

Smart Dead Stock Management in Pharmacies

1st Dr. Suresh Kumar S

*Dept. of Artificial Intelligence
and Data science*

*Rajalakshmi Engineering College
Chennai, India
sureshkumar.s@rajalakshmi.edu.in*

2nd Devika C

*Dept. of Artificial Intelligence
and Data science*

*Rajalakshmi Engineering College
Chennai, India
221801009@rajalakshmi.edu.in*

3rd Keerthika P

*Dept. of Artificial Intelligence
and Data science*

*Rajalakshmi Engineering College
Chennai, India
221801027@rajalakshmi.edu.in*

4th Lavanya S

*Dept. of Artificial Intelligence and Data science
Rajalakshmi Engineering College*

*Chennai, India
221801028@rajalakshmi.edu.in*

Abstract— Effective pharmaceutical inventory management is essential for minimizing waste, ensuring uninterrupted medicine availability, and adhering to regulatory compliance standards. Traditional inventory systems often fall short due to the lack of predictive analytics, real-time tracking, and automated alerts, which leads to the accumulation of expired stock, financial losses, and inefficient stock movement. This paper proposes an AI-powered dead stock management system that incorporates logistic regression-based expiry prediction, barcode-enabled product tracking, and seamless integration with e-commerce platforms such as Shopify to enhance overall warehouse efficiency and minimize wastage. The system categorizes medicines into high, medium, and low expiry risk levels based on parameters including expiry dates, historical demand patterns, and stock movement trends. Leveraging machine learning, it continuously analyzes inventory data to generate real-time alerts and maintain an interactive expiry calendar, enabling warehouse managers to take proactive actions such as redistribution, discount-based clearance, or return-to-vendor processes. The barcode scanning module simplifies data entry and facilitates accurate tracking of medicine batches, while Shopify integration allows for the clearance of near-expiry stock through discounted online sales, ensuring better inventory turnover and revenue recovery. Visual dashboards and pie-chart-based reports offer insights into expired versus sold stock ratios, enabling data-driven decision-making. This approach not only prevents expired medicines from entering circulation but also contributes to sustainable practices by reducing pharmaceutical waste. The system offers a scalable and adaptable solution suitable for pharmacies and warehouses of all sizes, particularly in resource-constrained settings, thereby transforming pharmaceutical supply chains into more intelligent, efficient, and regulatory-compliant operations.

Keywords— Travel Recommendation System, Hybrid Filtering, Collaborative Filtering, Singular Value Decomposition (SVD), Content-Based Filtering, Term Frequency-Inverse Document Frequency (TF-IDF), Personalized Travel Recommendations, User Experience.

I. INTRODUCTION

Effective pharmaceutical inventory management is critical to ensuring the availability of medicines while minimizing waste caused by expired or slow-moving stock. Traditional warehouse management systems often lack **predictive analytics, real-time tracking, and automated alerts**, making it difficult for businesses to prevent medicine wastage and optimize stock movement. **Dead stock accumulation and expiry mismanagement** lead to significant financial losses and regulatory risks, as expired medicines must be safely disposed of according to strict compliance standards. Additionally, pharmacies often struggle with **overstocking and stockouts** due to the lack of AI-powered demand forecasting. Without a proactive system, businesses face **inefficiencies in stock utilization, increased operational costs, and compliance challenges**, highlighting the need for an intelligent dead stock management solution.

The motivation behind this project is to address the **gaps in traditional inventory systems** by integrating **AI-driven expiry prediction, automated alerts, barcode-based stock tracking, and e-commerce integration for near-expiry stock clearance**. Expired medicines not only lead to **financial losses** but also pose serious **health risks** if not properly managed. The absence of predictive analytics makes it difficult for businesses to **anticipate demand trends** and take corrective actions before stock becomes obsolete. Additionally, **manual stock tracking is error-prone**, leading to inaccurate inventory records and inefficiencies in supply chain operations. By leveraging **logistic regression for expiry risk classification, AI-based stock movement analysis, and an automated expiry calendar**, this system ensures that businesses can proactively manage their stock, preventing unnecessary losses and optimizing stock turnover. Furthermore, integrating **Shopify for online sales** allows warehouses to **sell near-expiry stock at discounted rates**, reducing wastage and maximizing revenue recovery.

The primary objective of this project is to develop an **AI-powered dead stock management system** that enhances warehouse efficiency, optimizes stock movement, and prevents medicine wastage. The system will provide **real-time barcode scanning** for inventory updates, **logistic regression-based expiry predictions** to classify stock into risk categories, and an **automated alert system** to notify warehouse managers before medicines expire. Additionally, an **expiry calendar** will visually track expiring stock, allowing businesses to take timely actions such as redistribution, discounts, or disposal. To further reduce losses, an **e-commerce integration with Shopify** will enable the clearance of near-expiry medicines, ensuring **faster**

turnover and financial recovery. By combining **predictive analytics, automated alerts, and digital sales solutions**, this project aims to revolutionize **pharmaceutical inventory management**, making it more **data-driven, cost-effective, and compliant with industry regulations**.

II. RELATED WORKS

Efficient inventory management in pharmacies has been a critical area of research, with studies focusing on automated tracking, stock optimization, and supply chain analytics. Traditional inventory management systems rely on manual data entry, which often leads to inefficiencies and increased wastage. To address this, AI-based stock monitoring systems have been developed to minimize expired stock and optimize medicine availability. However, these systems lack predictive models that assess the risk of medicine expiry, an aspect that our proposed system aims to improve.

Expiry Risk Prediction Models

Machine learning models have been widely applied in predicting product shelf life and reducing stock wastage. Existing methods utilize time-series forecasting and rule-based approaches, but they often fail to generalize across different pharmacy inventory datasets. Recent advancements suggest that logistic regression, decision trees, and neural networks can improve the accuracy of expiry risk classification. However, many of these models are either computationally expensive or difficult to interpret in real-time pharmacy operations. Our approach leverages logistic regression for expiry risk prediction, offering a computationally efficient and interpretable solution.

Use of Logistic Regression in Healthcare Predictions

Logistic regression has been extensively used in medical predictions, such as disease diagnosis and drug effectiveness assessments. Its ability to classify outcomes based on multiple independent variables makes it suitable for expiry risk classification in pharmaceutical inventory management. While deep learning models provide better accuracy in some scenarios, logistic regression remains lightweight and interpretable, making it an ideal choice for pharmacies dealing with small to medium-scale datasets.

Barcode-Based Pharmacy Management

Pharmacies worldwide employ barcode scanning technologies such as QuaggaJS and Zebra SDK to streamline stock identification. These barcode systems primarily serve as product retrieval tools, enabling pharmacies to efficiently manage stock levels. However, most barcode-based inventory systems lack expiry risk assessment capabilities. Our proposed system enhances traditional barcode scanning by integrating it with an expiry prediction model, ensuring real-time risk classification of medicines.

Shopify Integration in Inventory Management

E-commerce platforms have become an integral part of retail pharmacy operations, with some businesses integrating Shopify for order and inventory management. While Shopify's API

allows synchronization of stock and sales, research on its integration with expiry prediction models is limited. The proposed system bridges this gap by incorporating Shopify with an AI-driven inventory system, enabling pharmacies to automate stock tracking, predict expiry risks, and optimize order fulfillment based on demand forecasting.

III. PROPOSED SYSTEM

Order Management Module

The Order Management Module in the Pharmacy Dead Stock Management System is designed to handle all inventory transactions efficiently, from order placement to fulfillment and stock updates. It supports CRUD operations (Create, Read, Update, Delete) for seamless order processing, allowing pharmacies to manage stock, track sales, and ensure real-time updates. The module follows a structured workflow: orders are placed manually or via Shopify Integration, stock availability is validated, payments are processed (including GPay and other online methods), and barcode scanning via QuaggaJS ensures accurate stock tracking. Automatic alerts notify users about low stock, delayed orders, and nearing expiry medicines, helping pharmacies take proactive actions. Shopify integration enables real-time synchronization of online and offline sales, ensuring smooth e-commerce operations. Additionally, a reporting and analytics system provides insights into sales trends, order history, and profitability analysis, optimizing inventory decisions. By automating order management, integrating multiple platforms, and providing detailed analytics, this module reduces manual errors, minimizes expired stock risks, and enhances overall pharmacy efficiency.

Warehouse Management System

The **proposed warehouse management system** leverages **AI-driven predictive analytics** to enhance **inventory tracking, expiry risk assessment, and stock movement classification** in pharmaceutical warehouses. Traditional inventory systems often fail to proactively manage medicine expiration and stock movement, leading to **dead stock accumulation and financial losses**. To address these challenges, the system utilizes **logistic regression** to predict the **expiry risk of medicines** by analyzing factors such as **expiry date, last issued date, stock movement rate, and supplier restock frequency**. Medicines are classified into **high-risk, medium-risk, and low-risk categories**, and those nearing expiration (within 30 days) trigger **automated alerts** to warehouse managers for timely action, such as redistribution, discounting, or disposal.

In addition to expiry prediction, the system analyzes **historical sales trends** to classify medicines as **fast-moving or slow-moving stock**. **Fast-moving medicines** require **priority restocking**, while **slow-moving medicines** pose a higher risk of becoming dead stock. By identifying slow-moving stock, the system enables warehouse managers to **redistribute unused medicines to high-demand locations, adjust procurement orders, and apply discount**

strategies to clear excess stock before expiration. Furthermore, an **Expiry Calendar** is integrated to provide a **visual representation of stock nearing expiration**, categorizing medicines into **Green Zone (safe stock)**, **Yellow Zone (warning)**, and **Red Zone (critical expiry risk)**. When medicines enter the **Red Zone**, automated **SMS and email alerts** notify warehouse managers, pharmacists, and suppliers, ensuring timely intervention.

By combining **logistic regression for expiry risk prediction**, **AI-based stock movement classification**, and **an automated alert system**, the proposed warehouse management solution **minimizes dead stock, improves inventory turnover, and prevents medicine wastage**. This system ensures a **proactive approach to warehouse management**, enhancing pharmaceutical supply chain efficiency and reducing financial losses due to expired medicines.

Barcode Integration

Barcode integration plays a crucial role in enhancing the efficiency and accuracy of pharmaceutical inventory management. By embedding barcodes on medicine packaging, pharmacies and warehouses can automate stock tracking, reduce manual errors, and improve operational efficiency. Each medicine is assigned a **unique barcode** that encodes essential details such as **medicine ID, name, batch number, expiry date, supplier details, and stock quantity**. Using barcode scanners or mobile applications, users can **instantly retrieve or update** product information by scanning the barcode. This integration ensures real-time stock updates, facilitating faster **stock reconciliation, expiry tracking, and order processing**. Additionally, the system can be configured to trigger **alerts** when scanning expired or low-stock medicines, preventing the risk of dispensing outdated drugs. Furthermore, barcode-enabled tracking aids in regulatory compliance by maintaining a **transparent log of medicine movements**, ensuring adherence to safety and quality standards. Integrating barcode technology with a **warehouse management system (WMS)** or an **online sales platform** further enhances supply chain efficiency, allowing seamless product identification and traceability. This digital transformation not only improves inventory accuracy but also optimizes the **redistribution of near-expiry stock**, reducing pharmaceutical wastage.

Shopify Integration

Integrating Shopify into the pharmaceutical inventory management system provides an efficient **online platform for selling medicines**, ensuring seamless stock management and order fulfillment. By syncing the inventory database with Shopify, businesses can **automatically update product availability**, preventing overselling or stockouts. Each product listing on Shopify includes critical details such as **medicine name, batch number, expiry date, supplier**

information, and pricing, retrieved directly from the warehouse management system. The integration also supports **barcode scanning**, allowing quick addition of products to the Shopify store while ensuring accurate stock tracking. Additionally, Shopify's built-in **order management system** facilitates smooth processing of customer purchases, while automated alerts notify warehouse teams to dispatch orders promptly. Secure **payment gateways** ensure compliance with pharmaceutical e-commerce regulations, offering a safe and convenient shopping experience. Furthermore, AI-driven analytics on Shopify help predict **demand trends, slow-moving stock, and expiry risks**, allowing businesses to strategize sales promotions for near-expiry medicines. This integration streamlines the entire sales process, reducing **manual efforts, optimizing inventory turnover, and minimizing medicine wastage**, making it a powerful tool for modern pharmaceutical businesses.

System Architecture

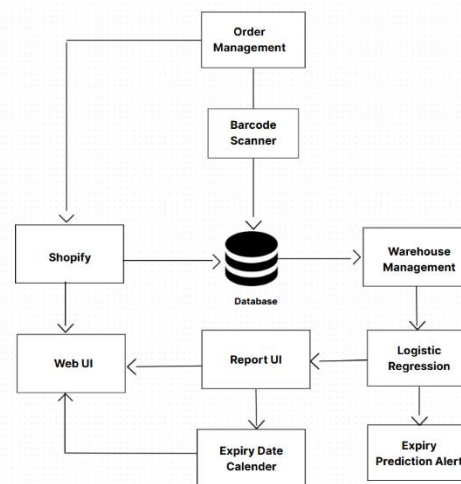


Fig. 1. System Architecture

The AI-powered Dead Stock Management System is designed to enhance pharmaceutical inventory management by integrating order processing, warehouse management, expiry prediction, and e-commerce integration. The system leverages barcode scanning, predictive analytics, automated alerts, and online sales platforms to optimize stock movement, prevent medicine wastage, and ensure regulatory compliance. The architecture consists of multiple interconnected modules, each playing a crucial role in maintaining efficient stock management.

Order Management and Barcode Scanning

The Order Management module is responsible for handling stock intake, tracking customer orders, and maintaining order history. When new medicines arrive at the warehouse or a pharmacy, they are scanned using a barcode scanner to record batch details, expiry dates, and quantities in the centralized database. The barcode scanning system ensures real-time updates, reducing human errors in stock registration and

preventing discrepancies between physical stock and recorded inventory. This data is then synchronized across different modules, allowing seamless inventory management. The integration of barcode scanning also facilitates quick identification of products, enabling efficient order processing, stock audits, and real-time tracking of medicine movement within the warehouse and distribution network.

Centralized Database for Inventory Tracking

The centralized database acts as the core data repository of the system, storing critical inventory details such as medicine names, expiry dates, stock levels, sales records, supplier information, and demand trends. The database enables all system modules to interact seamlessly by providing a single source of truth for inventory management. Order data from the barcode scanner, expiry risk classifications from the logistic regression model, and stock clearance actions from Shopify are all recorded and updated in real time. This approach ensures consistency across the system, minimizing errors in stock records and preventing overstocking or stockouts. Additionally, the centralized database supports quick retrieval of information for generating reports, making informed decisions, and automating expiry alerts, ensuring the efficient flow of information across all operational processes.

Warehouse Management and Expiry Risk Prediction

The Warehouse Management module plays a crucial role in monitoring inventory, tracking product movement, and ensuring the efficient utilization of stock. To prevent medicine wastage, this module integrates with a logistic regression-based expiry prediction system that classifies medicines into different risk categories. The expiry prediction model analyzes multiple parameters, including expiry date proximity, stock movement rate, demand patterns, storage conditions, and batch details. By leveraging this AI-driven classification, medicines are categorized as high-risk, medium-risk, or low-risk based on their probability of expiring soon. The warehouse management module uses these classifications to make informed decisions regarding inventory adjustments, such as redistributing stock to high-demand locations, offering discounts on near-expiry products, or alerting pharmacists about upcoming expirations. This predictive approach enables businesses to take preemptive actions, minimizing financial losses and ensuring that medicines are used before they become obsolete.

Expiry Prediction Alerts and Expiry Date Calendar

To ensure timely intervention, the system generates expiry prediction alerts for medicines that fall into the high-risk category. These automated alerts notify warehouse managers and pharmacists, allowing them to take corrective measures before the stock becomes unsellable. The alert system is integrated with the warehouse management module, ensuring that stock with a high probability of expiration is either redistributed or marked for discounts. Additionally, the expiry date calendar serves as a visual representation of upcoming expirations, providing a clear and intuitive way to monitor at-risk inventory. This feature enhances inventory planning by

allowing managers to prioritize stock usage, adjust procurement strategies, and optimize the replenishment process based on real-time expiry data. By automating expiry tracking and prediction, this module significantly improves stock turnover efficiency while reducing wastage.

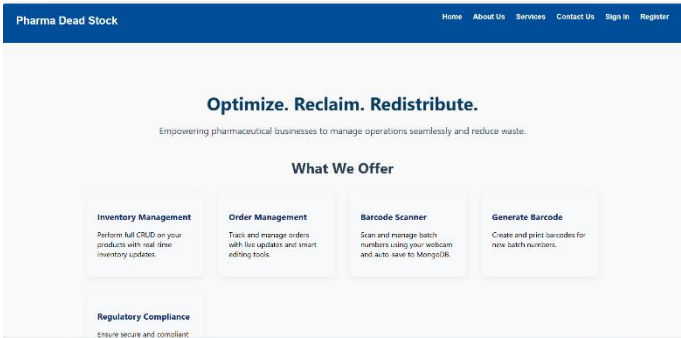
Reporting System and Web UI

The Report UI provides detailed analytics on stock movement, annual profitability, and medicine wastage, helping businesses track overall performance. This module allows users to monitor the financial impact of expired stock, identify trends in stock utilization, and optimize purchasing decisions based on historical data. The reporting system enables businesses to generate real-time reports on high-risk medicines, stock levels, and order histories, ensuring that stakeholders can make data-driven decisions. The Web UI serves as the primary interface for accessing the report system, making it accessible to warehouse managers, pharmacists, and business administrators. Through interactive dashboards and analytics tools, the system empowers decision-makers with insights that improve inventory efficiency, reduce losses, and enhance overall stock management.

Shopify Integration for E-commerce Sales

To further reduce dead stock losses, the system integrates with Shopify, allowing pharmacies and warehouses to list near-expiry medicines for online clearance sales. This module synchronizes inventory data with the centralized database, ensuring that available stock is accurately reflected in the Shopify store. The integration automates price adjustments based on expiry risk classification, allowing businesses to sell high-risk medicines at discounted rates before they expire. Shopify orders are directly linked to the order management system, ensuring seamless fulfillment and preventing stock discrepancies. By providing an additional sales channel, this module helps businesses maximize revenue recovery while minimizing waste, ensuring that medicines are utilized efficiently instead of being discarded.

IV. EXPERIMENTAL RESULT



The web application interface for the proposed pharmaceutical dead stock management system has been designed to provide a streamlined and intuitive user experience. The homepage showcases the core mission of the platform with the tagline “**Optimize. Reclaim. Redistribute.**”, reflecting the goal of minimizing

pharmaceutical waste and redistributing usable inventory effectively.

Feature Overview Section

Inventory Management: Enables full CRUD (Create, Read, Update, Delete) operations for pharmaceutical products, including stock updates in real time.

Order Management: Allows tracking and management of product orders with editing and live update support.

Barcode Scanner: Uses the device webcam to scan barcodes, extract batch details, and store them directly into a MongoDB database.

Pharma Dead Stock									
Home About Us Services Contact Us Sign In Register									
Order Management									
Search by customer or order ID: <input type="text"/> AI Create New Order									
Order ID	Customer	Medicine	Batch No	Quantity	Order Date	Status	Total Amount	Actions	
ORD1001	Anusha Rao	Paracetamol 500mg	PCTM123	11	1/12/2024	Delivered	₹252	Edit	Delete
ORD1002	Rahul Mehta	Amoxicillin 250mg	AMX250	5	10/1/2025	Pending	₹200	Edit	Delete
ORD1003	Sita Sharma	Ibuprofen 200mg	IBU200	8	5/11/2024	Cancelled	₹240	Edit	Delete
ORD1004	Karthik Iyer	Cough Syrup	COU1123	6	1/2/2025	Delivered	₹270	Edit	Delete
ORD1005	Divya Nair	Vitamin C Tablets	VITC367	12	15/12/2024	Delivered	₹240	Edit	Delete

The **Order Management** page in the Dead Stock Management System provides a user-friendly interface for tracking and managing pharmaceutical orders. It displays key details such as Order ID, Customer, Medicine, Batch Number, Quantity, Order Date, Status, and Total Amount in a structured table. Users can search, filter, edit, and delete orders efficiently. This module enables real-time monitoring of stock movement, supports better decision-making regarding near-expiry or surplus medicines, and contributes to minimizing pharmaceutical waste through effective redistribution.

Pharma Warehouse Dashboard

Add Warehouse Record

Warehouse ID

WH003

Location

Medicine Name

Batch Number

Stock Quantity

Received Date

dd-mm-yyyy

Expiry Date

dd-mm-yyyy

Expiry Risk

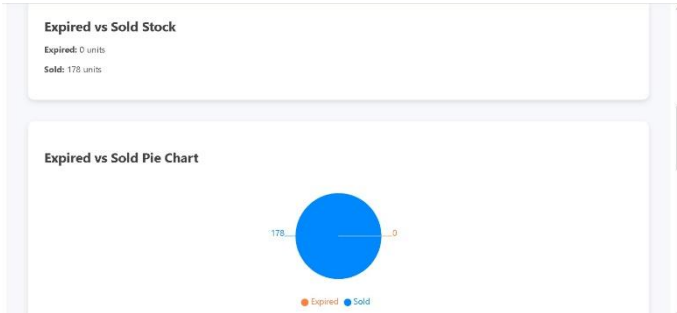
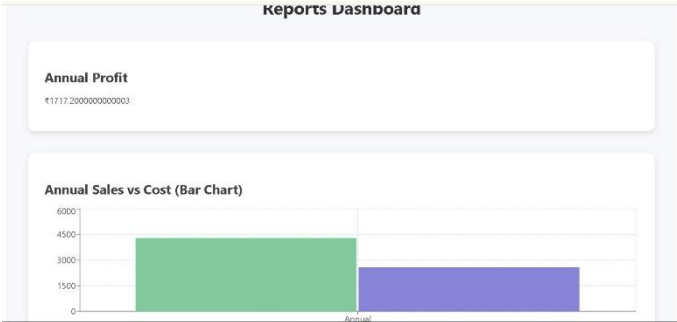
Low

Supplier Name

Add Record

Warehouse Inventory									
Warehouse ID	Location	Medicine Name	Batch No	Stock Qty	Received Date	Expiry Date	Expiry Risk	Supplier Name	
VH001	Chennai	Paracetamol 500mg	PCT500A	120	2024-06-15	2025-06-15	Low	ABC Pharma	
VH002	Delhi	Amoxicillin 250mg	AMX250B	200	2023-12-10	2025-01-01	Medium	Medico Supplies	
VH003	Bangalore	Cough Syrup	COF789	50	2024-03-01	2024-08-15	High	Dr. Cure Ltd	
VH004	Mumbai	Ibuprofen 200mg	IBU200C	120	2024-05-10	2025-03-10	Medium	Relief Pharma	
VH005	Hyderabad	Adrenaline 500mg	ADZ500D	80	2024-08-01	2025-08-01	Low	Healthy Pharma	
VH006	Kolkata	Vitamin C Tablets	VITC300	300	2024-01-15	2024-06-15	High	NatureMed Labs	
VH007	Pune	Metformin 850mg	MET850E	150	2024-02-15	2025-02-15	Low	DiabeCare Inc	
VH008	Ahmedabad	Cetirizine 10mg	CETZ10	60	2023-11-01	2024-05-01	High	AllergyMed	
VH009	Coimbatore	Losartan 50mg	LOS50X	90	2024-04-10	2025-01-10	Medium	HeartPlus Pharma	
VH010	Trichy	Dolo 650mg	DLO650Y	180	2024-07-20	2025-04-20	Low	PainRelief Corp	
VH011	Mysore	ORS Sachet	ORS111	500	2023-10-05	2024-04-05	High	HydraHealth	

The **Pharma Warehouse Dashboard** facilitates efficient tracking and management of medicine stocks across various locations. This form allows users to add warehouse records with detailed information such as Warehouse ID, Location, Medicine Name, Batch Number, Stock Quantity, Received and Expiry Dates, Supplier Name, and the associated Expiry Risk level. By systematically capturing these attributes, the system aids in identifying and addressing stock nearing expiry, thereby supporting proactive redistribution and minimizing pharmaceutical waste—crucial for enhancing supply chain efficiency in healthcare.



The **Reports Dashboard** in the Dead Stock Management System for Pharmacy provides critical business insights through visual analytics. It displays the **Annual Profit**, helping stakeholders assess overall financial performance. Additionally, a **bar chart comparison of Annual Sales vs Cost** offers a clear graphical representation of revenue generation against expenditure. This module supports data-driven decision-making, enabling pharmacies to optimize inventory strategies, reduce operational costs, and enhance profitability through better dead stock management.

The **pie chart** titled "**Expired vs Sold Pie Chart**" provides a visual representation of the stock outcome in your pharmacy's dead stock management system. Since the entire pie chart is blue, it signifies that **100% of the stock was sold** and **none of the inventory expired**. This indicates excellent stock rotation and proactive inventory management. The absence of expired items suggests that medicines were sold within their shelf life, which helps reduce wastage and financial losses.

System Benefits and Conclusion

The Dead Stock Management System offers a data-driven approach to pharmaceutical inventory management by integrating AI-powered expiry risk prediction, automated alerts, barcode tracking, real-time reporting, and Shopify-based stock clearance. By leveraging predictive analytics, businesses can

proactively manage their stock, ensuring that high-risk medicines are either sold, redistributed, or disposed of before expiration. The system enhances compliance with pharmaceutical regulations by preventing expired medicines from being sold or used while also reducing financial losses due to wastage. Additionally, the automation of inventory tracking and expiry alerts significantly improves operational efficiency, reducing the reliance on manual stock audits and record-keeping. By implementing this intelligent and AI-powered inventory solution, pharmacies and warehouses can optimize their supply chain, improve stock utilization, and maximize profitability while ensuring that medicines are used effectively before their expiry.

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