UGANDA CHRISTIAN UNIVERSITY

Design and Implementation of a Database Application

HIV Patient Care & Treatment Monitoring System

Mukono General Hospital ART Clinic

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Contents

1 Introduction

Uganda continues to experience a significant HIV burden, with an estimated 1.49 million people living with HIV as of 2023 [2]. Despite national progress, many public hospitals, including Mukono General Hospital, still rely heavily on paper-based record systems for HIV patient management. Before the adoption of digital health systems, manual documentation made it difficult to trace treatment histories, monitor adherence, and ensure timely follow-up. After transitioning to digital systems, healthcare facilities benefit from improved decision-making and accurate data analytics.

The Government of Uganda's **National Development Plan IV (NDP IV)** emphasizes digital transformation within the health sector, including improvements in data quality, health information systems integration, and evidence-based decision-making [6]. Likewise, the project aligns with **SDG 3: Good Health and Well-being**, specifically Target 3.3 (ending AIDS) and 3.8 (universal health coverage) [4]. The Uganda Ministry of Health also highlights the importance of robust monitoring systems in its consolidated HIV/AIDS treatment guidelines [5].

This project implements a secure, optimized relational database system for HIV patient care and treatment monitoring. The solution demonstrates database programming principles including EER modeling, constraints, triggers, stored procedures, roles, security, views, and automation—fully satisfying all CSC2209 project milestones. A structured approach following best practices in database systems design [3] ensures the system meets real-world clinical and operational requirements.

2 Problem Statement

Mukono General Hospital ART Clinic manages a large and growing population of HIV-positive patients. Before automation, the existing paper-driven approach presented several operational challenges:

- Fragmented patient histories and difficulty tracking clinical outcomes over time.
- Lack of automated reminders for overdue viral load tests, missed appointments, and missed drug refills.
- Inefficiencies in compiling HMIS reports due to dispersed registers.
- Limited ability to enforce data integrity, resulting in transcription errors and incomplete records.
- Poor monitoring of adherence, opportunistic infections, and treatment response.

After implementing a structured database solution, these constraints can be addressed, improving continuity of care and strengthening HIV program outcomes.

3 SDG and NDP IV Alignment

3.1 SDG 3: Good Health and Well-Being

This project contributes to SDG 3 by:

- **SDG 3.3:** Enabling improved monitoring of viral load suppression and adherence, essential indicators for ending AIDS as a public health threat.
- **SDG 3.8:** Supporting universal health coverage through better information systems.
- **SDG 3.d:** Enhancing Uganda's capacity for early warning and risk reduction by using automated alerts and indicators.

3.2 Alignment with Uganda's NDP IV

NDP IV identifies digital health systems as a priority for strengthening national health services. This database system supports the plan through:

- Improved health information management.
- Digitization of clinical processes.
- Reduction of inefficiencies in patient monitoring.
- Support for data-driven decision-making.

4 Milestone One: Requirements Specification

4.1 Requirements Elicitation Methods

The following methods were applied:

1. Stakeholder interviews (clinicians, lab technicians, pharmacists, counselors).
2. Observation of ART clinic workflow.
3. Examination of Uganda MOH HMIS forms (HMIS 031, viral load request forms).
4. Review of Uganda MOH HIV treatment guidelines [5].

4.2 Functional Requirements

The system must:

- Register HIV patients with demographic and NIN details.
- Record clinical visits, WHO stage, TB screening, and clinical notes.
- Store laboratory results (VL, CD4, HB, Creatinine, RDT).
- Manage ART dispensing and calculate next refill dates.
- Track counseling sessions and adherence metrics.
- Automate alerts: high VL, missed appointments, low adherence, overdue VL.
- Provide role-based access control.
- Generate SQL-based dashboard reports.

4.3 Assumptions

- All patients can present valid NIN numbers.
- Staff have basic computer literacy.
- Facility maintains consistent electricity and local network connectivity.
- Uganda MOH standards define clinical data elements.

5 Milestone Two: EER Design

The EER model incorporates:

- **Generalization:** `person` → `patient`, `staff`.
- **Overlapping specialization:** staff can hold multiple system roles.
- **Categorization:** laboratory tests grouped by `test_type`.
- **Disjoint constraints:** patient status (Active, Transferred-Out, Dead, LTFU).
- **Inheritance:** staff and patient inherit person attributes.

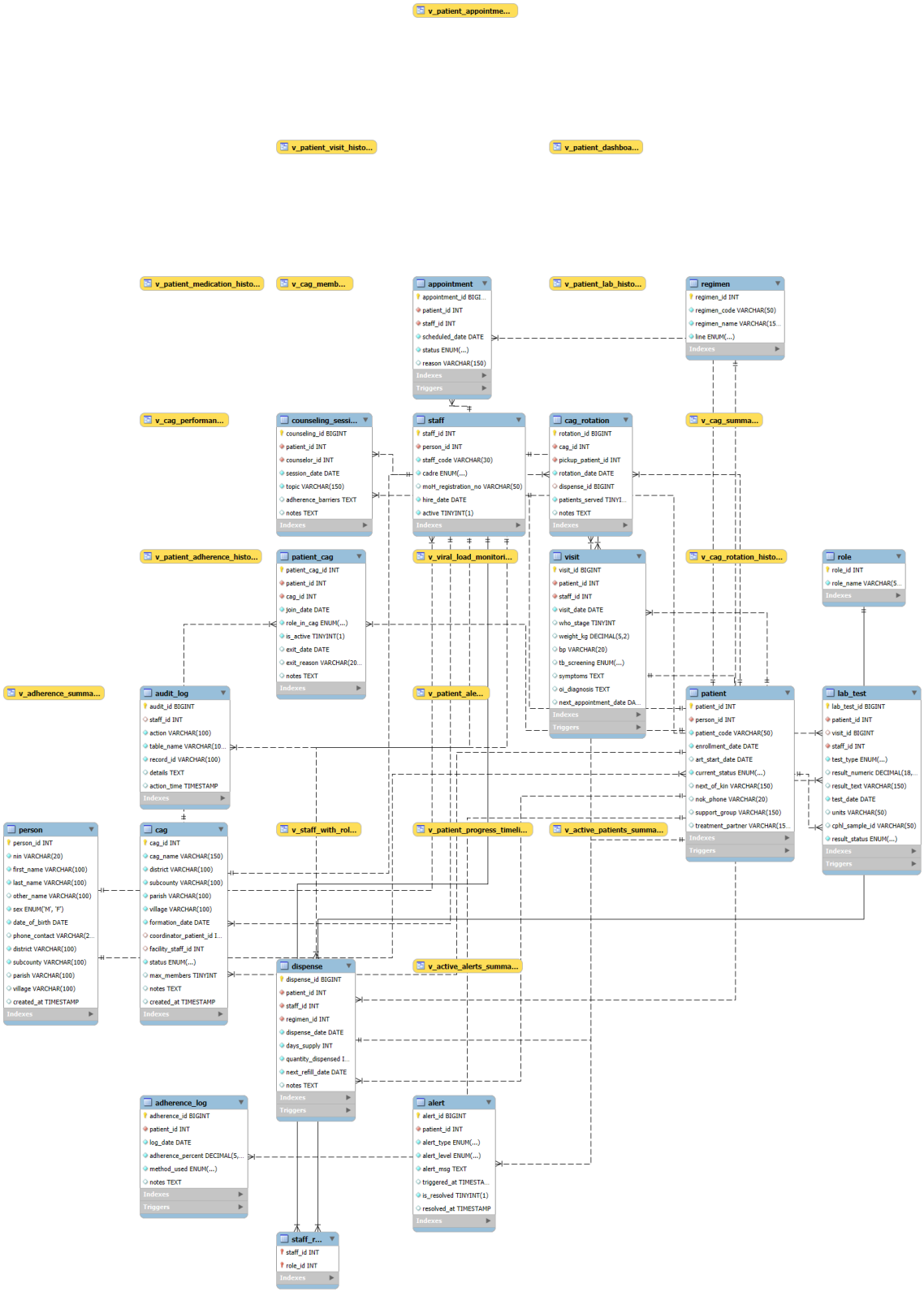


Figure 1: Enhanced Entity Relationship Diagram

6 Milestone Three: Database Development

6.1 Database Structure

The system includes 14 core tables:

- `person`
- `patient`
- `staff`, `role`, `staff_role`
- `visit`
- `lab_test`
- `regimen`
- `dispense`
- `appointment`
- `counseling_session`
- `adherence_log`
- `alert`
- `audit_log`

6.2 Data Validation

Validation techniques include:

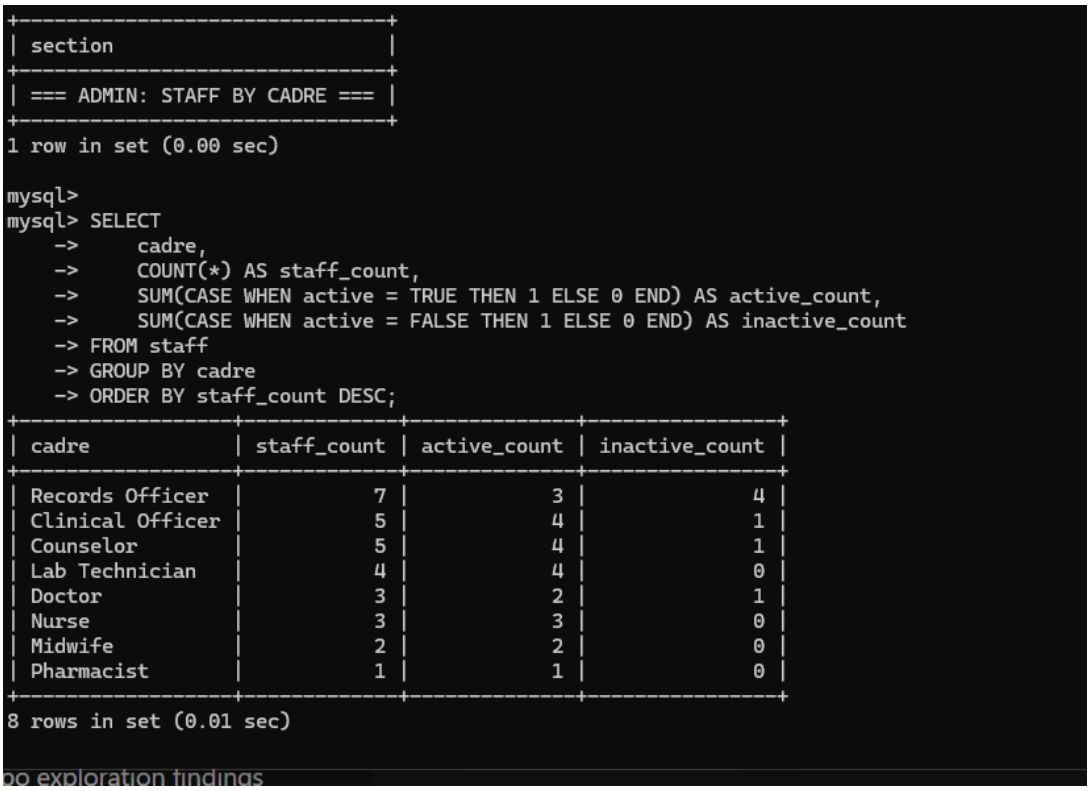
- CHECK constraints for numeric ranges (VL 0, adherence 0–100%).
- UNIQUE constraints: NIN, staff_code, patient_code.
- NOT NULL constraints on essential clinical fields.
- FOREIGN KEY constraints for referential integrity.
- ENUM definitions for standardized categories.

7 Milestone Four: Security and Automation

7.1 Role-Based Access Control

Roles include:

- db_admin
- db_clinician
- db_lab
- db_pharmacy
- db_counselor
- db_readonly



```
+------------------------------+
| section                      |
+------------------------------+
| === ADMIN: STAFF BY CADRE === |
+------------------------------+
1 row in set (0.00 sec)

mysql>
mysql> SELECT
    ->     cadre,
    ->     COUNT(*) AS staff_count,
    ->     SUM(CASE WHEN active = TRUE THEN 1 ELSE 0 END) AS active_count,
    ->     SUM(CASE WHEN active = FALSE THEN 1 ELSE 0 END) AS inactive_count
    -> FROM staff
    -> GROUP BY cadre
    -> ORDER BY staff_count DESC;
+-----------------+-------------+--------------+----------------+
| cadre           | staff_count | active_count | inactive_count |
+-----------------+-------------+--------------+----------------+
| Records Officer |           7 |            3 |              4 |
| Clinical Officer |           5 |            4 |              1 |
| Counselor       |           5 |            4 |              1 |
| Lab Technician  |           4 |            4 |              0 |
| Doctor          |           3 |            2 |              1 |
| Nurse           |           3 |            3 |              0 |
| Midwife         |           2 |            2 |              0 |
| Pharmacist      |           1 |            1 |              0 |
+-----------------+-------------+--------------+----------------+
8 rows in set (0.01 sec)

po exploration findings
```

Figure 2: Example Role-Based Staff Distribution Query

7.2 Stored Procedures

- `sp_compute_adherence`
- `sp_check_overdue_vl`
- `sp_mark_missed_appointments`

7.3 Triggers

- Trigger for high viral load alerts.
- Triggers for appointment and lab test audit logging.

7.4 Views

- `v_high_viral_load`
- `v_overdue_vl`
- `v_adherence_summary`

7.5 Backup Strategy

- Daily `mysqldump` backups.
- Weekly off-site copies.
- Binary logs for point-in-time recovery.
- Scripts available in project repository [1].

8 Milestone Five: Testing and Documentation

8.1 Testing Performed

- Validation of foreign keys and constraints.
- Verification of trigger execution.
- Accuracy checks on stored procedure outputs.
- View performance evaluation.

8.2 Documentation and Dissemination

This document constitutes the required examination submission. A full SQL dump and project slides accompany the final ZIP file.

9 Conclusion

Before digitalization, HIV patient monitoring at Mukono General Hospital faced persistent inefficiencies and data gaps. After applying structured database programming principles, this project successfully delivers a secure, scalable, and standards-aligned database application that enhances care quality, monitoring, and reporting. The database supports national goals under SDG 3 and Uganda's NDP IV, offering a robust model for digital health transformation.

References

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[6] National Planning Authority Uganda. National development plan iv (2024/25–2029/30), 2024. Digital Transformation and Health Systems Strengthening.