

**RV COLLEGE OF ENGINEERING®**  
**BENGALURU-560059**

(Autonomous Institution Affiliated to VTU, Belagavi)

**DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND  
MACHINE LEARNING**



**Vaccination Management System**

*Mini - Project Report*

*Submitted by*

**Chillale Naveen                      1RV22AI013**

**D Sai Siva Bhaswanth            1RV22AI016**

**Kota Vishnu Datta                1RV22AI024**

*in partial fulfillment for the requirement of 5<sup>th</sup> Semester*

***DBMS Laboratory (CD252IA)***

**Under the Guidance of**

**Dr. Vijayalakshmi.M.N**

**Associate Professor**

**Department of AIML**

**RV College of Engineering**

**Bengaluru-59**

**Academic Year**

**2024 - 2025**

**RV COLLEGE OF ENGINEERING®, BENGALURU – 560059**  
**(Autonomous Institution Affiliated to VTU, Belagavi)**

**DEPARTMENT OF ARTIFICIAL INTELLIGENCE AND  
MACHINE LEARNING**



**CERTIFICATE**

Certified that the project work titled ‘**Vaccination Management System**’ is carried out by **Chillale Naveen (1RV22AI013), D Sai Siva Bhaswanth(1RV22AI016), Kota Vishnu Datta(1RV22AI024)** who are bonafide students of RV College of Engineering, Bengaluru, in partial fulfillment of the curriculum requirement of 5<sup>th</sup> Semester Database Management Systems Laboratory Mini Project during the academic year **2024-2025**. It is certified that all corrections/suggestions indicated for the Internal Assessment have been incorporated in the report. The report has been approved as it satisfies the academic requirements in all respect laboratory mini-project work prescribed by the institution.

**Signature of Faculty In-charge**  
**Dr.Vijayalakshmi.M.N**

**Head of the Department**  
**Dept. of AIML, RVCE**

**External Examination**

**Name of Examiners**

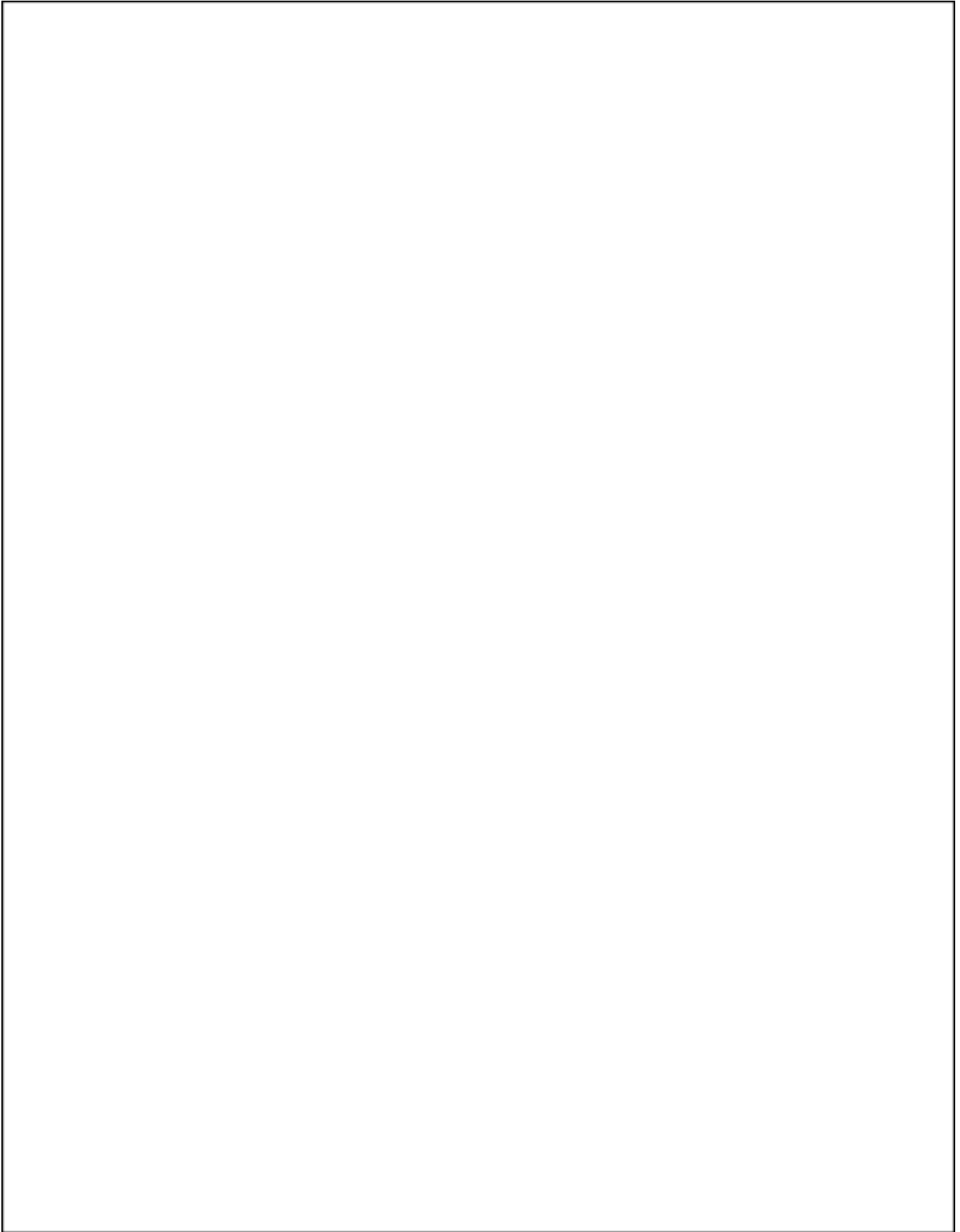
**Signature with date**

**1**

**2**

## Table of contents

Sl.No	Particulars	Page No.
1.	Introduction 1.1 Objective 1.2 Scope	1-2
2.	Software Requirement Specification	3-5
	2.1 Software Requirements 2.2 Hardware Requirements 2.3 Functional Requirements 2.4 Non Functional Requirements	
3.	Entity Relationship Diagram	6-8
4.	Detailed Design 4.1 DFD Level 0 4.2 DFD Level 1 4.3 DFD Level 2	9-13
5.	Relational Schema and Normalization	13-18
6.	Conclusion	19
7.	References	20-23
8.	Appendix: Snapshots	24-33



## Chapter 1: Introduction

Vaccination is a critical public health measure, protecting individuals from infancy to old age against various preventable diseases. With multiple vaccines required at different life stages—such as the MMR (Measles, Mumps, and Rubella) for children, the HPV vaccine for adolescents, and flu and shingles vaccines for the elderly—managing vaccination schedules is complex. Traditional methods using paper records or standalone systems are inefficient, leading to missed doses and incomplete immunisation. According to the World Health Organization, over 20 million children globally miss out on essential vaccines annually, and adult immunisation rates also remain suboptimal.

In India, immunisation coverage has seen improvements but still faces challenges. The National Family Health Survey indicates that overall vaccination coverage increased from 62.0% in 2015-16 to 76.6% in 2019-21. Despite these gains, disparities persist, especially among vulnerable populations. A study highlighted that vaccination coverage in India improved from 44% to 62% between 2006 and 2016; however, inequities continue among vulnerable groups, including tribal communities and migrant populations. Adult vaccination rates are notably low. For instance, among older adults, only 1.5% reported ever receiving an influenza vaccination, and a mere 0.6% had been vaccinated against pneumococcal disease.

This project aims to provide a unified platform to streamline vaccination management for all age groups, addressing these challenges and improving immunisation coverage across the nation.

### 1.1 Objectives

- Automate vaccination scheduling for all age groups, from infants to seniors.
- Provide personalised reminders and notifications to ensure timely vaccinations.
- Enable family health management by allowing users to track multiple profiles under one account.
- Implement real-time vaccine tracking to prevent shortages.
- Ensure data security through encryption and compliance with privacy regulations.

### 1.2 Scope

Comprehensive Vaccination Scheduling automates vaccine planning for all age groups, ensuring timely administration of vaccines such as BCG, DTP, and MMR for infants, HPV for adolescents, hepatitis and tetanus boosters for adults, and influenza, pneumococcal, and shingles vaccines for seniors. Personalized Notifications send reminders via SMS, email, or app alerts before scheduled doses, along with updates on

government immunization drives, booster dose requirements, and outbreak-specific vaccinations like COVID-19 and polio campaigns. Family Health Management enables users to maintain individualized digital records for multiple family members, allowing parents to track their children's vaccinations while also managing doses for elderly family members. Real-Time Vaccine Inventory Management integrates with hospital, clinic, and pharmacy databases to track stock levels, prevent shortages, and optimize cold chain logistics. It also alerts providers to expiring vaccines and assists in planning bulk procurement for vaccination drives. Enhanced Public Health Monitoring leverages AI-driven analytics and geographic mapping to identify regions with low immunization rates, demographic trends, and high-risk areas, supporting policy-making, outbreak prevention, and targeted vaccination campaigns, such as addressing low HPV vaccination rates in rural areas. Data Security ensures user data is encrypted using AES-256 encryption, stored securely on HIPAA and GDPR-compliant servers, and protected through multi-factor authentication (MFA) and role-based access control for healthcare providers.

## Chapter 2: Software Requirement Specification

### 2.1 Software Requirements

#### 2.1.1 Deployment Requirements:

- **Frontend:** HTML5, CSS3, JavaScript, and Bootstrap 5 for responsive user interfaces.
- **Backend:** Python 3.11 using the Flask 2.3 framework for API handling and server-side logic.
- **Database:** MySQL 8.0 for managing user, vaccine, and appointment data in a relational structure.
- **Security:** bcrypt 4.0 for secure password hashing, SSL/TLS 1.3 for encrypted communication over the network.

#### 2.1.2 Development Requirements

- **Frontend Development:** HTML, CSS, JavaScript, and optionally React for managing complex UI interactions.
- **Backend Development:** Python 3.11 with Flask, focusing on modular API design and flexible backend architecture.
- **Database Development:** MySQL 8.0, utilising tools like MySQL Workbench for effective database design and administration.
- **Data Analysis:** Pandas 2.1 and NumPy 1.26 for performing analytical operations on vaccination records and inventory management data.
- **Development Tools:** Visual Studio Code for coding and debugging.
- **Version Control:** Git 2.42 for source code management, with repository hosting on GitHub.

### 2.2 Hardware Requirements

#### 2.2.1 Deployment Requirements:

- **Processor:** Minimum Intel i5 10th Gen or AMD Ryzen 5 to efficiently handle backend processing.
- **RAM:** At least 8 GB for smooth handling of concurrent user connections and database queries.
- **Storage:** 250 GB SSD to enable fast data access and efficient storage management.

- **Network Speed:** 10 Mbps or higher for dependable data transfers and efficient user request handling.
- **Operating System:** Linux-based OS (preferably Ubuntu 22.04 LTS) or Windows Server 2019 for enhanced stability and compatibility.

### 2.2.2 Development Requirements:

- **Processor:** Minimum Intel i5 10th Gen or AMD Ryzen 5 for effective local server testing and backend operations.
- **RAM:** 8 GB or more to support multiple development tools, database connections, and local server testing.
- **Storage:** 250 GB SSD for quick access to project files, dependencies, and resources.
- **Operating System:** Windows 10, macOS, or Ubuntu 22.04 to allow development flexibility across different environments.

## 2.3 Functional Requirements

### 2.3.1 User Registration

**Input:** User details (name, contact, family member information, etc.)

**Process:** Create user accounts and store family member details in the system.

**Output:** Registered user profile, family member details.

### 2.3.2 Profile Management

**Input:** Personal details (age, gender, etc.)

**Process:** Create and manage profiles for family members with stored personal details.

**Output:** Family member profiles.

### 2.3.3 Vaccine Management

**Input:** Vaccine details (name, age group, schedule)

**Process:** Add, update, or delete vaccine information, including age-based schedules.

**Output:** Updated vaccine schedule, vaccine data.

### 2.3.4 Appointment Booking

**Input:** Vaccine choice, preferred time, user details

**Process:** Schedule appointments based on recommended vaccine schedules.

**Output:** Appointment confirmation, calendar updates.

### 2.3.5 Real-time Notifications

**Input:** Appointment date, contact details

**Process:** Generate and send notifications via email/SMS for upcoming vaccine



appointments.

**Output:** Reminder notifications via email/SMS.

### **2.3.6 Inventory Tracking**

**Input:** Inventory levels, expiry data

**Process:** Monitor vaccine stock levels, track expiry dates, and generate reorder alerts.

**Output:** Inventory updates, reorder alerts.

### **2.3.7 Reporting and Analytics**

**Input:** Vaccine coverage, appointment history, inventory data

**Process:** Generate detailed reports and visualizations of vaccination coverage and inventory status.

**Output:** Reports and visualizations.

## **2.4 Non Functional Requirements**

### **2.4.1 Scalability**

The system should handle a growing number of users and appointments without performance degradation.

**Requirement:** Must support up to 10,000 users concurrently.

### **2.4.2 Security**

Implement secure authentication and encryption of sensitive data.

**Requirement:** Use of SSL/TLS, bcrypt for password hashing, encryption of sensitive data.

### **2.4.3 Usability**

The system's UI should be user-friendly, with simple navigation and accessibility for all users.

**Requirement:** WCAG 2.1 AA standards compliance.

### **2.4.4 Reliability**

Ensure the system remains available with minimal downtime..

**Requirement:** 99.9% uptime, high availability configurations.

### **2.4.5 Performance**

The system should respond to user actions within 2-3 seconds for smooth interactions.

**Requirement:** Average response time under 3 seconds.

## Chapter 3: Entity Relationship Diagram

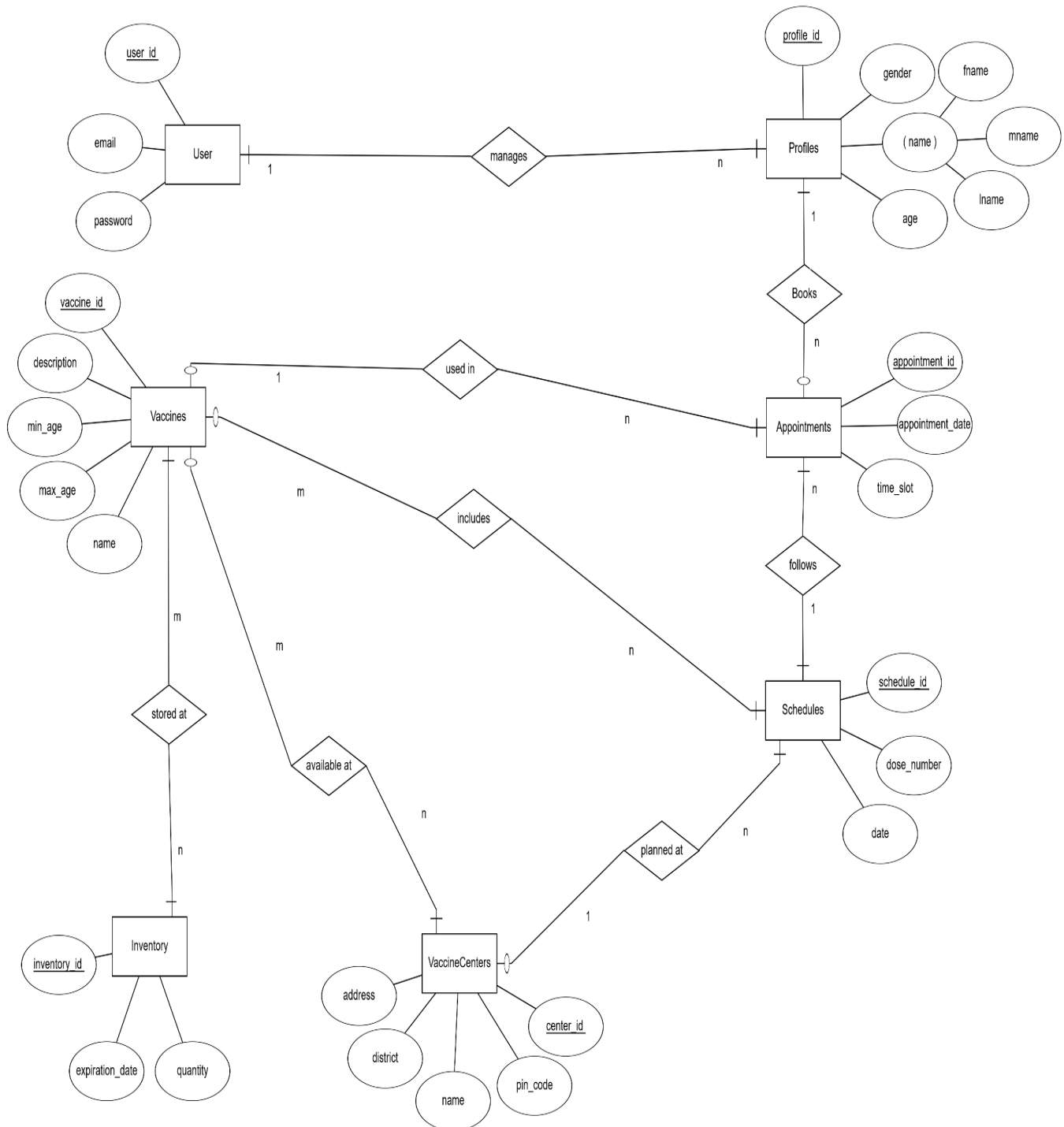


Figure 3.1 ER Diagram of Vaccine Management System

### 3.1 Entities and Attributes

#### 1.User

- Attributes: user\_id, email, password

#### 2.Profiles

- Attributes: profile\_id, gender, fname, mname, lname, age, user\_id

#### 3.Vaccines

- Attributes: vaccine\_id, description, min\_age, max\_age, name

#### 4.Inventory

- Attributes: inventory\_id, expiration\_date, quantity

#### 5.Appointments

- Attributes: appointment\_id, appointment\_date, time\_slot, vaccine\_id, profile\_id, schedule\_id

#### 6.Schedules

- Attributes: schedule\_id, date, dose\_number, centre\_id

#### 7.VaccineCentres

- Attributes: centre\_id, name, address, district, pincode

#### 8.Includes (for Vaccines ↔ Schedules)

- Attributes: vaccine\_id, schedule\_id

#### 9.Available at (for Vaccines ↔ VaccineCentres)

- Attributes: vaccine\_id, centre\_id

#### 10.Stored at (for Vaccines ↔ Inventory)

- Attributes: inventory\_id, vaccine\_id

### 3.2 Relationships

#### 1: n Relationships in Figure 3.1

##### 1.User → Profiles

- A user manages multiple profiles; each profile belongs to one user.

##### 2.Vaccines → Appointments

- A vaccine is part of multiple appointments; each appointment is associated with one vaccine.

##### 3.Profiles → Appointments

- A profile can book multiple appointments; each appointment is tied to one profile.

#### 4.Schedules → Appointments

- A schedule can include multiple appointments; each appointment is tied to one schedule.

#### 5.VaccineCentres → Schedules

- A vaccine center can have multiple schedules; each schedule is associated with one center.

### **m: n Relationships in Figure 3.1**

#### 1.Vaccines ↔ Schedules (Includes)

- A vaccine can be included in multiple schedules, and a schedule can include multiple vaccines.

#### 2.Vaccines ↔ VaccineCentres (Available at)

- A vaccine can be available at multiple centers, and a center can stock multiple vaccines.

#### 3.Vaccines ↔ Inventory (Stored at)

- A vaccine can be stored in multiple inventories, and an inventory can store multiple vaccines.

## Chapter 4: Detailed Design

### 4.1 Data Flow Diagram of Vaccine Management System - Level 0

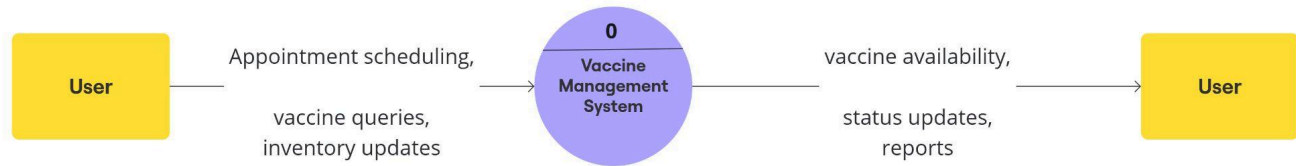


Figure 4.1 Data Flow Diagram of Vaccine Management System - Level 0

This level 0 diagram shows the highest-level view of the system where:

- Users can input requests for appointments, make queries about vaccines, and provide inventory updates
- The system processes these inputs and responds with information about vaccine availability, status updates of their requests, and generated reports
- All interactions between users and the system are shown as data flows (represented by arrows) in Figure 4.1
- This level 0 DFD establishes the system's boundaries and shows how external users interact with the system at its most basic level, without diving into the internal processes. It serves as a foundation for more detailed levels that would break down the internal workings of the Vaccine Management System.

## 4.2 Data Flow Diagram of Vaccine Management System - Level 1

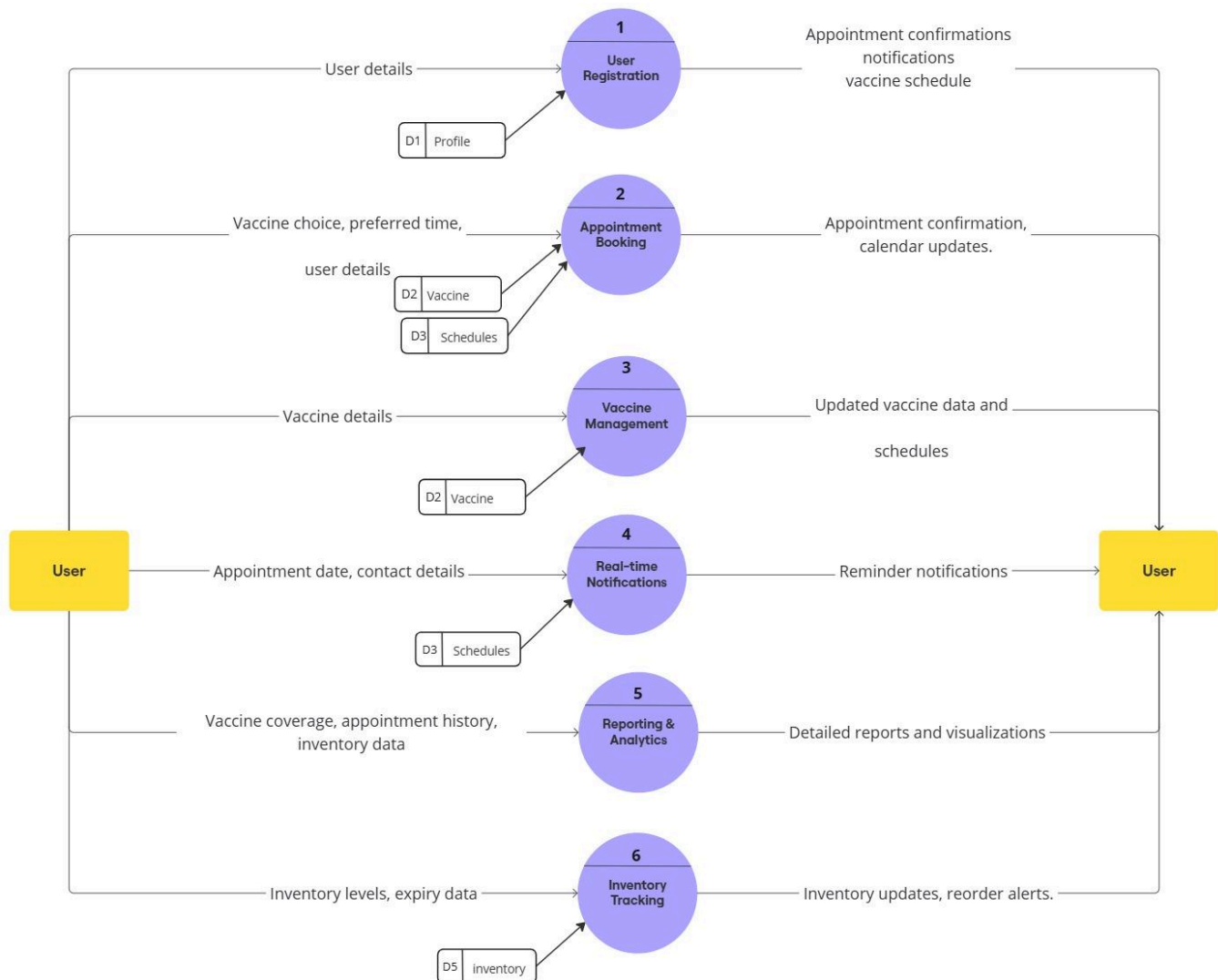


Figure 4.2 Data Flow Diagram of Vaccine Management System - Level-1

The Level 1 DFD of the Vaccine Management System provides a detailed breakdown of the core functionalities, showing how data flows between users and the system's major processes. This diagram refines the high-level context diagram into six interconnected processes, each handling specific tasks related to user registration, vaccine scheduling, inventory management, and reporting.

### User Registration (Process 1)

- Input: User details
- Output: Appointment confirmations, notifications, vaccine schedule
- Function: Handles new user registrations and profile management

#### Appointment Booking (Process 2)

- Input: Vaccine choice, preferred time, user details
- Output: Appointment confirmation, calendar updates
- Function: Manages the vaccination appointment scheduling system

#### Vaccine Management (Process 3)

- Input: Vaccine details
- Output: Updated vaccine data and schedules
- Function: Handles vaccine information and availability management

#### Real-time Notifications (Process 4)

- Input: Appointment date, contact details
- Output: Reminder notifications
- Function: Sends timely notifications and reminders to users

#### Reporting & Analytics (Process 5)

- Input: Vaccine coverage, appointment history, inventory data
- Output: Detailed reports and visualizations
- Function: Generates analytics and reports for system monitoring

#### Inventory Tracking (Process 6)

- Input: Inventory levels, expiry data
- Output: Inventory updates, reorder alerts
- Function: Monitors vaccine stock levels and manages inventory

#### Key Features:

- Each process has a unique number (1-6)
- Clear input and output data flows
- Single external entity (User) interacting with all processes
- Bi-directional flow of information between processes and users

This level shows how the system's main functions are divided into distinct processes while maintaining their interconnections through data flows. It provides a more detailed view than the context diagram while keeping the processes at a manageable level of abstraction.

### 4.3 Data Flow Diagram of Vaccine Management System - Level 2

This is a Level 2 DFD that further breaks down each main process from Level 1 into sub-processes:



Figure 4.3 Data Flow Diagram of Vaccine Management System - Level-2

User Registration Flow in Figure 4.3

- 1.1 Validate user details: Verifies input user information
- 1.2 Create and store user account: Processes verified data into user accounts
- 1.3 Link family member profiles: Associates family members with the main account  
Output: User profile and family member profiles



#### Appointment Booking Flow in Figure 4.3

- 2.1 User selects vaccine and preferred time: Captures initial booking preferences
- 2.2 System checks vaccine availability: Verifies slot availability
- 2.3 Confirm appointment and update calendar: Finalizes booking Output: Appointment confirmation and calendar updates

#### Vaccine Management Flow in Figure 4.3

- 3.1 Admin adds new vaccine data: Enters new vaccine information
- 3.2 Admin updates vaccine schedules: Modifies existing schedules
- 3.3 Admin deletes vaccine data if necessary: Removes outdated information Output: Updated vaccine data and schedules

#### Notification Flow in Figure 4.3

- 4.1 Send reminders: Initiates notification process
- 4.2 Notify schedule changes: Communicates updates
- 4.3 Update vaccine availability: Refreshes status Output: Reminder notifications

#### Reporting Flow in Figure 4.3

- 5.1 Generate detailed vaccination coverage reports: Creates initial reports
- 5.2 Analyze appointment history and inventory data: Processes data
- 5.3 Create visualizations for better understanding: Produces visual reports Output: Detailed reports and visualizations

#### Inventory Management Flow in Figure 4.3

- 6.1 Track inventory levels: Monitors stock
- 6.2 Monitor expiry dates: Tracks vaccine expiration
- 6.3 Alert for low stock: Generates warnings Output: Inventory updates and reorder alerts

#### Key Features:

- Each main process is broken down into three sub-processes
- Sequential flow within each group (x.1 → x.2 → x.3) in Figure 4.3
- Clear data flow between sub-processes
- Maintains connection to external entity (User)
- More detailed view of how each major function operates

This level provides the most granular view of the system's operations, showing exactly how each major function is accomplished through a series of smaller, more specific processes.

## Chapter 5: Relational Schema and Normalization

### 5.1 Relational Schema

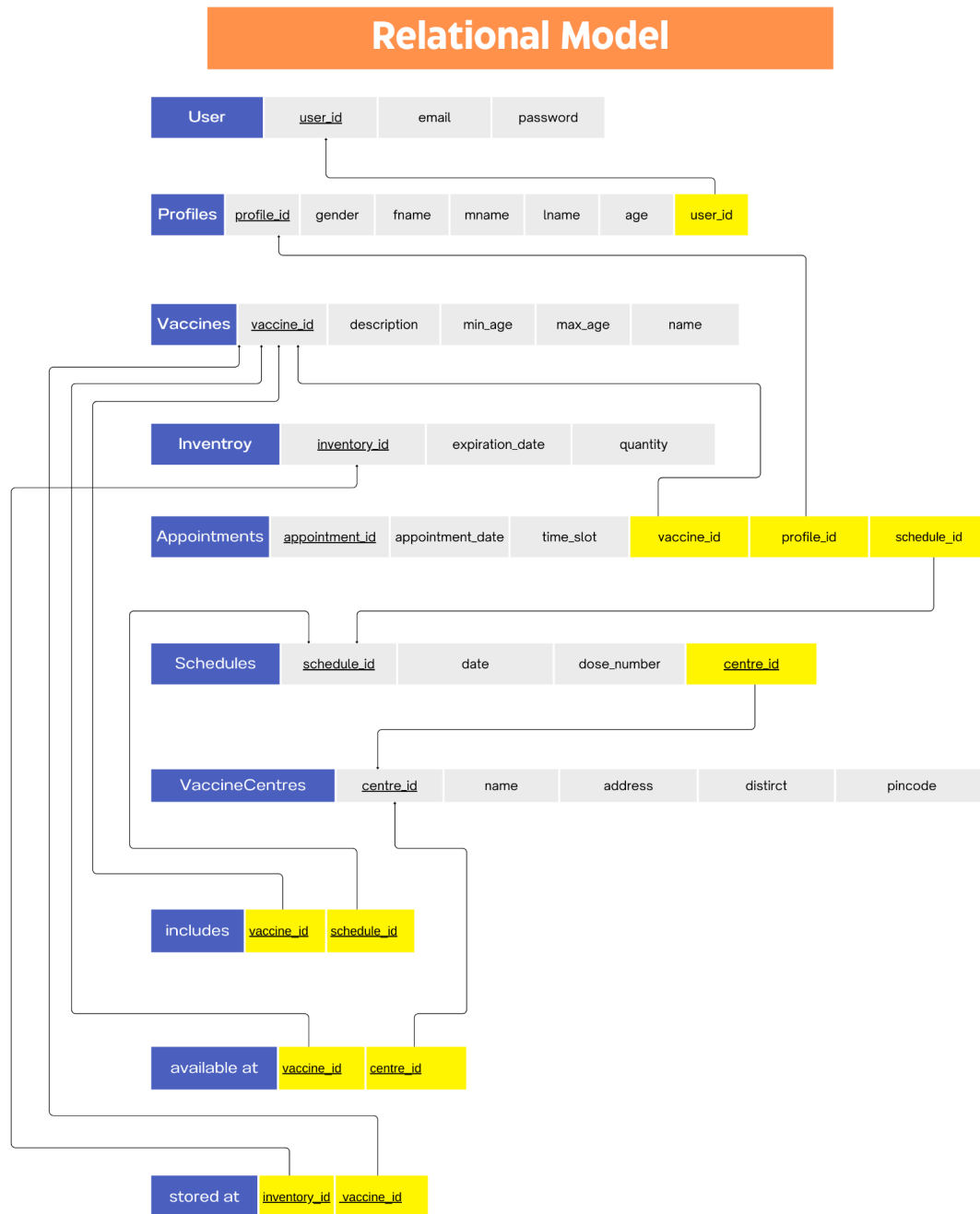


Figure 5.1 Relational Model of Vaccine Management System

**User**

- Primary Key: user\_id
- Fields: email, password
- Basic user authentication data

**Profiles**

- Primary Key: profile\_id
- Foreign Key: user\_id
- Fields: gender, fname, mname, lname, age
- Stores personal information

**Vaccines**

- Primary Key: vaccine\_id
- Fields: description, min\_age, max\_age, name
- Contains vaccine information

**Inventory**

- Primary Key: inventory\_id
- Fields: expiration\_date, quantity
- Tracks vaccine stock

**Appointments**

- Primary Key: appointment\_id
- Foreign Keys: vaccine\_id, profile\_id, schedule\_id
- Fields: appointment\_date, time\_slot
- Manages vaccination bookings

**Schedules**

- Primary Key: schedule\_id
- Foreign Key: centre\_id
- Fields: date, dose\_number
- Handles vaccination schedules

**VaccineCentres**

- Primary Key: centre\_id
- Fields: name, address, district, pincode
- Stores vaccination center details

**Junction Tables in Figure 5.1:****Includes**

- Foreign Keys: vaccine\_id, schedule\_id

- Links vaccines to schedules

available\_at

- Foreign Keys: vaccine\_id, centre\_id
- Maps vaccines to centers

stored\_at

- Foreign Keys: inventory\_id, vaccine\_id
- Connects inventory to vaccines

Key Relationships in Figure 5.1:

- One User can have multiple Profiles
- Appointments connect Profiles, Vaccines, and Schedules
- Schedules are linked to VaccineCentres
- Vaccines are tracked in Inventory
- Vaccines can be available at multiple centers
- Vaccines can be included in multiple schedules

This model in Figure 5.1 supports:

- User and profile management
- Vaccine inventory tracking
- Appointment scheduling
- Multiple vaccination centers
- Vaccine availability tracking
- Schedule management

The yellow highlighted fields indicate foreign keys, showing how the tables are interconnected to maintain referential integrity.

## 5.2 Normalization Tables

### 5.2.1 First Normal Form

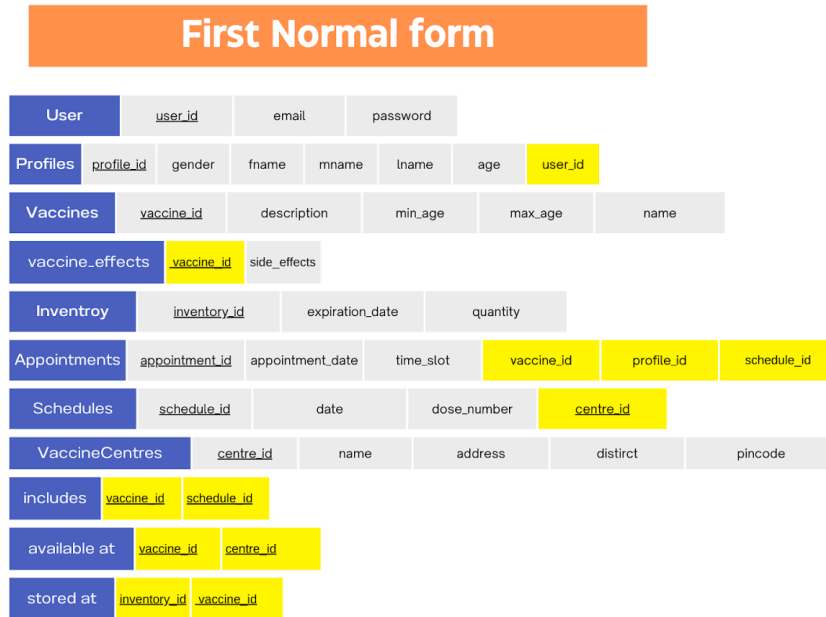


Figure 5.2 First Normal Form of Vaccine Management System

The side\_effects attribute in the Vaccines table is a multi-valued attribute (e.g., "fever, headache, fatigue"), which violates the rule of atomicity.(fig-5(b))

To bring the schema into 1NF, we decompose the Vaccines table by creating a new table called VaccineSideEffects. Each side effect is stored as a separate record.

### 5.2.2 Second Normal Form

For table: Appointments

Functional Dependencies (FDs) for Checking 2NF:

1.  $\text{appointment\_id} \rightarrow (\text{profile\_id}, \text{vaccine\_id}, \text{appointment\_date}, \text{time\_slot})$ 
  - The primary key appointment\_id uniquely determines all attributes.
2.  $(\text{profile\_id}, \text{vaccine\_id}) \rightarrow \text{appointment\_date}, \text{time\_slot}$ 
  - A profile cannot book the same vaccine at different times.

Checking for Partial Dependency:

- The primary key is appointment\_id (a single-column PK).
- Since no non-key attribute is dependent on part of a composite key (because there is no composite key here), Appointments is in 2NF.

Tables with single-column primary keys (e.g., Users, Vaccines, Inventory) are automatically in 2NF since no partial dependencies exist.

Many-to-many relationships (Includes, Available at, Stored at) ensure non-prime attributes depend on the full composite key (e.g., vaccine\_id, schedule\_id in Includes).

No partial dependencies were found.

### 5.2.3 Third Normal Form

Attributes in each table depend directly on the primary key.

For table: Profiles

Functional Dependencies (FDs):

$\text{profile\_id} \rightarrow (\text{fname}, \text{mname}, \text{lname}, \text{age}, \text{gender})$

- The primary key profile\_id uniquely determines all attributes.

Checking for Transitive Dependency:

- Each attribute (fname, mname, lname, age, gender) depends only on profile\_id.
- No attribute is dependent on another non-key attribute.
- No transitive dependency exists.

Profiles table satisfies 3NF.

Conclusion: All Tables Satisfy 3NF

- Profiles, Vaccines, and other tables have no transitive dependencies.
- Every attribute depends directly on the primary key.
- No transitive dependencies were identified in the schema.

Thus, the entire Vaccination Management System is in 3NF

## Chapter 6: Conclusion

The Vaccine Management System database is a well-structured and scalable solution designed to efficiently manage the vaccination process. By leveraging a relational model, the system ensures seamless data management across various interconnected entities, including Users, Profiles, Vaccines, Inventory, Appointments, Schedules, and Vaccine Centers. Additionally, junction tables such as Includes, Available\_At, and Stored\_At facilitate complex many-to-many relationships, ensuring accurate data representation and integrity.

This database design effectively supports core functionalities, including:

- **User Registration and Profile Management:** Enabling individuals to create accounts and manage multiple family members under a single user profile.
- **Vaccination Scheduling and Appointment Management:** Allowing users to book and track vaccination appointments while ensuring adherence to recommended vaccine schedules.
- **Inventory and Supply Chain Management:** Monitoring vaccine stock levels, expiration dates, and availability across multiple vaccination centers.
- **Vaccination Center Management:** Ensuring each center maintains an up-to-date record of available vaccines, appointment slots, and operational details.

To maintain data consistency and integrity, the system enforces proper primary and foreign key constraints, preventing anomalies and ensuring accurate record-keeping. The database architecture follows a normalized structure, eliminating redundancy and optimizing storage efficiency. Through structured data flow, the system efficiently handles processes at multiple levels:

1. **Context-Level Interactions:** Covering fundamental user operations such as profile creation, appointment booking, and vaccine information retrieval.
2. **Sub-Processes and Transactions:** Managing intricate backend operations like real-time inventory updates, schedule adherence tracking, and automated notification handling for upcoming vaccinations.

By implementing this robust and scalable database structure, the Vaccine Management System significantly enhances vaccine distribution, streamlines appointment scheduling, optimizes inventory control, and facilitates comprehensive reporting. This not only aids healthcare providers in effectively administering vaccination services but also ensures a user-friendly experience for individuals seeking vaccinations. Ultimately, the system plays a vital role in improving public health outcomes by promoting organized and accessible immunization services.

## Chapter 7: References

- [1] A. M. Mussa, A. M. Mremi, and A. A. Lyimo, "Assessment of vaccine management performance in health facilities of Mwanza Region, Tanzania," *PLOS Glob. Public Health*, vol. 3, no. 7, p. e0001612, Jul. 2023.
- [2] A. K. S. Kumar and S. S. Kumar, "Vaccine management system project report," *ResearchGate*, Apr. 2023.
- [3] S. Sripada, A. Jain, P. Ramamoorthy, and V. Ramamohan, "A decision support framework for optimal vaccine distribution across a multi-tier cold chain network," *arXiv*, Sep. 2021.
- [4] S. Dey, A. K. Kurbanzade, E. S. Gel, J. Mihaljevic, and S. Mehrotra, "Optimization modeling for pandemic vaccine supply chain management: A review and future research opportunities," *arXiv*, May 2023.
- [5] B. Abderrahmen and I. Almaraj, "A robust optimization approach model for a multi-vaccine multi-echelon supply chain," *arXiv*, Mar. 2024.
- [6] A. S. M. M. Mussa, A. M. M. Mremi, and A. A. Lyimo, "Vaccine management practices among healthcare workers in Morogoro Region, Tanzania," *J. Pharm. Policy Pract.*, vol. 15, no. 1, p. 96, Dec. 2022.
- [7] M. S. Hossain et al., "A reliable vaccine tracking and monitoring system for health clinics," *Sci. Rep.*, vol. 12, no. 1, p. 22029, Dec. 2022.
- [8] R. D. Mendonça et al., "BlockColdChain: Vaccine cold chain blockchain," *arXiv*, Apr. 2021.
- [9] A. K. S. Kumar and S. S. Kumar, "Vaccine management system," *Int. J. Res. Publ. Rev.*, vol. 3, no. 4, pp. 3669–3675, Apr. 2022.
- [10] Y. Zhang, X. Wang, and Y. Zhang, "A traceable vaccine supply management system," *Sensors*, vol. 22, no. 24, p. 9670, Dec. 2022.
- [11] G. Baralla, A. Pinna and G. Corrias, "Ensure traceability in European food supply chain by using a blockchain system," in *Proc. IEEE/ACM 2nd Int. Workshop Emerg. Trends Softw. Eng. Blockchain*, pp. 40-47, 2019.
- [12] R. M. Bani-Hani, Y. A. Wahsheh and M. B. Al-Sarhan, "Secure QR code system," in *Proc. 10th Int. Conf. Innovations Inf. Technol.*, pp. 1-6, 2014.
- [13] S. Zhang and J.-H. Lee, "Analysis of the main consensus protocols of blockchain," *ICT Exp.*, no. 6, pp. 93-97, 2020.
- [14] B. Sriman, S. Ganesh Kumar and P. Shamili, "Blockchain technology: Consensus protocol proof of work and proof of stake," in *Intelligent Computing and Applications. Advances in Intelligent Systems and Computing*, vol. 1172, Singapore: Springer, 2021.



- [15] J. Chen, X. Xia, D. Lo, J. Grundy, X. Luo and T. Chen, "Defining smart contract defects on Ethereum," *IEEE Trans. Softw. Eng.*
- [16] Y. Wu et al., "A Bitcoin transaction network analytic method for future blockchain forensic investigation," *IEEE Trans. Netw. Sci. Eng.*
- [17] C. Pop, T. Cioara, M. Antal, I. Anghel, I. Salomie and M. Bertoncini, "Blockchain-based decentralized management of demand response programs in smart energy grids," *Sensors*, vol. 18, no. 1, pp. 162, 2018.
- [18] C. Pop, T. Cioara, I. Anghel, M. Antal and I. Salomie, "Distributed ledger technology review and decentralized applications development guidelines," *Future Internet*, vol. 13, pp. 62, 2021.
- [19] A. A. Abd-alrazaq et al., "Mowafa Househ blockchain technologies to mitigate COVID-19 challenges: A scoping review," *Comput. Methods Programs Biomed. Update*, 2020.
- [20] C. Paris, "Supply-chain obstacles led to last month's cut to Pfizer's COVID-19 vaccine-rollout target," *Wall Street J.*, Dec. 2020.
- [21] C. Barnhill, *The COVID-19 Vaccine Supply Chain: Potential Problems and Bottlenecks*, United States: NC State Univ., Jan. 2020.
- [22] W. W. Gibbs, "This is how we'll vaccinate the world against COVID-19," *IEEE Spectr.*, Dec. 2020.
- [23] A. Chawla, "Counterpoint Technology Market Research," Dec. 2020.
- [24] N. Korin, "Using blockchain to monitor the COVID-19 vaccine supply chain," *World Economic Forum*, Nov. 2020.
- [25] C. Pop et al., "Blockchain-based scalable and tamper-evident solution for registering energy data," *Sensors*, vol. 19, 2019.
- [26] P. Ignaciuk and Ł. Wiczorek, "Continuous genetic algorithms in the optimization of logistic networks: Applicability assessment and tuning," *Appl. Sci.*, vol. 10, 2020.
- [27] M. J. Keeling and A. Shattock, "Optimal but unequitable prophylactic distribution of vaccine," *Epidemics*, vol. 4, no. 2, pp. 78-85, 2012.
- [28] A. Riewpaiboon et al., "Optimizing national immunization program supply chain management in Thailand: An economic analysis," *Public Health*, vol. 129, no. 7, pp. 899-906, 2015.
- [29] A. Asgary, M. M. Najafabadi, R. Karsseboom and J. Wu, "A drive-through simulation tool for mass vaccination during the COVID-19 pandemic," *Healthcare*, vol. 8, pp. 469, 2020.

- [30] Y. Yang, H. Bidkhori and J. Rajgopal, "Optimizing vaccine distribution networks in low and middle-income countries," *Omega*, vol. 99, 2021.
- [31] S. Enayati and O. Y. Özaltın, "Optimal influenza vaccine distribution with equity," *Eur. J. Oper. Res.*, vol. 283, no. 2, pp. 714-725, 2020.
- [32] S.-I. Chen, B. A. Norman, J. Rajgopal, T. M. Assi, B. Y. Lee and S. T. Brown, "A planning model for the WHO-EPI vaccine distribution network in developing countries," *IEE Trans.*, vol. 46, no. 8, pp. 853-865, 2014.
- [33] S. Zafar et al., "COVID-19: Current developments and further opportunities in drug delivery and therapeutics," *Pharmaceutics*, vol. 12, pp. 945, 2020.
- [34] H.-I. Shih, C.-J. Wu, Y.-F. Tu and C.-Y. Chi, "Fighting COVID-19: A quick review diagnoses therapies vaccines," *Biomed. J.*, vol. 43, no. 4, pp. 341-354, 2020.
- [35] M. Eisenstadt, M. Ramachandran, N. Chowdhury, A. Third and J. Domingue, "COVID-19 antibody test/vaccination certification: There's an app for that," *IEEE Open J. Eng. Med. Biol.*, vol. 1, pp. 148-155, 2020.
- [36] V. Chamola, V. Hassija, V. Gupta and M. Guizani, "A comprehensive review of the COVID-19 pandemic and the role of IoT Drones AI blockchain and 5G in managing its impact," *IEEE Access*, vol. 8, pp. 90225-90265, 2020.
- [37] S. P. Kaur and V. Gupta, "COVID-19 vaccine: A comprehensive status report," *Virus Res.*, vol. 288, 2020.
- [38] M. Rahia and A. Sharma, "Mass vaccination against COVID-19 may require replays of the polio vaccination drives," *EClinicalMedicine, Lancet*, vol. 25, Aug. 2020.
- [39] U. H. Kartoglu, K. L. Moore and J. S. Lloyd, "Logistical challenges for potential SARS-CoV-2 vaccine and a call to research institutions developers and manufacturers," *Vaccine*, vol. 38, no. 34, pp. 5393-5395, 2020.
- [40] "Race for a COVID-19 vaccine," *EBioMedicine Editorial, Lancet*, vol. 55, May 2020.
- [41] A. Haque and A. B. Pant, "Efforts at COVID-19 vaccine development: Challenges and successes," *Vaccines*, vol. 8, pp. 739, 2020.
- [42] E. Han et al., "Lessons learnt from easing COVID-19 restrictions: An analysis of countries and regions in Asia Pacific and Europe," *Lancet*, vol. 396, no. 10261, pp. P1525-P1534, Nov. 2020.
- [43] K. G. Andersen et al., "The proximal origin of SARS-CoV-2," *Nat. Med.*, vol. 26, pp. 450-452, 2020.
- [44] A. Rauf et al., "COVID-19 pandemic: Epidemiology etiology conventional and non-conventional therapies," *Int. J. Environ. Res. Public Health*, vol. 17, pp. 8155, 2020.

- [45] D. Cucinotta and M. Vanelli, "WHO declares COVID-19 a pandemic," *Acta Biomed.*, vol. 91, no. 1, pp. 157-160, 2020.
- [46] J. F. Ludvigsson, "Systematic review of COVID-19 in children shows milder cases and a better prognosis than adults," *Acta Paediatr.*, vol. 109, no. 6, pp. 1088-1095, 2020.
- [47] T. P. Velavan and C. G. Meyer, "The COVID-19 epidemic," *Trop. Med. Int. Health*, vol. 25, no. 3, pp. 278-280, 2020.
- [48] R. Li et al., "Substantial undocumented infection facilitates the rapid dissemination of novel coronavirus (SARS-CoV-2)," *Science*, vol. 368, no. 6490, pp. 489-493, 2020.
- [49] C. Wang, P. W. Horby, F. G. Hayden and G. F. Gao, "A novel coronavirus outbreak of global health concern," *Lancet*, vol. 395, no. 10223, pp. 470-473, 2020.
- [50] N. Zhu et al., "A novel coronavirus from patients with pneumonia in China, 2019," *N. Engl. J. Med.*, vol. 382, pp. 727-733, 2020.

## Chapter 8: Appendix

### 8.1 User Registration Form

Fields: Email, Password (with confirmation)

Validation:

- Email should be unique and properly formatted.
- Passwords must be at least 8 characters long and securely hashed before storage.
- Password confirmation must match the original password.

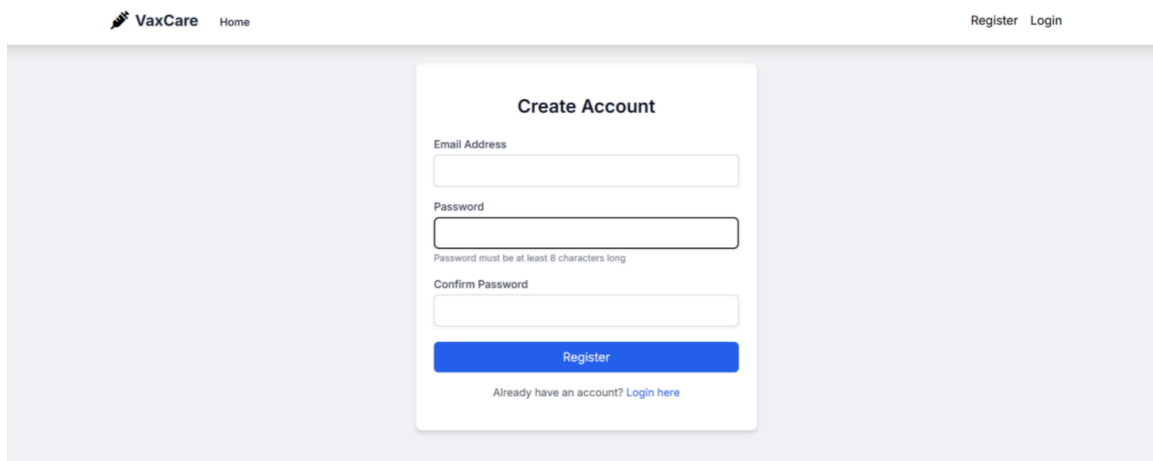
The image shows a web browser window with the VaxCare website. The header includes the VaxCare logo, a 'Home' link, and 'Register' and 'Login' links. The main content area features a 'Create Account' form. The form has three input fields: 'Email Address', 'Password', and 'Confirm Password'. Below the 'Password' field, there is a validation message: 'Password must be at least 8 characters long'. At the bottom of the form is a blue 'Register' button. Below the button, there is a link that says 'Already have an account? Login here'.

Figure 8.1 User Registration Form

### 8.2 Login Form

Fields: Email, Password

Validation:

- Checks if the email exists in the database.
- Verifies the password using `check_password_hash()`.
- Implements a login session using Flask-Login.

Pin		* user_id int	* email varchar(255)	* password varchar(255)
<input type="checkbox"/>	>	1	raj.kumar@gmail.com	ef92b778bafe771e89245b8f
<input type="checkbox"/>	>	2	priya.sharma@yahoo.com	80e9d0efe2d4f822c2ca5535
<input type="checkbox"/>	>	3	amit.patel@outlook.com	9dbd5c893b5b573a1aa909c
<input type="checkbox"/>	>	4	deepa.nair@gmail.com	a5c0a99db0e86a89c4ef411f
<input type="checkbox"/>	>	5	sandeep.reddy@yahoo.com	3eebce7ce845ba67d8c7f54f
<input type="checkbox"/>	>	6	meera.singh@gmail.com	ce4b0cd96cb2ec6375365a6
<input type="checkbox"/>	>	7	karthik.krishnan@outlook.co	a33cb7341360732bb1076ff
<input type="checkbox"/>	>	8	anita.desai@yahoo.com	a4bf3076cec9eea14ab0925f
<input type="checkbox"/>	>	9	vikram.mehta@gmail.com	b97726c7eb811b67eb0597f
<input type="checkbox"/>	>	10	lakshmi.iyer@outlook.com	196062a3f1bc539a6360ddd
<input type="checkbox"/>	>	11	new1801@vax.com	scrypt:32768:8:1\$X8oCvtGfe

Figure 8.2 Login Form

### 8.3 Profile Management Form

Fields: First Name, Middle Name, Last Name, Age, Gender

Validation:

- Name fields must only contain alphabetic characters.
- Age must be a positive integer.

Edit Profile

First Name

Middle Name (Optional)

Last Name

Age

Gender

Figure 8.3 Profile Management Form

## 8.4 Dashboard Form

Fields: Profile List, Upcoming Appointments, Recent Activity, Logout Button

Validation:

- Displays only the logged-in user's profiles and appointments.
- Ensures that users can only interact with their own data.

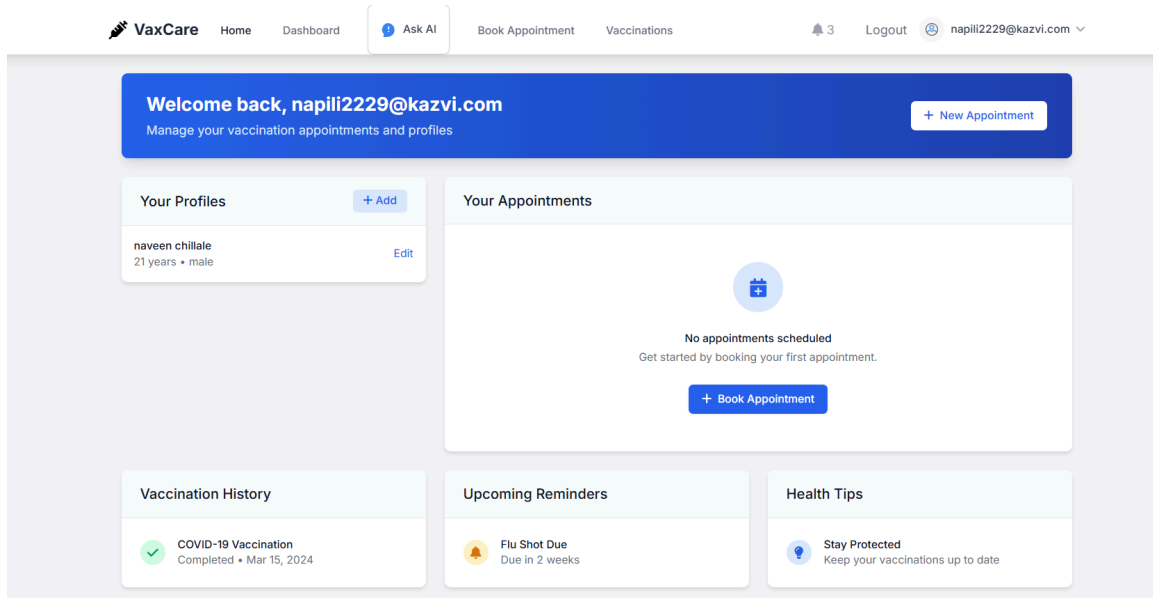


Figure 8.4 Dashboard Form

## 8.5 Appointment Booking Form

Fields: Profile Selection, Schedule Selection, Vaccine Selection, Time Slot

Validation:

- Profile selection must belong to the logged-in user.
- Selected schedule must be available.
- Selected vaccine must be available in the chosen schedule.
- Time slot must have available booking slots.

**VaxCare** Home Dashboard **Ask AI** Book Appointment 3 Logout new1801@vax.com

1 Profile 2 **Schedule** 3 Confirmation

**Schedule Your Appointment**

By Schedule By Vaccine

Select Date & Location: January 25, 2025 - Banashankari Hospital

Select Vaccine: Japanese Encephalitis (JE)-1

Select Time:

09:00	09:30	10:00	10:30
11:00	11:30	12:00	12:30
13:00	13:30	14:00	14:30

Figure 8.5 Appointment Booking Form

## 8.6 Chatbot Assistance

Fields: Chat Input Box, AI Response Display, Profile Context Selection (Optional)

Validation:

- Only registered users can interact with the chatbot.
- AI provides responses based on available user data.

**VaxCare** Home Dashboard **Ask AI** Book Appointment Vaccinations 3 Logout chillalaven@gmail.com

**VaxCare Assistant**  
Chat with our AI to manage your vaccination needs

**Quick Help**

- Book Appointment
- Create Profile
- View Appointments
- Vaccine Information

Hello! I'm your VaxCare assistant. I can help you with booking appointments, managing profiles, and answering your vaccination-related questions. How can I assist you today?

hi

Hello and welcome to the VaxCare vaccination management system. I'm happy to assist you with any questions or concerns you may have regarding vaccinations, appointments, or vaccination centers. To get started, I can help you with the following: 1. Viewing available vaccines and their descriptions 2. Finding vaccination centers near you 3. Checking your upcoming appointments (if any) 4. Creating a new profile or managing an existing one 5. Answering general questions about vaccines Please let me know how I can assist you today. You are currently logged in as chillalaven@gmail.com. If you need to switch to a different account, please let me know and I can guide you through the process. What would you like to do first?

create profile

To create a profile, you will need to provide some basic information about yourself. Here's a step-by-step guide to create your profile: 1. **Name**: Please provide your first and last name. 2. **Date of Birth** (YYYY-MM-DD): Enter your date of birth in the format YYYY-MM-DD. 3. **Email** (chillalaven@gmail.com): Your email address is already associated with your account. 4. **Phone Number**: Please provide your phone number. 5. **Address**: Enter your address, including district and pincode. Once you have this information, you can proceed to create your profile. Please note that all fields are required. Please respond with the above details to create your profile. Format of response: Name: [Your Name] Date of Birth: [YYYY-MM-DD] Phone Number: [Your Phone Number] Address: [Your Address], District: [Your District], Pincode: [Your Pincode] After receiving this information, I will guide you further on how to save this data and create your profile.

Figure 8.6 Chatbot Assistance

## 8.7 Digital Vaccination Certificate

Fields: Certificate ID, Beneficiary Name, DOB, Gender, Vaccine Name, Date of Vaccination, QR Code

Validation:

- Certificate must belong to the logged-in user.
- QR Code must be valid and scannable for verification.


Government of India Ministry of Health & Family Welfare		Official Vaccination Record Digital Certificate	
<b>DIGITAL VACCINATION CERTIFICATE</b>			
<b>Personal Information</b>			
Certificate ID:	IND/COV/00000027		
Beneficiary Name:	Aditi Rao		
Date of Birth:	01/01/2004		
Gender:	FEMALE		
Unique Health ID:	IN00000000027		
<b>Vaccination Details</b>			
Vaccine Name:	Pentavalent-1		
Description:	Administered at 6 weeks. Dose: 0.5 ml. Route: Intra-muscular. Site: Antero-lateral side of mid-thigh.		
Batch Number:	BATCH-0005		
Dose Number:	Dose 1		
Date of Vaccination:	25/01/2025		
Vaccination Center:	Banashankari Hospital		
Center Address:	50 Feet Road, 3rd Stage Banashankari - 560085		
			
		Scan to Verify Authenticity	
<b>OFFICIAL DOCUMENT - NOT TRANSFERABLE</b>			
<small>* This is a mock certificate generated for educational purposes as part of a DBMS project demonstration. Not valid for official use. For demonstration purposes only. Certificate Generated on: 04-02-2025 00:25:27</small>			

Figure 8.7 Digital Vaccination Certificate



## 8.8 Admin Dashboard

Fields: Vaccine Management, Schedule Management, Center Management, Inventory Tracking

Validation:

- Only admin users can access the dashboard.
- Input fields must follow predefined constraints (e.g., valid dates, numbers).

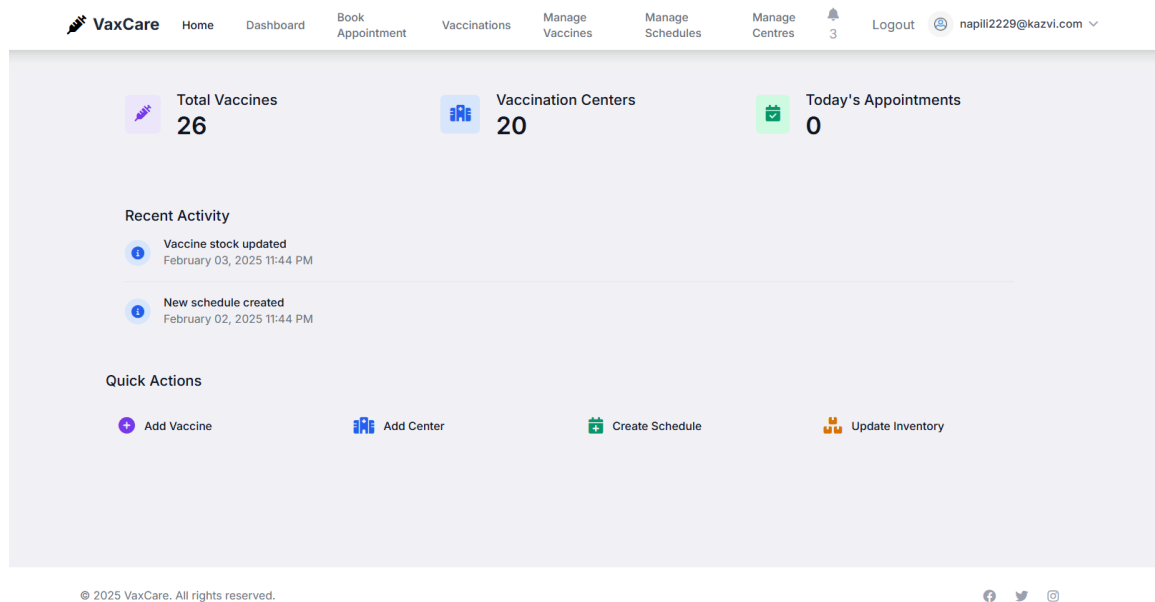


Figure 8.8 Admin Dashboard

## 8.9 Vaccine Management

Fields: Vaccine Name, Description, Minimum Age, Maximum Age

Features:

- Add new vaccines
- Edit existing vaccine details
- Delete vaccines
- Track vaccine information (name, description, age restrictions)

Validations:

- Only admin users can access vaccine management
- Vaccine cannot be deleted if associated with existing schedules
- Age restrictions enforced for vaccines

**Manage Vaccines**

**Add New Vaccine**

Vaccine Name

Description

Minimum Age

Maximum Age

**Add Vaccine**

**Existing Vaccines**

NAME	DESCRIPTION	AGE RANGE	ACTIONS
Bacillus Calmette Guerin (BCG)	Administered at birth or as early as possible till one year of age. Dose: 0.1ml (0.05ml until 1 month age). Route: Intra-dermal. Site: Left Upper Arm.	0 - 12 weeks	<a href="#">Edit</a> <a href="#">Delete</a>

Figure 8.9 Vaccine Management

## 8.10 Schedule Management

Fields: Date, Dose Number, Vaccination Centre, Associated Vaccines

Features:

- Create vaccination schedules
- Edit existing schedules
- Delete schedules
- Associate multiple vaccines with a schedule
- Manage dose numbers

Validations:

- Admin and Vaccine Admin can access schedule management
- Schedules cannot be deleted if appointments exist
- Date validation

DATE	CENTER	VACCINES	DOSE NUMBER	ACTIONS
2025-01-15	Indiranagar Health Center	Bacillus Calmette Guerin (BCG) Oral Polio Vaccine (OPV)-0 Hepatitis B birth dose	1	
2025-01-15	Koramangala PHC	Oral Polio Vaccine (OPV)-1 Pentavalent-1 Rotavirus Vaccine (RVV)-1	2	
2025-01-16	Jayanagar General Hospital	Fractional dose of Inactivated Polio Vaccine (fIPV)-1 Pneumococcal Conjugate Vaccine (PCV)-1 Oral Polio Vaccine (OPV)-2	1	
2025-01-16	JP Nagar Health Center	Pentavalent-2 Rotavirus Vaccine (RVV)-2 Oral Polio Vaccine (OPV)-3	2	
2025-01-17	Whitefield Medical Center	Pentavalent-3 Fractional dose of Inactivated Polio Vaccine (fIPV)-2 Rotavirus Vaccine (RVV)-3	1	
2025-01-17	Malleswaram Clinic	Pneumococcal Conjugate Vaccine (PCV)-2 Measles & Rubella (MR)-1 Japanese Encephalitis (JE)-1	2	

Figure 8.10 Schedules Management

## 8.11 Vaccination Centre Management

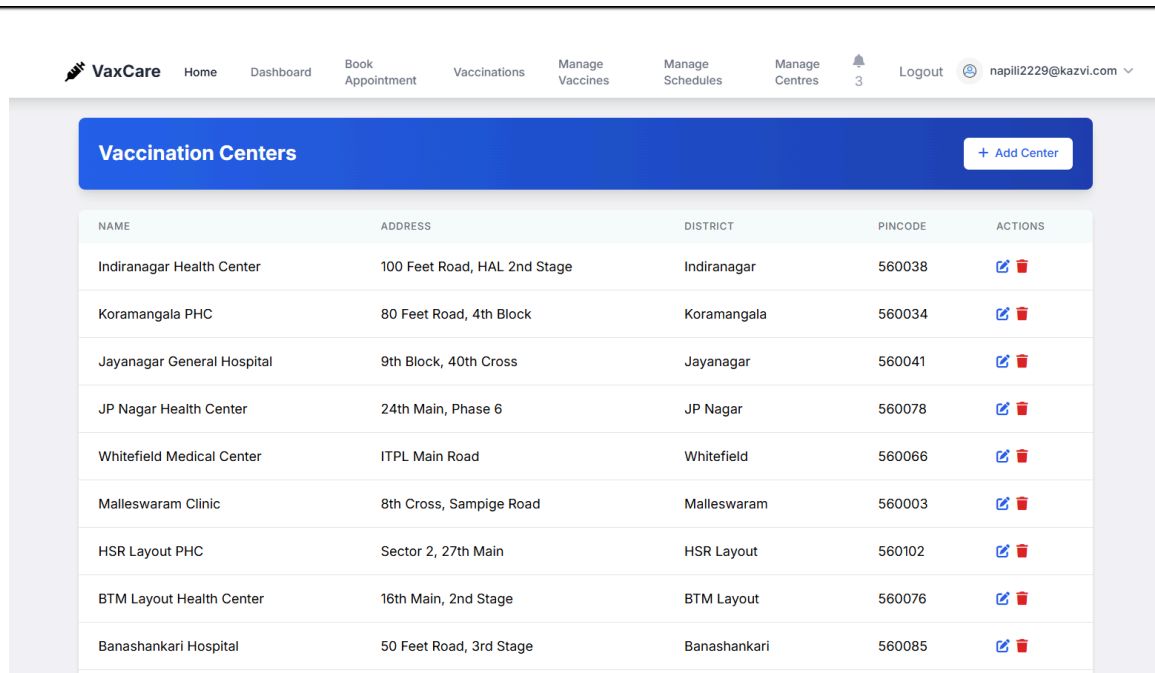
Fields: Centre Name, Address, District, Pincode.

Features:

- Add new vaccination centres
- Edit centre details
- Delete centres
- Track centre information

Validations:

- Only admin users can access centre management
- Centres cannot be deleted if associated with schedules



NAME	ADDRESS	DISTRICT	PINCODE	ACTIONS
Indiranagar Health Center	100 Feet Road, HAL 2nd Stage	Indiranagar	560038	
Koramangala PHC	80 Feet Road, 4th Block	Koramangala	560034	
Jayanagar General Hospital	9th Block, 40th Cross	Jayanagar	560041	
JP Nagar Health Center	24th Main, Phase 6	JP Nagar	560078	
Whitefield Medical Center	ITPL Main Road	Whitefield	560066	
Malleswaram Clinic	8th Cross, Sampige Road	Malleswaram	560003	
HSR Layout PHC	Sector 2, 27th Main	HSR Layout	560102	
BTM Layout Health Center	16th Main, 2nd Stage	BTM Layout	560076	
Banashankari Hospital	50 Feet Road, 3rd Stage	Banashankari	560085	

Figure 8.11 Vaccination Centers Management

## 8.12 Authentication & Authorization

User Authentication: Implemented via Flask-Login.

Role-Based Access Control (RBAC):

- Users: Can book and manage appointments.
- Admins: Manage vaccines, centers, and schedules.
- Vaccine Admins: Handle vaccine-related operations.

```
# User Roles Constants
ROLE_USER = 'user'
ROLE_ADMIN = 'admin'
ROLE_VACCINE_ADMIN = 'vaccine_admin'

# Admin email list
ADMIN_EMAILS = ['admin@example.com']
VACCINE_ADMIN_EMAILS = ['vaccine_admin@example.com']
```

Figure 8.12 Authentication and Authorization

### 8.13 Password Security

Storage: Passwords are hashed using `generate_password_hash()`.

Verification: Passwords are checked using `check_password_hash()`.

```
hashed_password = generate_password_hash(password)
new_user = User(email=email, password=hashed_password)
db.session.add(new_user)
db.session.commit()
```

Figure 8.13 Password Security

### 8.14 Error Handling

Flask error handlers are implemented for 404 (Not Found) and 500 (Server Error).

`try-except` blocks handle unexpected errors gracefully.

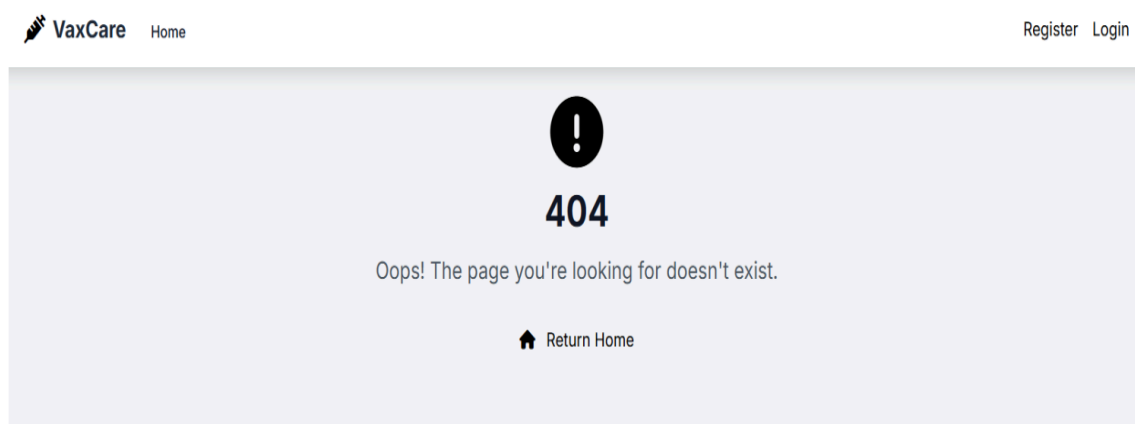


Figure 8.14 Error Handling