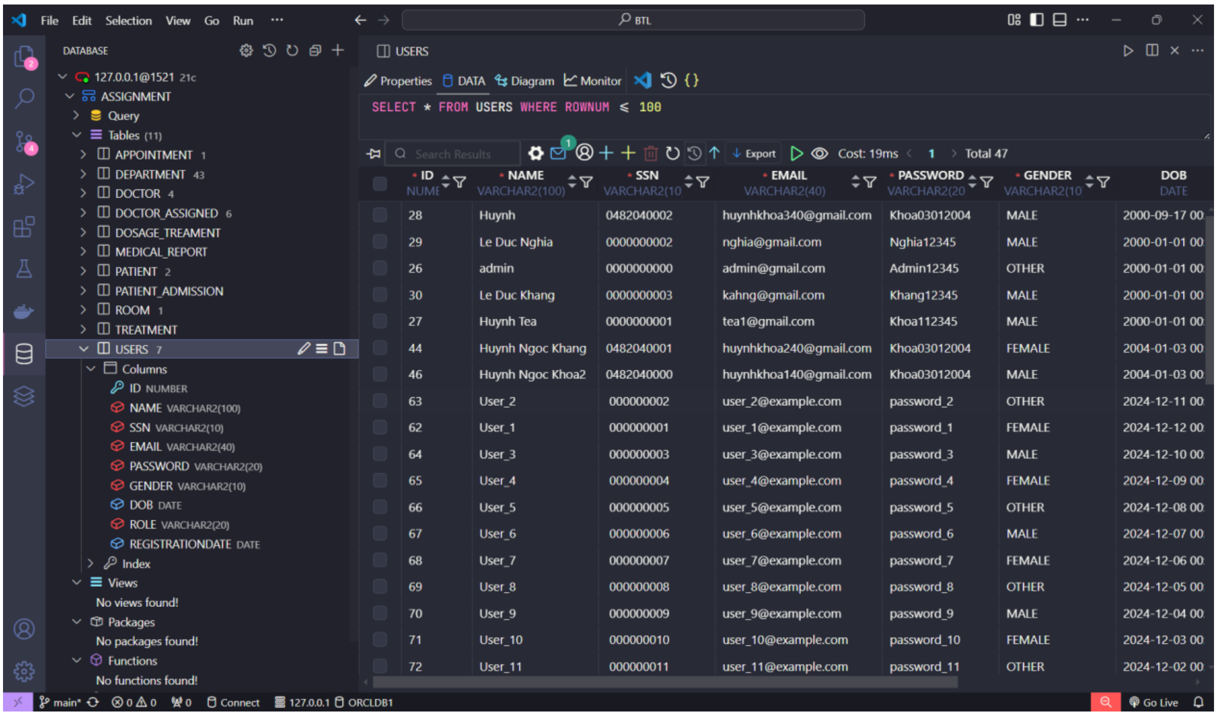


Figure 23: Result in database

We can conclude that the result when editing on website can affect to the database.

8 Indexing

The index structures are additional files on disk that provide secondary access paths, which provide alternative ways to access the records without affecting the physical placement of records in the primary data file on disk. They enable efficient access to records based on the indexing fields that are used to construct the index. Basically, any field of the file can be used to create an index, and multiple indexes on different fields - as well as indexes on multiple fields - can be constructed on the same file. A variety of indexes are possible; each of them uses a particular data structure to speed up the search.

The most prevalent types of indexes are based on ordered files (single-level indexes) and use tree data structures (multilevel indexes, B+-trees) to organize the index. Indexes can also be constructed based on hashing or other search data structures.

This section demonstrates the performance improvement achieved by implementing indexing in the Users table with a large dataset. We will compare the query execution time for a query without an index and with an index on the departmentID column.

8.1 Setup and Table Creation

The following table schema represents the Users table, which is used to store information about medical staff members, such as their ID, SSN, name, phone number, salary, and department affiliation.

```
CREATE Table Users (
    id            INT PRIMARY KEY,
    name          VARCHAR(100) NOT NULL,
    SSN           VARCHAR(10) NOT NULL UNIQUE,
    email         VARCHAR(40) NOT NULL,
    password      VARCHAR(20) NOT NULL,
    gender VARCHAR(10) not null check (gender in ('MALE', 'FEMALE',
'OTHER')),
    DOB DATE,
    role          VARCHAR(20) not null check (role in ('ADMIN','DOCTOR',
'PATIENT')),
    registrationDate DATE
);
```

We populate the table with a large number of rows for the demo. A sample population scriptmight look like this:

```
BEGIN
    FOR i IN 1..1000000 LOOP
        INSERT INTO Users (id, name, ssn, email, password, gender, dob,
role, registrationDate)
        VALUES (
```

```
            i,
            'User_' || i,
            TO_CHAR(i, '0000000000'),
            'user_' || i || '@example.com',
            'password_' || i,
            CASE MOD(i, 3)
                WHEN 0 THEN 'MALE'
                WHEN 1 THEN 'FEMALE'
                ELSE 'OTHER'
            END,
            TRUNC(SYSDATE) - MOD(i, 365),
            'PATIENT',
            TRUNC(SYSDATE) - MOD(i, 100)
        );
    END LOOP;
    COMMIT;
END;
/
```

8.2 Query To find time using an Index

The following code execute and the time difference between using index and no using index is shown below.

```
SET SERVEROUTPUT ON;

DECLARE
    start_time NUMBER;
    end_time NUMBER;
BEGIN
    start_time := DBMS_UTILITY.GET_TIME;
    FOR rec IN (SELECT * FROM users WHERE name = 'User_83') LOOP
        NULL;
    END LOOP;
    end_time := DBMS_UTILITY.GET_TIME;
```

```
    DBMS_OUTPUT.PUT_LINE('Time before creating index: ' || (end_time -
start_time) || ' hundredths of seconds');
    EXECUTE IMMEDIATE 'CREATE INDEX idx_users_name ON Users(name)';
    start_time := DBMS_UTILITY.GET_TIME;
    FOR rec IN (SELECT * FROM users WHERE name = 'User_83') LOOP
        NULL;
    END LOOP;
    end_time := DBMS_UTILITY.GET_TIME;
    DBMS_OUTPUT.PUT_LINE('Time after creating index: ' || (end_time -
start_time) || ' hundredths of seconds');
    EXECUTE IMMEDIATE 'DROP INDEX idx_users_name';
END;
/
```

8.3 Results Comparison

The following table summarizes the execution times for the query before and after indexing:

Scenario	Execution Time (Example)
Without Index	0.044 seconds
With Index	0.006 seconds

Table 2: Execution Time Comparison for HMS.Medical Staff Table

8.4 Python Automation

The process can be automated using a Python script, which connects to the Oracle database,executes the queries, and measures the execution time:

```
def indexing():
        conn = oracledb.connect(
            user="KHOA",  # Oracle username
            password="Khoa0301#",  # Oracle password
            dsn="localhost/ORCLDB1",  # DSN: hostname/servicename (or
SID)
        )
        cursor = conn.cursor()

        start_time = time.time()
        cursor.execute("SELECT * FROM users WHERE name = 'User_83'")
        data = cursor.fetchall()
        end_time = time.time()
        print(f"Execution Time Without Index: {end_time -
start_time:.2f} seconds")
        cursor.execute("CREATE INDEX idx_users_name ON Users(name)")

        start_time = time.time()
        cursor.execute("SELECT * FROM users WHERE name = 'User_83'")
        data = cursor.fetchall()
        end_time = time.time()
        print(f"Execution Time With Index: {end_time - start_time:.2f}
seconds")
        cursor.execute("DROP INDEX idx_users_name")
```

```
    cursor.close()
    conn.close()
```

8.5 Conclusion

The experiment demonstrates a significant performance improvement when using indexing. With- out an index, the query scans the entire table, which can be slow for large datasets. By creating an index on the name column, the query performance improves drastically, making it more efficient for large-scale applications. This shows the importance of indexing for optimizing database performance in real-world scenarios.