IARJSET ISSN (O) 2393-8021, ISSN (P) 2394-1588

International Advanced Research Journal in Science, Engineering and Technology

Impact Factor 8.311 ⁜ Peer-reviewed & Refereed journal ⁜ Vol. 13, Issue 3, March 2026

DOI: 10.17148/IARJSET.2026.13322

Smart Pharmaceutical Medical Inventory System Using Secure OTP-Based Authentication

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Abstract: The Smart Pharmaceutical Medical Inventory System is a digital platform designed to manage and monitor medicine stock in clinics, hospitals, and pharmacies in a secure and organized manner. The system separates inventory into two categories, namely General Medicines and Cardio Medicines, to provide stricter control over sensitive cardiovascular drugs. Security is enforced through a two-step authentication mechanism involving standard login credentials followed by a One-Time Password (OTP) sent to the registered email or phone of the authorized user. Core functionalities include adding medicines, updating stock quantities, soft delete support for cardio medicines, generating low stock alerts, monitoring expiry dates, and maintaining a complete transaction and activity log. The system is built on a relational database with six primary tables and provides a scalable, accountable, and efficient solution for pharmaceutical inventory management.

Keywords: Medical Inventory, OTP Authentication, Pharmaceutical System, Cardio Medicines, Low Stock Alert, Expiry Monitoring, Transaction Logging, Database Management, BSc Information Technology.

I. INTRODUCTION

Medicine inventory management is a critical operational function in any healthcare institution. Hospitals, clinics, and pharmacies maintain large quantities of medicines that must be tracked accurately to prevent stockouts, wastage from expiry, and unauthorized access. Traditional manual methods of recording medicine stock are error-prone, time-consuming, and difficult to audit. There is an urgent need for a digital system that automates these tasks while maintaining data integrity and security [1].

The Smart Pharmaceutical Medical Inventory System addresses these challenges by providing a web-based platform where authorized personnel can manage medicine stock in real time. The system introduces OTP-based two-factor authentication to ensure that only verified users can perform sensitive operations such as updating or deleting stock records. This is particularly important for cardio medicines, which are regulated and require careful monitoring due to their direct impact on patient safety [2].

A. Problem Statement

Existing inventory systems in many small and mid-sized healthcare facilities lack proper access control, automated alerts, and traceability. Medicines are frequently misplaced, duplicated, or used beyond their expiry dates due to poor record-keeping. Cardio medicines, which carry higher risk and regulatory requirements, are often managed using the same basic methods as general medicines, leading to compliance issues and patient safety concerns [3].

B. Objectives

To design and implement a secure, OTP-authenticated inventory management system for pharmaceutical use. To separate inventory into General Medicines and Cardio Medicines for specialized control. To automate low stock alerts and expiry date monitoring to prevent operational gaps. To maintain a complete audit trail of all inventory transactions for accountability.

II. SIGNIFICANCE OF THE SYSTEM

This project presents the design and implementation of a Smart Pharmaceutical Medical Inventory System secured by OTP-based authentication. The Related Work is discussed in Section III, System Architecture in Section IV, Core Functionalities in Section V, Database Design in Section VI, Transaction Logging in Section VII, Results in Section VIII, and Conclusion in Section IX.

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III. RELATED WORK

Several prior studies have explored digital solutions for pharmaceutical inventory management. Bhatia and Kumar [3] proposed an automated pharmaceutical inventory management system using RFID and IoT, demonstrating significant improvements in stock accuracy. Their work highlighted the importance of real-time tracking but lacked a robust authentication layer for sensitive drug categories.

Anderson [4] provided comprehensive coverage of security engineering principles applicable to healthcare information systems, emphasizing the need for multi-factor authentication when handling sensitive medical records.

IV. SYSTEM ARCHITECTURE

The system is organized into four functional layers as illustrated in Figure 1. The User Interface Layer provides the admin dashboard, stock management panel, expiry monitoring view, and reports module. The Authentication Layer handles credential verification and OTP generation and validation. The Core Processing Layer executes business logic including add, update, delete, and alert operations. The Database Layer stores all data across six relational tables.

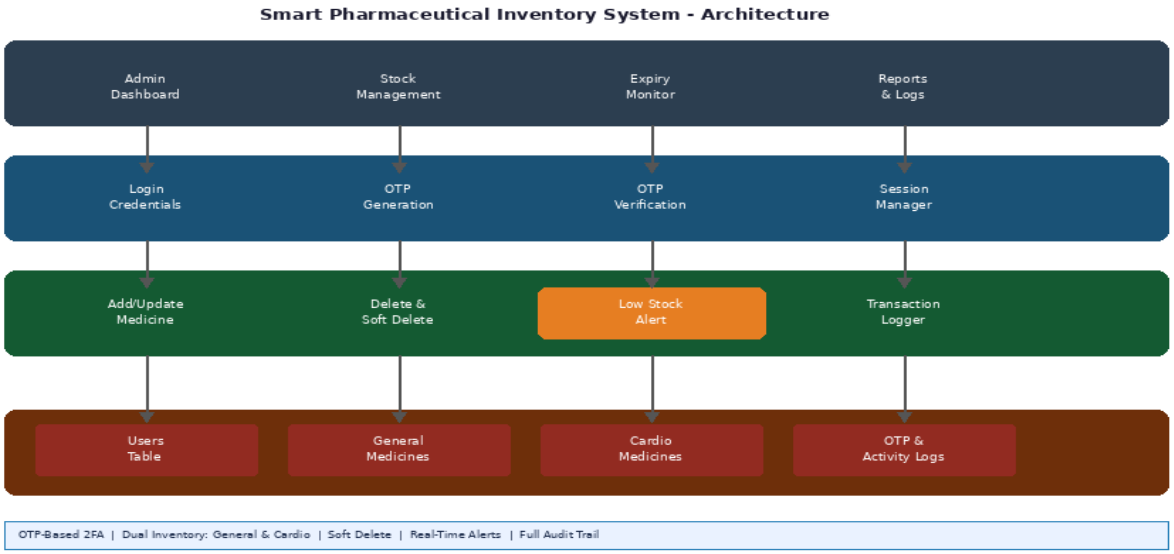

Fig. 1 Smart Pharmaceutical Inventory System - Four-Layer Architecture

A. Technology Stack

Component	Technology Used
Frontend Interface	HTML, CSS, JavaScript
Backend Processing	Python (Flask) / PHP
Database	MySQL / SQLite
OTP Delivery	SMTP Email / SMS Gateway
Authentication	Session-Based with OTP 2FA
Hosting	Local Server / XAMPP

B. Security Design

All passwords are stored as hashed values using bcrypt. OTPs are time-limited to five minutes and become invalid after three failed attempts to prevent brute-force attacks. Every login, OTP event, and inventory action is recorded in the Activity Logs and OTP Logs tables, ensuring a complete and tamper-evident audit trail for review by administrators and auditors [4].

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V. OTP AUTHENTICATION MECHANISM

The system employs a two-factor authentication process to verify the identity of users before granting access to sensitive inventory operations. The first factor is a standard username and password login. Upon successful credential verification, a six-digit OTP is automatically generated and dispatched to the registered email address or phone number of the user. The user must then enter this OTP within the validity window to complete authentication [5].

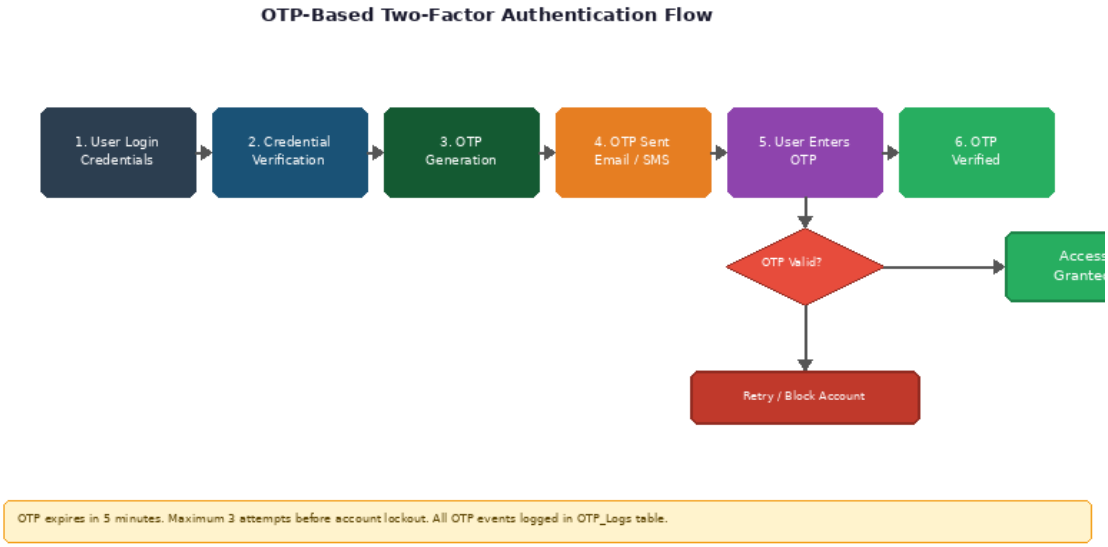

Fig. 2 OTP-Based Two-Factor Authentication Flow with Decision Logic

A. OTP Generation and Validation

A random six-digit numeric code is generated server-side using a cryptographically secure random number generator. The OTP, along with its creation timestamp and expiry timestamp, is stored in the OTP_Logs table linked to the user record. When the user submits the OTP, the system checks the code against the stored value and verifies that the current time is within the five-minute validity window. Expired or incorrect OTPs are rejected and the event is logged.

B. OTP Delivery Channels

Channel	Method	Delivery Time
Email	SMTP via registered email address	Under 30 seconds
SMS	SMS Gateway API to registered phone	Under 15 seconds
Fallback	Admin resend option available	On demand

VI. CORE INVENTORY FUNCTIONALITIES

The system provides a comprehensive set of inventory management operations accessible through the admin dashboard. All write operations including stock updates and deletions require OTP confirmation before execution to prevent unauthorized modifications. Separate management workflows are maintained for general medicines and cardio medicines to reflect their different handling requirements [6].

A. Add Medicine

Authorized administrators can add new medicines by entering: medicine name, batch number, quantity, expiry date, supplier name, unit price, and reorder level threshold. General medicines are inserted into the General_Medicines table while cardio medicines are inserted into the Cardio_Medicines table. All fields are validated before the record is committed to the database.

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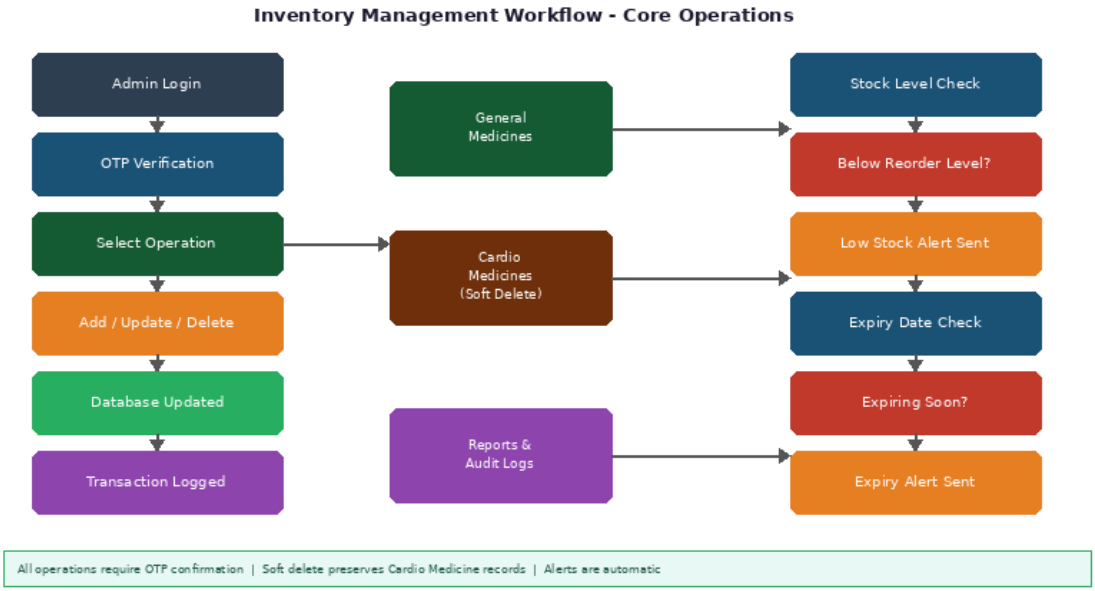

Fig. 3 Core Inventory Management Workflow - Operations and Monitoring

B. Update Stock

Stock quantities can be increased when new stock arrives or decreased when medicines are dispensed. Each update operation requires the administrator to first complete OTP verification. Upon confirmation, the system updates the quantity field in the relevant medicine table and creates a corresponding entry in the Transactions table recording the user, action type, quantity change, and timestamp.

C. Low Stock Alert & Expiry Monitoring

When stock quantity falls at or below the configurable reorder level, the system automatically generates an alert on the admin dashboard with an optional email notification. The expiry monitoring module scans all records and identifies medicines whose expiry date falls within a 30 to 90 day warning window. Expired medicines are flagged separately to prevent continued use, critical for patient safety and regulatory compliance.

VII. DATABASE DESIGN

The system uses a relational database comprising six primary tables designed to support all functional requirements while maintaining referential integrity. The schema is illustrated in Figure 4. Primary keys uniquely identify each record while foreign keys establish relationships between tables [7].

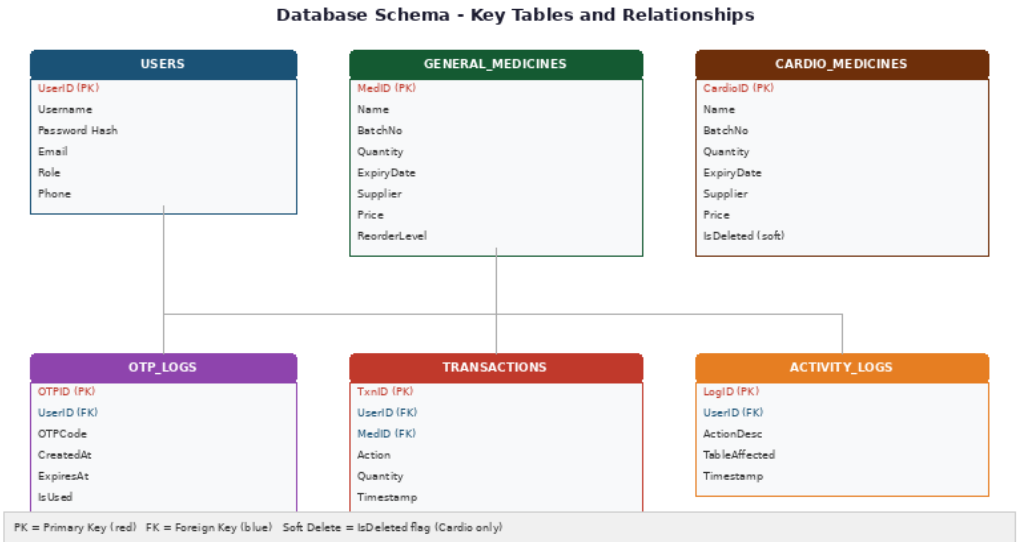

Fig. 4 Database Schema - Tables, Fields, and Relationships

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A. Table Descriptions

Table Name	Purpose	Key Fields
Users	Stores user credentials and roles	UserID, Username, PasswordHash, Role
General_Medicines	Tracks all non-cardio medicines	MedID, Name, Quantity, ExpiryDate, ReorderLevel
Cardio_Medicines	Tracks cardio medicines with soft delete	CardioID, Name, Quantity, IsDeleted
Transactions	Records every stock change with user & time	TxnID, UserID, MedID, Action, Timestamp
OTP_Logs	Stores OTP codes, expiry, and usage status	OTPID, UserID, OTPCode, ExpiresAt, IsUsed
Activity_Logs	Full audit log of all system actions	LogID, UserID, ActionDesc, Timestamp

B. Data Integrity and Constraints

The database enforces referential integrity through foreign key constraints linking transaction and log records to the relevant user and medicine entries. NOT NULL constraints are applied to critical fields such as medicine name, quantity, and expiry date. CHECK constraints prevent negative quantity values. The IsDeleted flag in the Cardio_Medicines table defaults to false and can only be set to true through the authenticated soft delete operation.

VIII. TRANSACTION LOGGING AND AUDIT TRAIL

Every action performed within the system is automatically recorded to maintain a complete and verifiable audit trail. This logging mechanism provides administrators with a detailed history of all inventory changes for internal review and satisfies external regulatory requirements for pharmaceutical record-keeping. Logs cannot be modified or deleted through the standard user interface, ensuring their integrity [8].

Field	Description
TxnID	Unique identifier for each transaction record
UserID	References the Users table to identify who performed the action
MedID	References the medicine record that was affected
Action	Type of operation: ADD, UPDATE, DELETE, or SOFT_DELETE
Quantity	Quantity value involved in the transaction
Timestamp	Exact date and time the action was performed

IX. RESULTS AND TESTING

The system was tested using a dataset of 200 medicine records across both general and cardio categories. Functional testing confirmed that all core operations performed correctly under normal and edge case conditions. Security testing verified that OTP expiry and attempt limits functioned as specified and that no inventory modification was possible without successful OTP verification.

Test Case	Expected Result	Outcome
OTP expires after 5 minutes	Login rejected after expiry	Pass
3 failed OTP attempts	Account temporarily locked	Pass
Stock below reorder level	Alert displayed on dashboard	Pass
Medicine expiring within 30 days	Warning flag shown on dashboard	Pass
Soft delete on cardio medicine	Record marked deleted, not removed	Pass
Unauthorized stock update attempt	Blocked, event logged in audit trail	Pass

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X. CONCLUSION AND FUTURE WORK

The Smart Pharmaceutical Medical Inventory System successfully delivers a secure, organized, and scalable solution for managing medicine stock in clinical environments. The integration of OTP-based two-factor authentication ensures that only authorized personnel can modify inventory records, significantly reducing the risk of unauthorized access. The separation of general and cardio medicine inventories, combined with soft delete functionality for cardiovascular drugs, addresses heightened safety and compliance requirements.

The automated low stock alert and expiry monitoring modules eliminate reliance on manual checks, reducing the likelihood of stockouts and expired medicine usage. The comprehensive transaction logging and activity audit trail provide the accountability and traceability required by healthcare regulatory standards. Future work will focus on barcode scanning integration, a mobile application interface, and multi-branch inventory management with centralized reporting.

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