



University  
Mohammed VI  
Polytechnic



# Deliverable 5: Views, Triggers and Application Development

Data Management Course

UM6P College of Computing

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# 1 Task 1: Views and Triggers

This section details the implementation of SQL Views and Triggers for the MNHS database.

## 1.1 Views

### 1.1.1 UpcomingByHospital

**Description:** Returns scheduled appointment counts per hospital for the next 14 days.

```

1 CREATE VIEW UpcomingByHospital AS
2 SELECT
3     h.Name AS HospitalName ,
4     ca.Date AS ApptDate ,
5     COUNT(*) AS ScheduledCount
6 FROM Appointment a
7 JOIN ClinicalActivity ca ON ca.CAID = a.CAID
8 JOIN Department d ON d.DEP_ID = ca.DEP_ID
9 JOIN Hospital h ON h.HID = d.HID
10 WHERE a.Status = 'Scheduled'
11     AND ca.Date BETWEEN CURDATE() AND DATE_ADD(CURDATE(), INTERVAL
12         14 DAY)
13 GROUP BY h.HID , h.Name , ca.Date ;

```

Listing 1: UpcomingByHospital View

### 1.1.2 Drug Pricing Summary

**Description:** Summarizes average, minimum, and maximum medication prices per hospital.

```

1 CREATE VIEW DrugPricingSummary AS
2 SELECT
3     H.HID ,
4     H.Name AS HospitalName ,
5     M.DrugID ,
6     M.Name AS MedicationName ,
7     AVG(S.Unit_Price) AS AvgUnitPrice ,
8     MIN(S.Unit_Price) AS MinUnitPrice ,
9     MAX(S.Unit_Price) AS MaxUnitPrice ,
10    MAX(S.StockTimestamp) AS LastStockTimestamp
11 FROM Stock S
12 JOIN Hospital H ON S.HID = H.HID
13 JOIN Medication M ON S.DrugID = M.DrugID
14 GROUP BY H.HID , H.Name , M.DrugID , M.Name ;

```

Listing 2: DrugPricingSummary View

### 1.1.3 StaffWorkloadThirty

**Description:** Shows staff appointment counts (total and by status) for the last 30 days.

```

1 CREATE VIEW StaffWorkloadThirty AS
2 SELECT
3     Staff.STAFF_ID ,
4     Staff.FullName ,
5     COUNT(Appointment.CAID) AS TotalAppointments ,
6     SUM(CASE WHEN Appointment.Status = 'Scheduled' THEN 1 ELSE 0
7           END) AS ScheduledCount ,
8     SUM(CASE WHEN Appointment.Status = 'Completed' THEN 1 ELSE 0
9           END) AS CompletedCount ,
10    SUM(CASE WHEN Appointment.Status = 'Cancelled' THEN 1 ELSE 0
11           END) AS CancelledCount
12   FROM Staff
13   LEFT JOIN ClinicalActivity ON Staff.STAFF_ID = ClinicalActivity.
14           STAFF_ID
15           AND DATEDIFF(NOW(), ClinicalActivity.Date) < 30
16   LEFT JOIN Appointment ON ClinicalActivity.CAID = Appointment.CAID
17   GROUP BY Staff.STAFF_ID , Staff.FullName;

```

Listing 3: StaffWorkloadThirty View

#### 1.1.4 Patient Next Visit

**Description:** Shows the next scheduled appointment details for each patient.

```

1 CREATE VIEW PatientNextVisit AS
2 SELECT
3     p.IID ,
4     p.FullName ,
5     ca.Date AS NextApptDate ,
6     d.Name AS DepartmentName ,
7     h.Name AS HospitalName ,
8     h.City
9   FROM Patient p
10  JOIN ClinicalActivity AS ca ON ca.IID = p.IID
11  JOIN Appointment a ON ca.CAID = a.CAID
12  JOIN Department d ON ca.DEP_ID = d.DEP_ID
13  JOIN Hospital h ON d.HID = h.HID
14 WHERE a.Status = 'Scheduled'
15 AND ca.Date > CURDATE()
16 AND ca.Date = (
17     SELECT MIN(ca2.Date)
18     FROM ClinicalActivity AS ca2
19     JOIN Appointment a2 ON ca2.CAID = a2.CAID
20     WHERE ca2.IID = p.IID
21     AND a2.Status = 'Scheduled'
22     AND ca2.Date > CURDATE()
23 );

```

Listing 4: PatientNextVisit View

## 1.2 Triggers

### 1.2.1 Reject Double Booking

**Description:** Blocks concurrent appointments for the same staff member.

```

1  DELIMITER //
2
3  CREATE TRIGGER prevent_double_booking_insert
4    BEFORE INSERT ON Appointment
5    FOR EACH ROW
6    BEGIN
7      DECLARE v_staff INT;
8      DECLARE v_date DATE;
9      DECLARE v_time TIME;
10
11     SELECT STAFF_ID, Date, Time INTO v_staff, v_date, v_time
12     FROM ClinicalActivity
13     WHERE CAID = NEW.CAID;
14
15     IF EXISTS (
16       SELECT 1
17       FROM ClinicalActivity
18       WHERE STAFF_ID = v_staff
19       AND Date = v_date
20       AND Time = v_time
21       AND CAID <> NEW.CAID
22     ) THEN
23       SIGNAL SQLSTATE '45000'
24         SET MESSAGE_TEXT = 'Double booking detected: Staff is
25           already scheduled at this time.';
26     END IF;
27   END//
```

```

28  CREATE TRIGGER prevent_double_booking_update
29    BEFORE UPDATE ON Appointment
30    FOR EACH ROW
31    BEGIN
32      DECLARE v_staff INT;
33      DECLARE v_date DATE;
34      DECLARE v_time TIME;
35
36      SELECT STAFF_ID, Date, Time INTO v_staff, v_date, v_time
37      FROM ClinicalActivity
38      WHERE CAID = NEW.CAID;
39
40      IF EXISTS (
41        SELECT 1
42        FROM ClinicalActivity
43        WHERE STAFF_ID = v_staff
44        AND Date = v_date
45        AND Time = v_time
46        AND CAID <> NEW.CAID

```

```

47    ) THEN
48        SIGNAL SQLSTATE '45000'
49            SET MESSAGE_TEXT = 'Double booking detected: Staff is
50                already scheduled at this time.';
51        END IF;
52    END//  

53 DELIMITER ;

```

Listing 5: Double Booking Prevention Triggers

### 1.2.2 Recompute Expense Total

**Description:** Updates expense totals upon prescription changes; blocks if prices are missing.

```

1 DELIMITER //
2
3 CREATE PROCEDURE RecomputeExpenseTotal(IN p_prescription_id INT)
4 BEGIN
5     DECLARE hosp_id INT;
6     DECLARE new_total DECIMAL(10,2);
7     DECLARE missing_price INT DEFAULT 0;
8
9     SELECT h.HID INTO hosp_id
10    FROM Prescription p
11      JOIN ClinicalActivity ca ON p.CAID = ca.CAID
12      JOIN Department d ON ca.DEP_ID = d.DEP_ID
13      JOIN Hospital h ON d.HID = h.HID
14 WHERE p.PID = p_prescription_id;
15
16     SELECT COUNT(*) INTO missing_price
17    FROM Include i
18      LEFT JOIN Stock s ON i.DrugID = s.DrugID AND s.HID = hosp_id
19 WHERE i.PID = p_prescription_id AND s.Unit_Price IS NULL;
20
21     IF missing_price > 0 THEN
22         SIGNAL SQLSTATE '45000'
23             SET MESSAGE_TEXT = 'Cannot compute expense: missing unit
24                 price for one or more medications';
25     ELSE
26         SELECT COALESCE(SUM(s.Unit_Price), 0) INTO new_total
27         FROM Include i
28           JOIN Stock s ON i.DrugID = s.DrugID AND s.HID = hosp_id
29 WHERE i.PID = p_prescription_id;
30
31         UPDATE Expense e
32           JOIN Prescription p ON e.CAID = p.CAID
33             SET e.Total = new_total
34             WHERE p.PID = p_prescription_id;
35     END IF;
36 END//
```

```

36
37 CREATE TRIGGER RecomputeExpenseAfterInsert
38 AFTER INSERT ON Include
39 FOR EACH ROW
40 BEGIN
41     CALL RecomputeExpenseTotal(NEW.PID);
42 END //
43
44 CREATE TRIGGER RecomputeExpenseAfterUpdate
45 AFTER UPDATE ON Include
46 FOR EACH ROW
47 BEGIN
48     CALL RecomputeExpenseTotal(NEW.PID);
49 END //
50
51 CREATE TRIGGER RecomputeExpenseAfterDelete
52 AFTER DELETE ON Include
53 FOR EACH ROW
54 BEGIN
55     CALL RecomputeExpenseTotal(OLD.PID);
56 END //
57
58 DELIMITER ;

```

Listing 6: Expense Recalculation Triggers

### 1.2.3 Prevent Negative or Inconsistent Stock

**Description:** Enforces positive prices and prevents negative stock quantities.

```

1 DELIMITER //
2
3 CREATE TRIGGER PreventInvalidStock
4 BEFORE INSERT ON Stock
5 FOR EACH ROW
6 BEGIN
7     IF NEW.Qty < 0 THEN
8         SIGNAL SQLSTATE '45000'
9         SET MESSAGE_TEXT = 'ERROR: Quantity cannot be negative.';
10    END IF;
11
12    IF NEW.Unit_Price <= 0 THEN
13        SIGNAL SQLSTATE '45000'
14        SET MESSAGE_TEXT = 'ERROR: Unit price must be positive.';
15    END IF;
16
17    IF NEW.ReorderLevel < 0 THEN
18        SIGNAL SQLSTATE '45000'
19        SET MESSAGE_TEXT = 'ERROR: Reorder level cannot be
20            negative.';
21    END IF;
22 END //

```

```

22
23 CREATE TRIGGER PreventInvalidStockUpdate
24 BEFORE UPDATE ON Stock
25 FOR EACH ROW
26 BEGIN
27     IF NEW.Qty < 0 THEN
28         SIGNAL SQLSTATE '45000'
29         SET MESSAGE_TEXT = 'ERROR: Quantity cannot be negative.';
30     END IF;

31
32     IF NEW.Unit_Price <= 0 THEN
33         SIGNAL SQLSTATE '45000'
34         SET MESSAGE_TEXT = 'ERROR: Unit price must be positive.';
35     END IF;

36
37     IF NEW.ReorderLevel < 0 THEN
38         SIGNAL SQLSTATE '45000'
39         SET MESSAGE_TEXT = 'ERROR: Reorder level cannot be
40             negative.';
41     END IF;

42     IF NEW.Qty < OLD.Qty AND NEW.Qty < 0 THEN
43         SIGNAL SQLSTATE '45000'
44         SET MESSAGE_TEXT = 'ERROR: Cannot decrease quantity below
45             zero.';
46     END IF;
47
48 END//
```

DELIMITER ;

Listing 7: Stock Validation Triggers

#### 1.2.4 Protect Referential Integrity on Patient Delete

**Description:** Prevents deleting patients who have existing clinical activities.

```

1 DELIMITER //
2
3 CREATE TRIGGER PreventPatientDelete
4 BEFORE DELETE ON Patient
5 FOR EACH ROW
6 BEGIN
7     IF EXISTS (
8         SELECT IID FROM ClinicalActivity ca
9         WHERE ca.IID = OLD.IID
10    ) THEN
11        SIGNAL SQLSTATE '45000'
12        SET MESSAGE_TEXT = 'Cannot delete patient. Please
13            reassign or delete dependent clinical activities first
14            .';
15    END IF;
16 END//
```

15

16 DELIMITER ;

Listing 8: Patient Delete Protection Trigger

## 2 Task 2: Application Layer for MNHS Database

### 2.1 Summary

The primary objective of this project is to develop a secure and user-friendly "Application Layer" for the MNHS database. The project prioritizes architectural robustness through the implementation of security best practices, including parameterized queries and environment-based credential management.

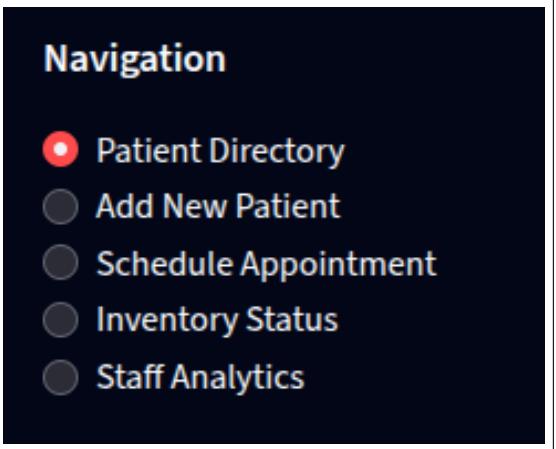
### 2.2 Technical Stack

#### 2.2.1 The Frontend: Streamlit

The application interface is built using **Streamlit**, a Python-based framework designed for the rapid development of data-driven web applications. Streamlit abstracts the frontend complexity (HTML/CSS/JavaScript), allowing for a direct integration of the Python application logic with the user interface.

In this implementation, Streamlit serves three critical functions:

- **Navigation Control:** `st.sidebar` is utilized to create a modular navigation menu, separating distinct business functions (e.g., Patient Directory, Scheduling, Analytics) into isolated views.



```

1   st.sidebar.markdown("### Navigation")
2   menu_options = [
3       "Patient Directory",
4       "Add New Patient",
5       "Schedule Appointment",
6       "Inventory Status",
7       "Staff Analytics"
8   ]
9   choice = st.sidebar.radio("Go to", menu_options, label_visibility="collapsed")

```

Figure 1: Navigation Menu

Listing 9: Python code for sidebar/navigation

- **Input Handling:** `st.form` and `st.form_submit_button` are employed to batch user inputs. This prevents premature database queries by ensuring that transactional data (such as appointment details) is only sent to the backend upon explicit user confirmation.

```

1   with st.form("appt_form"):
2       st.markdown("### Appointment Details")
3       c1, c2, c3 = st.columns(3)
4       with c1:

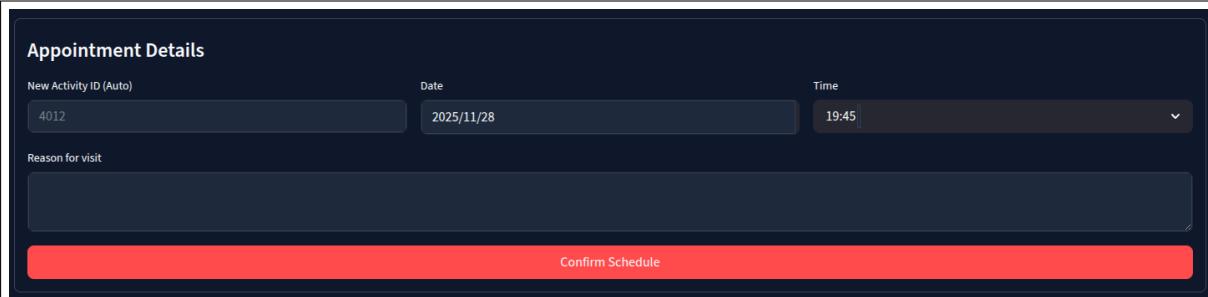
```

```

5         st.text_input("New Activity ID (Auto)", value
6             =next_caid, disabled=True)
7         with c2:
8             date = st.date_input("Date")
9         with c3:
10            time = st.time_input("Time")
11
12    reason = st.text_area("Reason for visit", height
13        =100)
14    submitted = st.form_submit_button("Confirm
15        Schedule", type="primary", use_container_width
16        =True)

```

Listing 10: Python code for the form in the schedule appointment section



The screenshot shows a dark-themed web form titled "Appointment Details". It contains four input fields: "New Activity ID (Auto)" with the value "4012", "Date" set to "2025/11/28", "Time" set to "19:45", and "Reason for visit" (an empty text area). Below the form is a large red button labeled "Confirm Schedule".

Figure 2: Appointment Form

- **Data Visualization:** The framework native integration with **Pandas** allows for the direct rendering of SQL query results into interactive tables (`st.dataframe`) and charts.

```

1  if st.button("Load Data"):
2      with st.spinner("Fetching..."):
3          results = list_patients_ordered_by_last_name(
4              limit)
5          if results:
6              df = pd.DataFrame(results)
7              st.dataframe(df, use_container_width=True
8                  , hide_index=True)
8      else:
9          st.info("No records found.")

```

Listing 11: Python code for the rendering of the patients table using `st.dataframe`

| Patient Directory                    |         |                      |            |     |            |            |            | Limit rows |     |
|--------------------------------------|---------|----------------------|------------|-----|------------|------------|------------|------------|-----|
|                                      |         |                      |            |     |            |            |            | 20         | - + |
| View and filter registered patients. |         |                      |            |     |            |            |            |            |     |
| Load Data                            |         |                      |            |     |            |            |            |            |     |
| IID                                  | CIN     | FullName             | Birth      | Sex | BloodGroup | Phone      | Email      |            |     |
| 120                                  | JK58746 | chakhabani 3tihabani | 1970-12-31 | M   | A+         | 0649811327 | None       |            |     |
| 118                                  | S990    | Youssef Alkhour      | 2010-09-20 | M   | A+         | 0600000019 | None       |            |     |
| 112                                  | M334    | Driss Alaoui         | 1955-10-10 | M   | O-         | 0600000013 | None       |            |     |
| 113                                  | N445    | Layla Amrani         | 2018-12-25 | F   | AB+        | 0600000014 | None       |            |     |
| 110                                  | K112    | Othmane Bakkali      | 1999-09-09 | M   | B-         | 0600000011 | None       |            |     |
| 115                                  | P667    | Soukaina Belhaj      | 2000-11-11 | F   | B+         | 0600000016 | None       |            |     |
| 100                                  | A100    | Ahmed Benali         | 1960-01-01 | M   | A+         | 0600000001 | None       |            |     |
| 105                                  | F600    | Salma Bennani        | 2024-02-01 | F   | A+         | 0600000006 | None       |            |     |
| 104                                  | E500    | Karim Bouanani       | 1992-11-20 | M   | O-         | 0600000005 | kb@tech.ma |            |     |
| 106                                  | G700    | Mourad Chraibi       | 1978-08-08 | M   | B+         | 0600000007 | mc@bank.ma |            |     |

Figure 3: Patients Table

### 2.2.2 The Backend: TiDB

The application backend relies on **TiDB**, an open-source distributed SQL database.

### Implementation Logic:

- **Protocol:** The application interacts with TiDB exactly like a standard single-node MySQL instance. The `mysql-connector-python` library is used to manage the connection, requiring no specialized TiDB-specific client code.
  - **Secure Connection:** To maintain security best practices, the connection logic is encapsulated in a helper function. This function reads sensitive credentials (Host, Port, User, Password) dynamically from environment variables (`.env`) rather than hard-coding them, ensuring the distributed cluster is accessed securely.

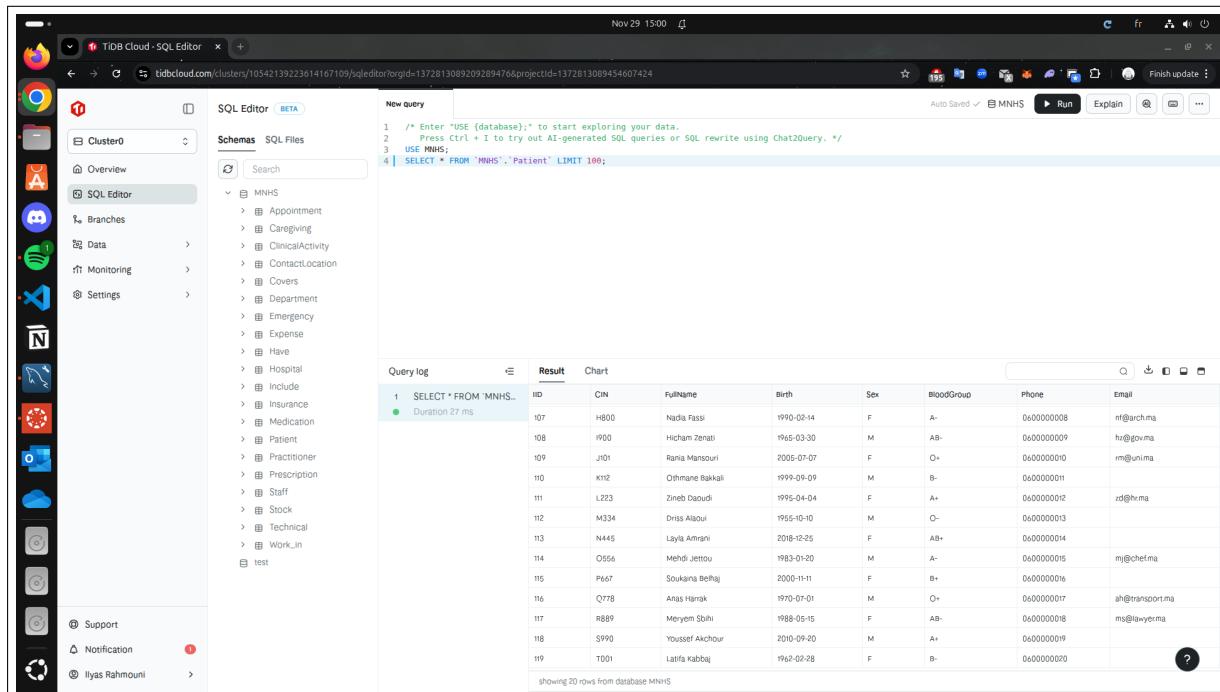
```
1 # Local .env configuration
2 def get_connection():
3     """
4         Establishes a database connection with a hybrid approach:
5             1. Tries to load from Streamlit Secrets (st.secrets) for
6                 Cloud deployment.
7             2. Falls back to local .env file using python-dotenv for
8                 local dev.
9     """
10    try:
11        # Attempt to access Streamlit Secrets
12        # This will work if .streamlit/secrets.toml exists or on
13        # Streamlit Cloud
14        return mysql.connector.connect(
15            host=st.secrets["mysql"]["host"],
16            port=st.secrets["mysql"]["port"],
17            database=st.secrets["mysql"]["database"],
18            user=st.secrets["mysql"]["user"],
19            password=st.secrets["mysql"]["password"]
20        )
21    except Exception as e:
22        print(f"Error connecting to MySQL: {e}")
23
```

```

18     except (FileNotFoundException, KeyError):
19         # Fallback: Load environment variables from .env file
20         load_dotenv()
21
22     # Ensure port is an integer
23     port_val = os.getenv("MYSQL_PORT", 3306)
24
25     return mysql.connector.connect(
26         host=os.getenv("MYSQL_HOST"),
27         port=int(port_val),
28         database=os.getenv("MYSQL_DB"),
29         user=os.getenv("MYSQL_USER"),
30         password=os.getenv("MYSQL_PASSWORD")
31     )

```

Listing 12: TiDB Connection Implementation



The screenshot shows the TiDB Cloud SQL Editor interface. On the left, there's a sidebar with icons for Overview, SQL Editor (selected), Branches, Data, Monitoring, Settings, Support, Notification (with a red dot), and Ilyas Rahmouni. The main area has tabs for SQL Editor (Beta) and New query. The SQL Editor tab shows a query history with the following code:

```

1 /* Enter "USE {database};" to start exploring your data.
2    Press Ctrl + I to try out AI-generated SQL queries or SQL rewrite using Chat2Query. */
3 USE MNHS;
4 | SELECT * FROM `MNHS`.`Patient` LIMIT 100;

```

The New query tab is active, showing the results of the last query. The results table has columns: ID, CIN, FullName, Birth, Sex, BloodGroup, Phone, and Email. The data is as follows:

| ID  | CIN  | FullName        | Birth      | Sex | BloodGroup | Phone      | Email           |
|-----|------|-----------------|------------|-----|------------|------------|-----------------|
| 107 | H800 | Nadia Fassi     | 1990-02-14 | F   | A-         | 0600000008 | nf@arch.ma      |
| 108 | I900 | Hicham Zenati   | 1965-03-30 | M   | AB-        | 0600000009 | hz@cv.ma        |
| 109 | J101 | Rania Mansouri  | 2005-07-07 | F   | O+         | 0600000010 | rm@unima.ma     |
| 110 | K112 | Othmane Bakalli | 1999-09-09 | M   | B-         | 0600000011 |                 |
| 111 | L223 | Zineb Daoudi    | 1995-04-04 | F   | A+         | 0600000012 | zd@hr.ma        |
| 112 | M334 | Oriès Alidou    | 1955-10-10 | M   | O-         | 0600000013 |                 |
| 113 | N445 | Layla Amrahi    | 2018-12-25 | F   | AB+        | 0600000014 |                 |
| 114 | O566 | Mehdi Jettou    | 1983-01-20 | M   | A-         | 0600000015 | mj@chef.ma      |
| 115 | P667 | Soukaina Benhaj | 2000-11-11 | F   | B+         | 0600000016 |                 |
| 116 | Q778 | Anas Harkik     | 1970-07-01 | M   | O+         | 0600000017 | ah@transport.ma |
| 117 | R889 | Meyyoub Sbhi    | 1988-05-15 | F   | AB-        | 0600000018 | ms@lawyer.ma    |
| 118 | S990 | Youssef Akchour | 2010-09-20 | M   | A+         | 0600000019 |                 |
| 119 | T001 | Latifa Kabbaj   | 1962-02-28 | F   | B-         | 0600000020 |                 |

At the bottom, it says "showing 20 rows from database MNHS".

Figure 4: TiDB SQL Editor

## 2.3 Implementation Code Logic

### 2.3.1 Module 1: Patient Directory (list\_patients)

The Patient Directory module provides the user with a searchable, ordered view of registered patients. The lab specifically asks for the first 20 patients, this is set as the default value for the limit rows option. But we took the liberty to add the possibility of choosing the number of rows to show as an option.

**2.3.1.1 UI Implementation: Server-Side Pagination** To ensure optimal performance, the application avoids fetching the entire dataset at once. Instead, it implements a "Server-Side Pagination" strategy controlled by the user.

- **Dynamic Limit Control:** A Streamlit number input (`st.number_input`) allows the user to specify exactly how many records to retrieve (e.g., 10, 20, 50).

```
1  limit = st.number_input("Limit rows", 5, 100, 20)
```

Listing 13: Python code for the limit choice



Figure 5: Dynamic Limit Control

- **Performance Impact:** This input is passed directly to the SQL `LIMIT` clause. This ensures that the heavy lifting is done by the database engine (TiDB), and only the requested subset of data is transmitted over the network to the Python frontend.

```
1  if st.button("Load Data"):
2      with st.spinner("Fetching..."):
3          results = list_patients_ordered_by_last_name(
4              limit)
```

Listing 14: Python code calling the function list patients ordered by last name at the press of Load Data button with the limit as an argument to the function

**2.3.1.2 SQL Logic: String Manipulation for Sorting** A task to implement for this application layer was to order patients by their **Last Name**. However, the database schema provided stores the name as a single string in the `FullName` column (e.g., "Ahmed Benali").

Standard SQL sorting (`ORDER BY FullName`) would incorrectly sort by the first name. To resolve this without altering the schema, the application utilizes the `SUBSTRING_INDEX` function.

#### The Sorting Algorithm:

1. The query isolates the string segment occurring after the last space character using `SUBSTRING_INDEX(FullName, ' ', -1)`.

2. This extracted token (the surname) is used as the primary sort key.
3. The full name is used as a secondary sort key to resolve ties.

```

1 def list_patients_ordered_by_last_name(limit=20):
2     sql = """
3         SELECT IID, CIN, FullName, Birth, Sex, BloodGroup, Phone,
4             Email
5         FROM Patient
6         ORDER BY SUBSTRING_INDEX(FullName, ' ', -1)
7         LIMIT %s
8     """
9     try:
10         with get_connection() as cnx:
11             with cnx.cursor(dictionary=True) as cur:
12                 cur.execute(sql, (limit,))
13                 return cur.fetchall()
14             except Exception as e:
15                 st.error(f"Error fetching patients: {e}")
16             return []

```

Listing 15: Python code including SQL Query for Surname Sorting



The screenshot shows a web-based application titled "Patient Directory". The header includes a "Load Data" button and a "Limit rows" dropdown set to 20. The main content is a table with the following columns: IID, CIN, FullName, Birth, Sex, BloodGroup, Phone, and Email. The table contains 10 rows of patient information:

| IID | CIN     | FullName             | Birth      | Sex | BloodGroup | Phone      | Email      |
|-----|---------|----------------------|------------|-----|------------|------------|------------|
| 120 | JK58746 | chakhabani 3thlabani | 1970-12-31 | M   | A+         | 0649811327 | None       |
| 118 | S990    | Youssef Akhour       | 2010-09-20 | M   | A+         | 0600000019 | None       |
| 112 | M334    | Driss Alaoui         | 1955-10-10 | M   | O-         | 0600000013 | None       |
| 113 | N445    | Layla Amrani         | 2018-12-25 | F   | AB+        | 0600000014 | None       |
| 110 | K112    | Othmane Bakkali      | 1999-09-09 | M   | B-         | 0600000011 | None       |
| 115 | P667    | Soukaina Belhaj      | 2000-11-11 | F   | B+         | 0600000016 | None       |
| 100 | A100    | Ahmed Benali         | 1960-01-01 | M   | A+         | 0600000001 | None       |
| 105 | F600    | Salma Bennani        | 2024-02-01 | F   | A+         | 0600000006 | None       |
| 104 | E500    | Karim Bouanani       | 1992-11-20 | M   | O-         | 0600000005 | kb@tech.ma |
| 106 | G700    | Mourad Chraibi       | 1978-08-08 | M   | B+         | 0600000007 | mc@bank.ma |

Figure 6: Patients Table Output

### 2.3.2 Module 2: Intelligent Scheduling System (schedule\_appt)

The implementation of this module/functionality prioritizes user experience by abstraction the actual complex data base identifiers and automating the CAID choice.

**2.3.2.1 User-Friendly Input Abstraction** A key usability challenge in database applications is that end-users (medical staff) do not know internal Primary Keys (e.g., that "Dr. Leila" is STAFF\_ID=2 or "Cardiology" is DEP\_ID=11).

To resolve this, the application implements a **Translation Layer** using Streamlit and Python dictionaries:

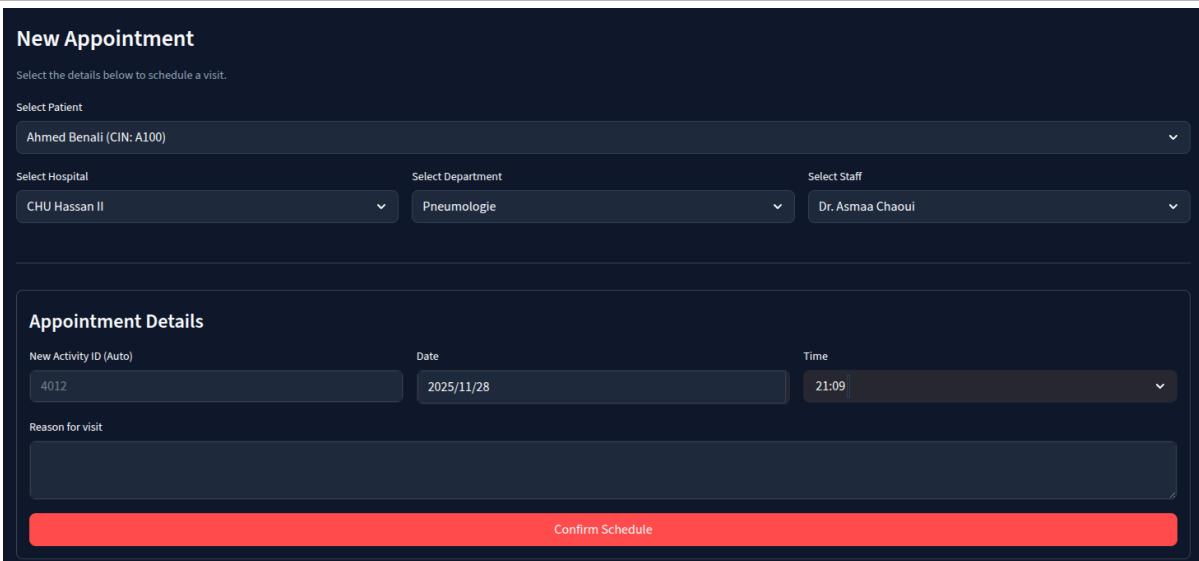


Figure 7: User-Friendly interface

1. **Fetching:** On page load, the application executes SELECT queries to retrieve human-readable names (Staff Full Name, Hospital Name, Department Name).

```

1  all_patients = get_all_patients()
2  all_hospitals = get_all_hospitals()
3  all_staff = get_all_staff()
```

Listing 16: Python code for fetching process on page load

2. **Mapping:** These results are stored in a Python dictionary mapping the Name (Key) to the ID (Value) as seen above.

```

1  patient_options = {f"{p['FullName']}": (CIN: {p['CIN']}) :
2      p['IID'] for p in all_patients}
# patient_options is the dictionary in question
# it contains patient names and cin as keys and iids as
# values
```

Listing 17: Python code for patients dictionary as an example

3. **Selection:** The user interacts with a st.selectbox displaying only the names.

```
1     selected_patient_label = st.selectbox("Select Patient",
  options=list(patient_options.keys()))
```

Listing 18: Python code for selection

4. **Translation:** Upon submission, the application looks up the corresponding ID from the dictionary to use in the SQL INSERT statement.

```
1     selected_iid = patient_options[selected_patient_label]
```

Listing 19: Python code for iid lookup

**2.3.2.2 Automated ID Generation** To prevent "Duplicate Key" errors and reduce manual entry, the application automatically calculates the next available Clinical Activity ID (CAID).

**Logic:** Before the transaction begins, the application queries the maximum existing ID in the ClinicalActivity table. The new ID is calculated as  $\text{MAX}(\text{CAID}) + 1$ .

```
1     def get_next_caid():
 2         sql = "SELECT MAX(CAID) as max_id FROM ClinicalActivity"
 3         try:
 4             with get_connection() as cnx:
 5                 with cnx.cursor(dictionary=True) as cur:
 6                     cur.execute(sql)
 7                     res = cur.fetchone()
 8                     if res and res['max_id']:
 9                         return res['max_id'] + 1
10                     return 1000
11         except: return 1000
```

Listing 20: Next CAID Calculation helper function

```
1     next_caid = get_next_caid()
```

Listing 21: Function call at page load

**2.3.2.3 Transactional Integrity** The scheduling process involves two distinct SQL write operations:

1. Creating the parent event in the ClinicalActivity table.
2. Creating the specific status in the Appointment table.

To ensure data consistency, if the second insert fails (e.g., due to a constraint violation), the first insert is automatically reversed (**ROLLBACK**)

```
1     if submitted:
 2         if selected_dep_id is None:
 3             st.error("Invalid Department.")
 4         else:
 5             try:
```

```

6         schedule_appointment(next_caid, selected_iid,
7             selected_staff_id, selected_dep_id, str(date), str
8             (time), reason)
9                 st.success(f"Appointment scheduled (ID: {next_caid})")
except Exception as e:
    st.error(f"Failed to schedule: {e}")

```

Listing 22: schedule\_appointment function call at the press of Confirme Schedule button

```

1 def schedule_appointment(caid, iid, staff_id, dep_id, date_str,
2     time_str, reason):
3     """
4         Schedules an appointment with 'Double Booking' protection.
5     """
6     # 1. Validation SQL: Check if staff is already booked
7     check_sql = """
8         SELECT CAID
9             FROM ClinicalActivity
10            WHERE STAFF_ID = %s AND Date = %s AND Time = %s
11            LIMIT 1
12     """
13     ins_ca = """
14         INSERT INTO ClinicalActivity (CAID, IID, STAFF_ID, DEP_ID,
15             Date, Time)
16         VALUES (%s, %s, %s, %s, %s, %s)
17     """
18     ins_appt = """
19         INSERT INTO Appointment (CAID, Reason, Status)
20         VALUES (%s, %s, 'Scheduled')
21     """
22     with get_connection() as cnx:
23         try:
24             with cnx.cursor() as cur:
25                 # --- [TRIGGER LOGIC START] ---
26                 # Check for double booking before doing anything
27                 cur.execute(check_sql, (staff_id, date_str,
28                     time_str))
29                 conflict = cur.fetchone()
30                 if conflict:
31                     # STOP! Raise an error to prevent the insert
32                     raise ValueError(f"Double Booking Error:
33                         Staff {staff_id} is already busy at {
34                         time_str} on {date_str}.")
35                 # --- [TRIGGER LOGIC END] ---
36                 # If no conflict, proceed with the transaction
37                 cur.execute(ins_ca, (caid, iid, staff_id, dep_id,
38                     date_str, time_str))
39                 cur.execute(ins_appt, (caid, reason))
40                 cnx.commit()
41                 return True
42             except Exception as e:

```

```
37     cnx.rollback()  
38     raise e
```

Listing 23: schedule\_appointment function

**2.3.2.4 Note on Architectural Adaptation** The final implementation of this scheduling module includes specific validation logic to enforce the "Double Booking" constraint. However, due to the architectural differences between standard MySQL and the distributed TiDB backend, specifically the lack of support for CREATE TRIGGER, this validation was strategically shifted from the database layer to the application layer. A detailed technical justification for this design choice is presented in [2.4 Adaptation Strategy]

### 2.3.3 Module 3: Inventory & Low Stock (low\_stock)

This module detects only low quantity medication stocks including also medications with no stock at all. Unlike a standard data retrieval, this functionality utilizes various techniques to filter and load only the wanted rows in the specified format.

**2.3.3.1 SQL Query Explanation:** A standard SQL query on the `Stock` table can easily find items where `Qty < ReorderLevel`. However, if a hospital has completely run out of a medication, or never logged it, there may be **no row at all** in the `Stock` table for that specific Hospital-Drug combination.

To solve this, the application implements a **Cross-Join Strategy**:

1. **Cartesian Product:** A CROSS JOIN is performed between the `Hospital` table and the `Medication` table. This generates a theoretical matrix of every possible medication in every hospital.

```

1   FROM Medication M
2   CROSS JOIN Hospital H

```

Listing 24: Cross-Join Logic for Missing Stock

2. **Left Join:** The application then LEFT JOINS the actual `Stock` table against this matrix.

```

1   LEFT JOIN Stock S ON M.DrugID = S.DrugID AND H.HID = S.
2       HID

```

Listing 25: Left Join the actual Stock Table

3. **Null Handling:** If no stock record matches, the database returns NULL. The query uses COALESCE(`Qty`, 0) to interpret this NULL as a quantity of zero, triggering the alert.

```

1   COALESCE(S.Qty, 0) AS CurrentQuantity,
2   COALESCE(S.ReorderLevel, 0) AS ReorderLevel ,

```

Listing 26: COALESCE Function

4. **COALESCE Function:** The COALESCE function safeguards the query logic by converting any NULL values, resulting from missing inventory records, into a computational zero, ensuring that complete stockouts are accurately identified and flagged.

```

1   SELECT
2       M.Name AS MedicationName ,
3       H.Name AS HospitalName ,
4       COALESCE(S.Qty, 0) AS CurrentQuantity ,
5       COALESCE(S.ReorderLevel, 0) AS ReorderLevel ,
6       CASE
7           WHEN S.Qty IS NULL THEN 'No Stock'
8           WHEN S.Qty < S.ReorderLevel THEN 'Low Stock'
9           ELSE 'Adequate'
10      END AS StockStatus

```

```

11   FROM Medication M
12     CROSS JOIN Hospital H
13     LEFT JOIN Stock S ON M.DrugID = S.DrugID AND H.HID = S.HID
14     WHERE S.Qty IS NULL OR S.Qty < S.ReorderLevel
15   ORDER BY M.Name, H.Name;

```

Listing 27: Full Sql Query

**2.3.3.2 UI Implementation — Visual Alerting :** To make this data actionable for administrators, the application avoids displaying a raw wall of text. Instead, it utilizes **Pandas Styling** to apply conditional formatting to the data before rendering it in Streamlit.

**Logic:** A Python function iterates through the result set:

- **Red Highlight:** Applied if the status is "No Stock" (Qty = 0).
- **Orange Highlight:** Applied if the status is "Low Stock" (0 < Qty < ReorderLevel).

```

1 def style_status(val):
2     color = '#ef4444' if val == 'No Stock' else '#f59e0b'
3     if val == 'Low Stock' else '#94A3B8'
4     return f'color: {color}; font-weight: 500'

```

Listing 28: Python Function used for the styling

**2.3.3.3 UI Implementation — Donut Chart :** To provide an immediate assessment of the hospital's overall inventory health, the interface includes a summary Donut Chart built using **Plotly Express**.

**Code Logic:**

1. **Aggregation:** The application aggregates the SQL results using `value_counts()` on the 'StockStatus' column to determine the distribution of critical vs. adequate stock.

```

1 status_counts = df['StockStatus'].value_counts()

```

Listing 29: `value_counts()` function on the StockStatus

2. **Visualization:** A pie chart with a center hole (`hole=0.6`) is generated to create a modern "Donut" aesthetic.
3. **Semantic Coloring:** To ensure consistency with the table highlights, the chart utilizes a specific color sequence: Red (#ef4444) for shortages, Orange (#f59e0b) for low stock, and Grey for adequate items.

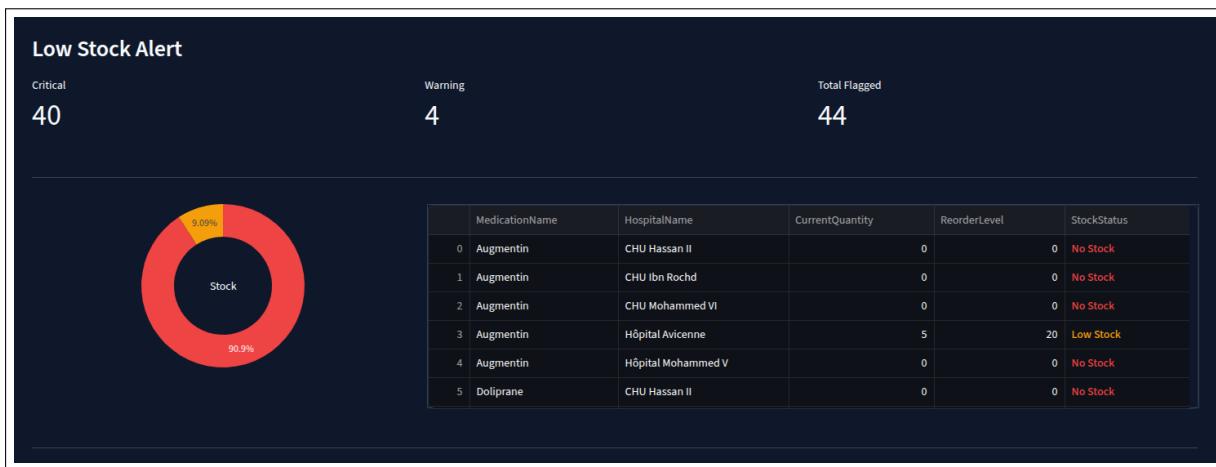


Figure 8: Low Stock Interface

```

1 # Create a Donut chart with semantic colors
2 fig = px.pie(
3     values=status_counts.values,
4     names=status_counts.index,
5     hole=0.6, # Creates the donut shape
6     # Red for Critical, Orange for Warning
7     color_discrete_sequence=['#ef4444', '#f59e0b', '#475569'],
8     template="plotly_dark"
9 )
10 st.plotly_chart(fig, use_container_width=True)

```

Listing 30: Plotly Donut Chart Configuration

### 2.3.4 Module 4: Staff Workload Analytics (staff\_share)

This module provides the user with performance metrics, calculating the share of appointments handled by each staff member relative to their specific hospital's total workload. This requires an SQL aggregation and a visualization strategy capable of handling multi-hospital employment.

**2.3.4.1 SQL Logic:** Calculating a percentage share requires: the count for the individual staff member and the total count for the hospital. We will use Subqueries to achieve the desired result (Nested Subqueries).

#### The Query Structure:

1. **Subquery S (Staff):** Counts appointments grouped by STAFF\_ID and HID. This yields the numerator (Individual Workload).

```

1   SELECT ca.STAFF_ID, st.FullName, dep.HID, COUNT(a.CAID)
2     AS StaffApp
3   FROM Appointment a
4   JOIN ClinicalActivity ca ON a.CAID = ca.CAID
5   JOIN Staff st ON ca.STAFF_ID = st.STAFF_ID
6   JOIN Department dep ON ca.DEP_ID = dep.DEP_ID
    GROUP BY ca.STAFF_ID, st.FullName, dep.HID

```

Listing 31: Staff Subquery

2. **Subquery H (Hospital):** Counts appointments grouped by HID only. This yields the denominator (Hospital Total).

```

1   SELECT dep.HID, Hosp.Name, COUNT(a.CAID) AS HospitalApp
2   FROM Appointment a
3   JOIN ClinicalActivity ca ON ca.CAID = a.CAID
4   JOIN Department dep ON ca.DEP_ID = dep.DEP_ID
5   JOIN Hospital Hosp ON dep.HID = Hosp.HID
6   GROUP BY dep.HID, Hosp.Name

```

Listing 32: Hospital Subquery

3. **Main Query:** Joins these two virtual tables on HID to calculate the percentage:  

$$\frac{\text{Staff Apps}}{\text{Hospital Apps}} \times 100.$$

```

1   SELECT
2     s.STAFF_ID,
3     s.FullName AS StaffName,
4     h.Name AS HospitalName,
5     s.StaffApp AS TotalAppointments,
6     ROUND((s.StaffApp / h.HospitalApp) * 100, 2) AS
      PercentageShare
7   FROM (
8     SELECT ca.STAFF_ID, st.FullName, dep.HID, COUNT(a.CAID)
9       AS StaffApp
10      FROM Appointment a
11      JOIN ClinicalActivity ca ON a.CAID = ca.CAID

```

```

11      JOIN Staff st ON ca.STAFF_ID = st.STAFF_ID
12      JOIN Department dep ON ca.DEP_ID = dep.DEP_ID
13      GROUP BY ca.STAFF_ID, st.FullName, dep.HID
14  ) s
15  JOIN (
16      SELECT dep.HID, Hosp.Name, COUNT(a.CAID) AS HospitalApp
17      FROM Appointment a
18      JOIN ClinicalActivity ca ON ca.CAID = a.CAID
19      JOIN Department dep ON ca.DEP_ID = dep.DEP_ID
20      JOIN Hospital Hosp ON dep.HID = Hosp.HID
21      GROUP BY dep.HID, Hosp.Name
22  ) h ON s.HID = h.HID
23  ORDER BY h.HID, PercentageShare DESC;

```

Listing 33: Full Query for appointment share

**2.3.4.2 UI Implementation — Bar Chart** A significant challenge in visualizing this data is that many doctors work across multiple hospital sites. Using a standard bar chart often results in data points for the same doctor overlapping illegibly.

**The Solution:** To resolve this, the application utilizes the **Plotly Express** library to render a **\*\*Horizontal Grouped Bar Chart\*\***. This approach offers superior clarity over standard charts through three key mechanisms:

- **Grouped Mode (barmode='group')**: Instead of stacking values, this setting forces the chart to place bars side-by-side for the same staff member. If a doctor works in "Casablanca" and "Rabat," they appear as two distinct, adjacent bars, preventing any visual overlap.
- **Semantic Coloring**: The `HospitalName` is mapped to a discrete color sequence. This allows users to visually distinguish which hospital contributes to the specific workload share at a glance.
- **Horizontal Orientation**: Given that staff names can be long, setting `orientation='h'` ensures all labels are readable without rotation or truncation.

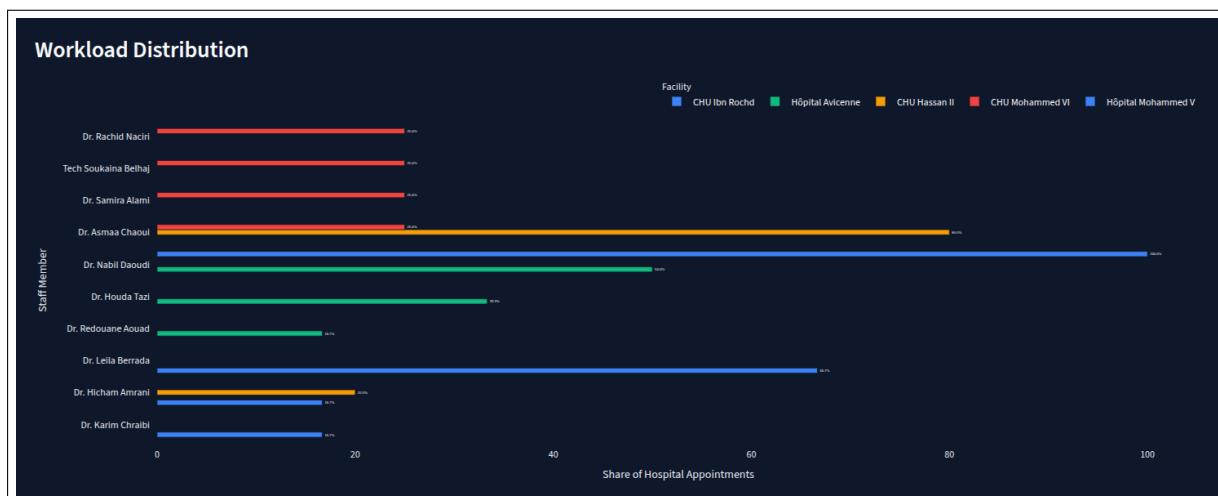


Figure 9: BarChart Final Result

```

1 # Using Plotly Express to handle multi-site overlaps
2 # Using px.bar with barmode='group' prevents overlapping.
3 fig = px.bar(
4     df,
5     x="PercentageShare",
6     y="StaffName",
7     color="HospitalName",
8     orientation='h',
9     barmode='group',
10    text="PercentageShare",
11    color_discrete_sequence=['#3b82f6', '#10b981', '#f59e0b', '#ef4444',
12      "#b3ff00"],
13    labels={"PercentageShare": "Share (%)", "StaffName": "Staff Member", "HospitalName": "Facility"}
14 )
15
16 fig.update_traces(texttemplate=' %{text:.1f}%', textposition='outside')
17 fig.update_layout(
18     title="",
19     xaxis_title="Share of Hospital Appointments",
20     template="plotly_dark",
21     height=500,
22     margin=dict(l=0, r=0, t=0, b=0),
23     paper_bgcolor='rgba(0,0,0,0)',
24     plot_bgcolor='rgba(0,0,0,0)',
25     font=dict(color='#F8FAFC'),
26     xaxis=dict(showgrid=False),
27     yaxis=dict(showgrid=False),
28     legend=dict(orientation="h", yanchor="bottom", y=1.02,
29                 xanchor="right", x=1)
30 )
31 st.plotly_chart(fig, use_container_width=True)

```

Listing 34: Plotly Grouped Bar Chart Logic

View Raw Data Table

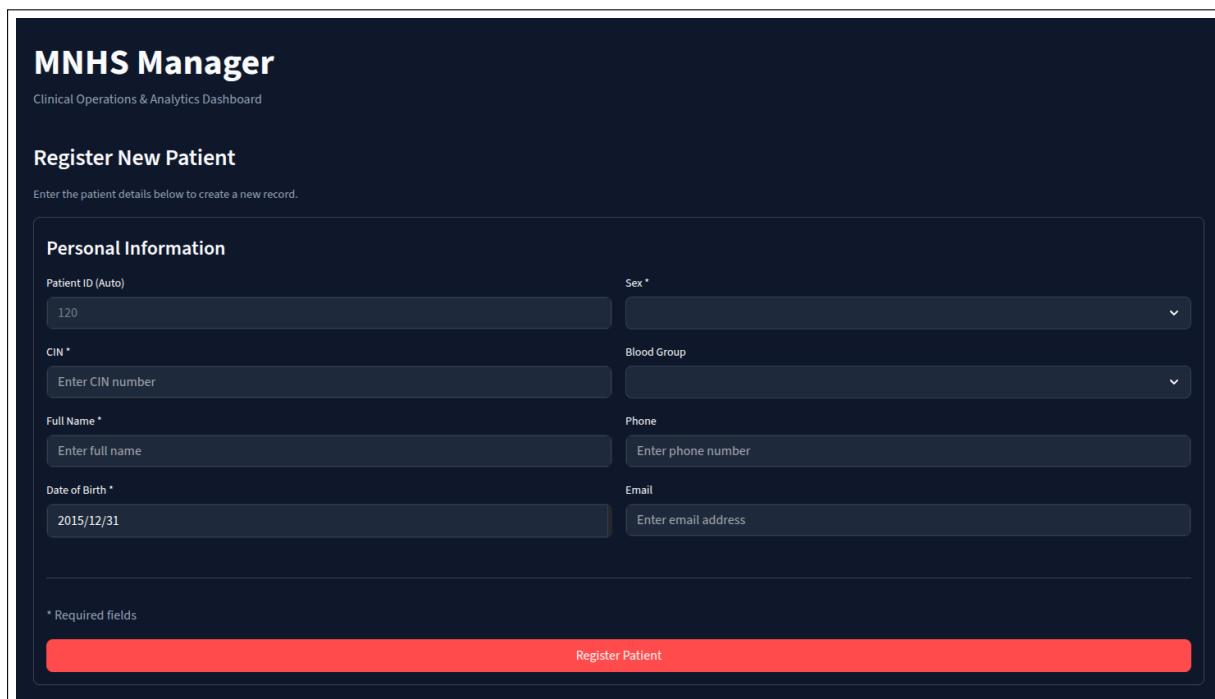
|    | STAFF_ID | StaffName            | HospitalName     | TotalAppointments | PercentageShare |
|----|----------|----------------------|------------------|-------------------|-----------------|
| 1  | 7        | Dr. Karim Chraibi    | CHU Ibn Rochd    | 1                 | 16.67           |
| 2  | 26       | Dr. Hicham Amrani    | CHU Ibn Rochd    | 1                 | 16.67           |
| 5  | 18       | Dr. Redouane Aouad   | Hôpital Avicenne | 1                 | 16.67           |
| 11 | 26       | Dr. Hicham Amrani    | CHU Hassan II    | 1                 | 20              |
| 7  | 19       | Dr. Samira Alami     | CHU Mohammed VI  | 1                 | 25              |
| 9  | 24       | Tech Soukaina Belhaj | CHU Mohammed VI  | 1                 | 25              |
| 8  | 20       | Dr. Rachid Naciri    | CHU Mohammed VI  | 1                 | 25              |
| 6  | 12       | Dr. Asmaa Chaoui     | CHU Mohammed VI  | 1                 | 25              |
| 4  | 10       | Dr. Houda Tazi       | Hôpital Avicenne | 2                 | 33.33           |
| 3  | 11       | Dr. Nabil Daoudi     | Hôpital Avicenne | 3                 | 50              |

Figure 10: Raw Data Table

### 2.3.5 Module 5: Patient Registration Utility (add\_new\_patient)

**2.3.5.1 Context** This module was not part of the original lab specifications. It was integrated into the final application following a recommendation from our Teaching Assistant, Miss Guerbouzi. We determined that a dedicated interface for registering new patients would serve as an invaluable tool for population and debugging, allowing us to rapidly generate test cases for the other modules.

**2.3.5.2 Implementation Overview** From a technical perspective, the architecture of this module is similar to the **Intelligent Scheduling System** (Module 2). It employs a similar strategy of form-based input handling and parameterized SQL insertion. To avoid redundancy, the functional logic of this module is not detailed in this document.



The screenshot shows a dark-themed web application interface. At the top, it says "MNHS Manager" and "Clinical Operations & Analytics Dashboard". Below that, a section titled "Register New Patient" with the sub-instruction "Enter the patient details below to create a new record." contains a form titled "Personal Information". The form has several input fields: "Patient ID (Auto)" with value "120", "Sex" dropdown, "CIN \*" with placeholder "Enter CIN number", "Blood Group" dropdown, "Full Name \*" with placeholder "Enter full name", "Phone" with placeholder "Enter phone number", "Date of Birth" with value "2015/12/31", and "Email" with placeholder "Enter email address". At the bottom left of the form area, there is a note: "\* Required fields". At the bottom right of the form area, there is a large red button with the text "Register Patient".

Figure 11: Add Patient Form

## 2.4 Adaptation Strategy: Handling TiDB Limitations

A core requirement of the lab specification was the implementation of four specific SQL Triggers to enforce business rules. However, the backend selected for this project, **TiDB**, does not currently support the `CREATE TRIGGER` statement found in standard MySQL 5.7.

To maintain functional parity with the requirements while leveraging the scalability of TiDB, the application implements a **Python Based Validation Architecture**. All constraints normally enforced by the database engine were migrated to the Python application layer.

The Requested Triggers were written as requested in [1.2 Triggers](#) this choice was only made to allow deployment of the app while enforcing business rules.

The only trigger that was implemented is the double-booking prevention trigger as it is the only one needed in the tasks that were specified in the Lab.

### 2.4.1 The "No-Trigger" Architecture

In a traditional architecture, the database acts as the final gatekeeper of data integrity using procedural SQL. In this adapted architecture, the Python plays this role.

### 2.4.2 Double-Booking Prevention

**Requirement:** The system must reject an appointment request if the staff member is already scheduled for the exact same Date and Time.

1. **Verification Query:** Before any write operation, the application executes a `SELECT` query on the `ClinicalActivity` table, filtering by the requested `STAFF_ID`, Date, and Time.
2. **Conflict Detection:** The results are analyzed using `cursor.fetchone()`. If a record is returned, the time slot is identified as occupied.
3. **Transaction Abort:** Instead of letting the database throw a constraint error, the Python application explicitly raises a `ValueError`. This halts the execution flow immediately, preventing the `INSERT` statements from running and triggering a `ROLLBACK` of the transaction.

```

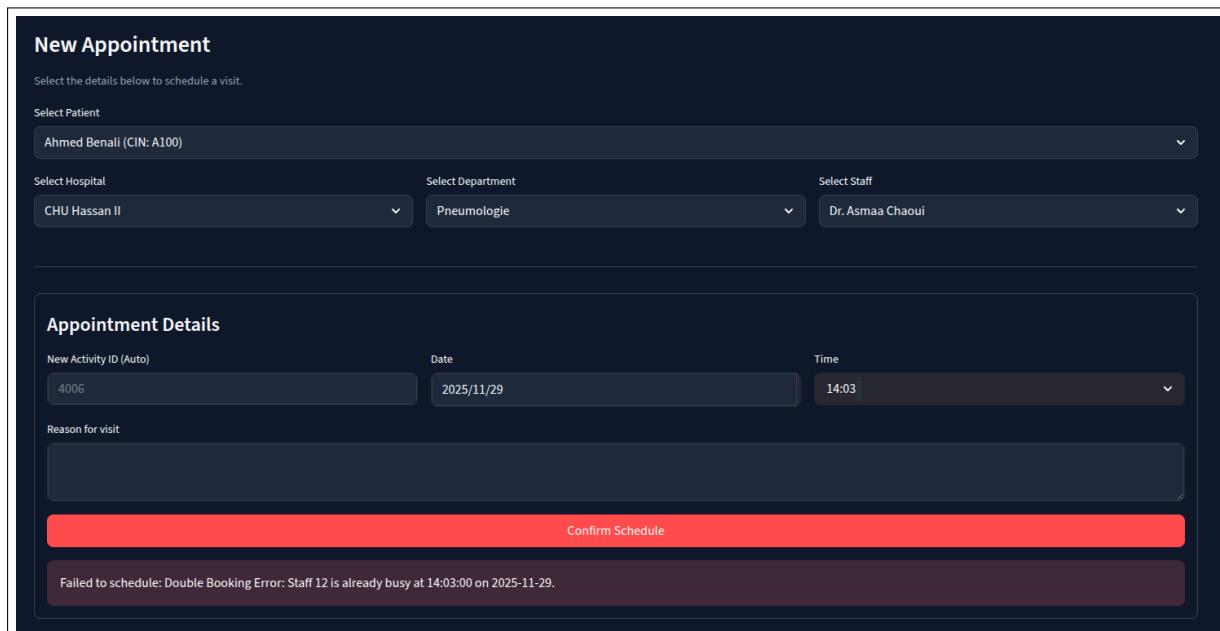
1 # 1. Validation SQL: Check if staff is already booked
2 check_sql = """
3     SELECT CAID FROM ClinicalActivity
4     WHERE STAFF_ID = %s AND Date = %s AND Time = %s LIMIT 1
5 """
6
7 # ... Inside the transaction ...
8 cur.execute(check_sql, (staff_id, date_str, time_str))
9 conflict = cur.fetchone()
10
11 if conflict:
12     # STOP! Raise an error to prevent the insert
13     raise ValueError(f"Double Booking Error: Staff {staff_id} is
already busy.")

```

```
14
15 # If no conflict, proceed with the transaction
16 cur.execute(ins_ca, ...)
17 cur.execute(ins_appt, ...)
```

Listing 35: Double Booking Check Implementation

The full Python function can be found in [2.3.2 Module 2 : Intelligent Scheduling System](#)



The screenshot shows a dark-themed user interface for scheduling a new appointment. At the top, there's a header titled "New Appointment" with a sub-instruction: "Select the details below to schedule a visit." Below this, there are three dropdown menus: "Select Patient" (set to "Ahmed Benali (CIN: A100)", "Select Hospital" (set to "CHU Hassan II"), and "Select Department" (set to "Pneumologie"). To the right of these is another dropdown for "Select Staff" (set to "Dr. Asmaa Chaoui"). The next section, "Appointment Details", contains fields for "New Activity ID (Auto)" (set to "4006"), "Date" (set to "2025/11/29"), and "Time" (set to "14:03"). Below these fields is a text area labeled "Reason for visit" which is currently empty. At the bottom of this section is a large red button labeled "Confirm Schedule". In the bottom right corner of the main form area, there is a dark red rectangular message box containing the text "Failed to schedule: Double Booking Error: Staff 12 is already busy at 14:03:00 on 2025-11-29."

Figure 12: Double Booking Error Message

---

## 2.5 Conclusion

### 2.5.1 Summary of Achievements

This application layer successfully delivered a robust, full-stack "Application Layer" for the Moroccan National Health Services (MNHS) database. By integrating a Python-based Streamlit frontend with a distributed TiDB backend, the solution effectively bridges the gap between complex relational data and end-user accessibility.

Key technical achievements include:

- **Transactional Integrity:** The scheduling module ensures that the database maintains consistent states, even during complex multi-table write operations.
- **Architectural Adaptability:** The successful migration of business logic (constraints and validations) from the database layer to the application layer demonstrated the flexibility required when working with modern distributed SQL engines like TiDB, which may lack legacy features like Triggers.

### 2.5.2 Performance and Scalability

The chosen technology stack offers significant advantages for future growth. The use of **TiDB** ensures that the backend can scale horizontally to handle millions of patient records without complexity, while maintaining MySQL protocol compatibility. Furthermore, the **Streamlit** framework showed that complex, interactive dashboards can be deployed rapidly with a minimal code, making the system highly maintainable and easy to extend with new modules in the future.

## 2.6 Disclosure of AI Utilization

To maximize development efficiency and ensure a modern user interface, the frontend component of this application was developed with the assistance of Generative AI tools.

While the core database logic and SQL architecture were designed based on the lab specifications, We selected the **Streamlit** framework for the frontend interface. As we had no prior experience with this specific library, AI assistance was utilized to generate the initial code for the UI components (e.g., sidebars, forms, and layout containers).

It is important to note that we made a concerted effort to analyze, debug, and fully understand the generated code. The in-depth technical explanations provided in [2.3 Implementation and Code Logic](#), along with the specific code snippets details, serve as evidence of our understanding of the codebase.

---

## 2.7 Appendices

### Project Repository and Source Code

To maintain the readability of this report, the full source code for the application is hosted in a public GitHub repository. This repository serves as the definitive source for the project's codebase, version history, and configuration files.

#### Repository Link:

<https://github.com/I-l-y-a-Z-z/DBMSApplicationLayerDeliverable6>

### Local Deployment and Database Replication

The repository includes all necessary files to replicate the project environment locally:

- **Comprehensive Documentation (README.md):** A detailed guide providing step-by-step instructions for setting up the Python virtual environment, installing dependencies via pip, and launching the Streamlit server.
- **Database Generation Script (query.sql):** A monolithic SQL script is provided to fully reconstruct the MNHS database schema and populate it with the hyper-realistic dataset described in this report. This allows the application to be tested in a local MySQL or TiDB environment without requiring access to the production cluster.

### Live Demonstration

For immediate testing and evaluation purposes, the application has been deployed to the Streamlit Cloud platform. This live instance connects directly to the production TiDB cluster, allowing users to interact with the full system functionality without the need for local installation or configuration.

#### Live Application URL:

<https://mnhslab6.streamlit.app>