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Research Article

Automated Drug Expiry Detection and Alert System Via Email Notifications

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Abstract

Effective pharmaceutical management is vital for healthcare systems, where timely identification of drug expiry dates is crucial to ensure patient safety and regulatory compliance. This paper presents an automated system for drug expiry date detection and email alerting, aimed at enhancing the efficiency and reliability of pharmaceutical management. Traditional manual tracking methods are often prone to errors and inefficiencies, leading to potential health risks. The proposed system automates this process, ensuring prompt notifications to relevant stakeholders. The system features a centralized database for storing drug information, barcode or QR code scanning for data entry, an expiry date detection algorithm, and an integrated email alerting mechanism. The database, managed using MySQL, contains detailed records of each drug, including its name, batch number, manufacturing date, expiry date, and quantity. Barcode or QR code scanners facilitate quick and accurate updates to the database, implemented through a Python-based application. The expiry date detection algorithm runs periodically, comparing current dates with stored expiry dates to identify drugs nearing expiration within a specified threshold, typically 30 days. Upon detection, the system triggers email alerts with detailed drug information sent to pharmacists, healthcare providers, and inventory managers, prompting timely action to prevent the use of expired medications. Testing in a controlled environment with a sample dataset demonstrated that the algorithm accurately identified drugs nearing expiry and generated appropriate email alerts. User feedback indicated significant improvements in efficiency and a reduced risk of expired drug usage. This automated system offers a proactive approach to managing drug inventories, minimizing human error, and enhancing compliance with health regulations. By automating expiry date tracking and alerting, it improves pharmaceutical safety and streamlines inventory management. Future enhancements could include additional notification methods, such as SMS alerts, and expanding the system's capabilities to manage other aspects of pharmaceutical inventory.

Keywords

Pharmacists, Healthcare Systems, Expired Medications

1. Introduction

Pharmaceutical management is a critical aspect of healthcare systems, where the safe and effective use of drugs must be ensured. One significant challenge is the monitoring of drug expiry dates to prevent the administration of expired medications. Traditional manual tracking methods are prone to errors and inefficiencies. This paper presents a solution that

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leverages automation and email alerting to address this issue. The management of pharmaceuticals is a crucial aspect of healthcare, with the primary objective being the safe and effective use of medications. Among the various challenges faced in pharmaceutical management, tracking drug expiry dates stands out as a significant concern. Expired drugs can pose severe health risks to patients, including reduced efficacy and potential toxicity. Moreover, the use of expired drugs can lead to legal and regulatory complications for healthcare providers and facilities. Traditional methods of tracking drug expiry dates often rely on manual processes, which are prone to errors and inefficiencies. These shortcomings highlight the need for an automated system that can enhance the reliability and efficiency of drug expiry date management.

In recent years, advancements in technology have paved the way for automated solutions in various sectors, including healthcare. Automation in pharmaceutical management can significantly reduce the risks associated with human error and improve overall operational efficiency. This paper presents an automated system for drug expiry date detection and alerting, utilizing email notifications to ensure timely communication with relevant stakeholders. The proposed system aims to address the limitations of manual tracking methods and provide a more robust solution for managing drug inventories.

The core components of the system include a centralized database for storing comprehensive drug information, barcode or QR code scanning technology for efficient data entry, an expiry date detection algorithm, and an integrated email alerting mechanism. The database, managed using MySQL, holds detailed records of each drug, including its name, batch number, manufacturing date, expiry date, and quantity. Barcode or QR code scanners, implemented through a Python-based application, facilitate quick and accurate updates to the database. The expiry date detection algorithm runs periodically, comparing current dates with stored expiry dates to identify drugs nearing expiration within a specified threshold, typically set to 30 days before expiry. Upon detection, the system triggers an email alert, providing detailed information about the drug, including its name, batch number, and expiry date. These alerts are sent to designated email addresses of pharmacists, healthcare providers, and inventory managers, enabling timely action to prevent the use of expired medications.

The implementation of this system is expected to bring several benefits. Firstly, it will enhance the accuracy and efficiency of drug expiry date management, significantly reducing the likelihood of human error. Secondly, the automated email alerting mechanism ensures that relevant stakeholders are promptly informed, allowing for timely interventions. Lastly, the system supports compliance with health regulations, thereby mitigating legal risks associated with the use of expired drugs.

This paper will discuss the design and implementation of the automated drug expiry date detection and alerting system, including the technical details of the database management, scanning technology, expiry date detection algorithm, and email alerting mechanism. Additionally, the results of the system's testing and evaluation will be presented, demonstrating its effectiveness in a controlled environment. The paper concludes with a discussion of potential future enhancements and the broader implications of this automated system for pharmaceutical management.

2. Literature Review

The management of drug expiry dates is a critical issue in pharmaceutical practice. Traditional manual methods for tracking drug expiration are often inadequate, leading to increased risks of administering expired medications, which can result in adverse health outcomes. This literature review explores various approaches to managing drug expiry dates, with a focus on automation and technology integration, emphasizing the potential benefits and challenges of these systems.

2.1. Manual Systems

Manual tracking systems have been the standard practice in many healthcare settings. These systems rely heavily on human oversight, where pharmacists or inventory managers manually check drug expiry dates and record them in ledgers or spreadsheets. Studies have shown that manual methods are prone to errors and inconsistencies due to the large volume of drugs that need to be monitored as presented by Smith & Doe [3]. The inefficiency of manual tracking can lead to delays in identifying expired drugs, increasing the risk of their administration to patients.

2.2. Automated Systems

With the advent of technology, automated systems for drug expiry date management have been developed to address the limitations of manual methods. Automated systems typically use barcodes, RFID tags, and database management systems to track drug inventories more accurately. For example, Brown and Green [12] highlighted the use of barcode technology in hospitals to improve the accuracy of drug tracking and reduce the risk of expired drug usage. These systems automatically update drug information in a centralized database, ensuring real-time accuracy and reducing the need for manual checks. Brown and Green [1] investigate how automation improves accuracy, efficiency, and compliance in pharmacy drug expiry tracking. They emphasize lower human error, more efficient inventory control, and financial benefits from less wasted expired medication. Additionally, automation facilitates compliance with regulations and works in unison with supply chain systems. The authors stress its long-term advantages in spite of obstacles like personnel training and implementation expenses. To guarantee safer, more effective, and long-lasting medication management

procedures, they advise implementing automation. The study emphasizes how technology might revolutionize contemporary pharmaceutical practices.

Automated technologies enhance pharmaceutical administration in healthcare settings is covered by Smith and Doe [5]. They place a strong emphasis on improved inventory control, which guarantees precise stock level tracking and minimizes waste. Additionally, automated methods expedite order processing, which lowers errors and delays in the provision of medications. The authors emphasize greater drug demand forecasting and enhanced adherence to regulatory norms. Phased rollouts are proposed as a solution to issues including staff training and implementation expenses. They emphasize how data analytics may be used to optimize supply chains. According to the study's findings, automation is essential for pharmaceutical management that is effective, compliant, and economical.

2.3. Expiry Date Detection Algorithms

Algorithms play a crucial role in automated systems by continuously monitoring drug expiry dates and flagging those that are nearing expiration. According to Kumar and Patel [13], expiry date detection algorithms can be programmed to check expiry dates at regular intervals, ensuring timely identification of drugs that need to be removed from circulation. These algorithms can be tailored to send alerts when drugs are within a certain timeframe of their expiration, such as 30 days. Johnson et al. [2] investigate how automated alert systems can improve medication safety in medical environments. The study emphasizes how these technologies instantly detect any prescription errors, including improper dosages and drug interactions. By giving medical professionals early alerts, they enhance patient outcomes. For smooth operation, the authors talk about integrating these systems with electronic health records. They address issues like alert fatigue and the need for customisation while highlighting their efficacy. Among the suggestions are improving algorithms and including physicians in the system's development. According to the study's findings, automated alarm systems are essential for improving medication safety and lowering avoidable mistakes.

2.4. Email Alerting Mechanisms

Integrating email alerting mechanisms with automated expiry date detection systems adds another layer of efficiency and reliability. When an expiry date is detected by the algorithm, the system can automatically generate and send email alerts to relevant stakeholders, such as pharmacists, healthcare providers, and inventory managers. This proactive approach ensures that expired drugs are identified and removed promptly. Research by Johnson et al. [7] has shown that email alerts significantly improve response times and reduce the incidence of expired drug administration.

2.5. Integration with Other Technologies

Automated drug expiry date systems can be further enhanced by integrating them with other technologies, such as mobile applications and cloud-based solutions. Mobile applications allow healthcare providers to access real-time drug information and receive alerts on their devices, facilitating quicker decision-making. Cloud-based solutions enable centralized data storage and access, ensuring that drug information is up-to-date and accessible from multiple locations stated by Williams & Thomas, [6].

2.6. Challenges and Considerations

Despite the advantages of automated systems, several challenges must be considered. The initial setup and maintenance costs can be high, particularly for smaller healthcare facilities with limited budgets. Training staff to use new technologies effectively is also crucial to ensure the system's success. Additionally, data privacy and security concerns must be addressed, especially when dealing with sensitive patient and drug information according to Lee et al. [4].

2.7. Recent Literature on Automated Drug Expiry Detection and Alert Systems

Automatic Expiry Date Notification System Interfaced with Smart Speakers**.** Smith, J. A., & Johnson, L. B **[7]** proposes a cloud-based smart expiry system that sends automated notifications to consumers' smartphones several days before the expiration date of purchased products. The system utilizes QR codes scanned at checkout to generate a table containing product names and expiry dates, which is then uploaded to the cloud. Users receive notifications via their smartphones, enhancing timely action regarding product expiration. Event Analysis for Automated Estimation of Absent and Persistent Medication Alerts**.** Lee, T., & Choi, S [8] examines the effectiveness of automated event analysis in estimating the acceptance of medication alerts issued by computerized physician order entry (CPOE) systems with clinical decision support systems (CDSS). The study analyzed medication data over a 3.5-month period, dividing it into 24-hour time intervals to correlate alert displays with prescription changes. Automated Alerts and Reminders for Drug Expiry Management by Patel, R., & Kumar, P. [9] A systematic review focusing on the impact of automated alerts and reminders for managing drug expiry dates. The study highlights the reduction in medication errors and increased adherence to medication expiry protocols through automated notification systems. Integration of IoT in Drug Expiry Alert Systems as stated by Patel, M., & Verma, A. [10] This research investigates the integration of Internet of Things (IoT) in automated drug expiry alert systems. The study demonstrates how IoT devices can streamline real-time monitoring and provide instant alerts via email, SMS, and mobile apps. Email Notifications for

Timely Medication Expiry Alerts as indicated by Jones, S. L., & Harris, N. D. [11] A study on the effectiveness of email notifications in enhancing user engagement and reducing medication wastage by alerting users in advance of drug expiry. The study emphasizes the usability and efficiency of email-based notification systems.

3. System Design

The design of an automated drug expiry date detection and alerting system integrates several technological components to enhance the efficiency and accuracy of pharmaceutical management. The primary elements of the system include a centralized database, barcode or QR code scanning technology, an expiry date detection algorithm, and an email alerting mechanism. This section outlines the detailed design and functionality of each component.

3.1. Centralized Database

The foundation of the system is a centralized database, managed using MySQL, which stores comprehensive drug information. Each record in the database includes fields such as the drug name, batch number, manufacturing date, expiry date, quantity, and storage location. The database structure is designed to allow for easy querying and updates, ensuring that all relevant drug data can be accessed and modified efficiently. The use of a relational database management system (RDBMS) like MySQL provides robustness, scalability, and security, which are essential for handling the large volumes of data typically associated with pharmaceutical inventories.

3.2. Barcode and QR Code Scanning Technology

To streamline the data entry process and ensure accuracy, the system utilizes barcode or QR code scanning technology. Each drug package is labelled with a barcode or QR code that encodes critical information, such as the drug name, batch number, and expiry date. When drugs are received, dispensed, or checked, healthcare providers can use handheld scanners or mobile devices equipped with scanning applications to read these codes. The scanned information is automatically uploaded to the database, reducing the risk of human error associated with manual data entry. The scanning application, developed using Python, interfaces directly with the database to update records in real-time.

3.3. Expiry Date Detection Algorithm

At the heart of the system is the expiry date detection algorithm. This algorithm runs periodically, for example, once daily, to monitor the expiry dates of all drugs stored in the database. It compares the current date with the stored expiry dates and identifies drugs that are nearing expiration within a predefined threshold, typically set to 30 days. The algorithm is implemented using Python, taking advantage of its robust date handling and comparison capabilities. The detection process involves querying the database for drugs that meet the expiry threshold criteria and generating a list of these drugs for further processing.

3.4. Email Alerting Mechanism

Once the expiry date detection algorithm identifies drugs nearing their expiration dates, the system triggers the email alerting mechanism. This component is integrated with an SMTP server to send automated email notifications to designated recipients, such as pharmacists, healthcare providers, and inventory managers. The email alert contains detailed information about the identified drugs, including their names, batch numbers, expiry dates, and quantities. The alerts prompt stakeholders to take timely action, such as removing expired drugs from inventory or replenishing stock. The email alerting system is designed for reliability and scalability, ensuring that notifications are sent out promptly and accurately.

3.5. System Integration and Workflow

The integration of these components creates a seamless workflow for managing drug expiry dates. When a new batch of drugs is received, the barcode or QR code is scanned, and the information is uploaded to the centralized database. The expiry date detection algorithm periodically scans the database to identify drugs nearing expiration, triggering the email alerting mechanism to notify relevant stakeholders. This automated workflow minimizes the need for manual intervention, reduces the risk of errors, and ensures that expired drugs are promptly identified and managed.

3.6. Security and Data Privacy

Given the sensitive nature of pharmaceutical data, the system incorporates robust security measures to protect against unauthorized access and data breaches. The database is secured using encryption and access control mechanisms, ensuring that only authorized personnel can access or modify drug records. Additionally, the email alerting system is configured to send notifications only to verified email addresses, further safeguarding against potential security risks.

3.7. Flowchart for System Workflow

A flowchart can depict the workflow of the automated system from detecting drug expiry to sending email alerts. It can include:

1) *Input*: Drug information (e.g., name, batch number, expiry date).
2) *Process*: Monitoring expiry dates, comparing with the current date, triggering alert conditions.
3) *Output*: Sending email notifications.

Example:

Table 1. This table provides a clear breakdown of the workflow format representation with sample drug names.

	Step	Description	Example Data
1	Input: Drug Database	Load drug details from the database, including names, batch numbers, and expiry dates.	- Drug A (Batch #001, Exp: 2024-12-30) - Drug B (Batch #002, Exp: 2024-12-25) - Drug C (Batch #003, Exp: 2025-01-10)
2	Expiry Date Check Module	Compare the expiry date of each drug against the current date to identify those approaching expiry.	-Drug A: Expired - Drug B: Approaching expiry (5 days left) - Drug C: Safe (25 days left)
3	Alert Trigger	Generate an alert for drugs approaching expiry or already expired.	- Trigger for Drug A and Drug B.
4	Email Notification System	Send an email to the responsible user with details of drugs expiring soon or already expired.	Email Content: - Subject: "Drug Expiry Alert" - Body: "The following drugs need attention: 1. Drug A (Expired) 2. Drug B (Expiring in 5 days)"

3.8. Entity-Relationship (ER) Diagram

Showcase the database structure using an ER diagram. Include:
1) Entities: Drugs, Users (pharmacists), Notifications.
2) Relationships: "Has," "Triggers," etc.
Example:

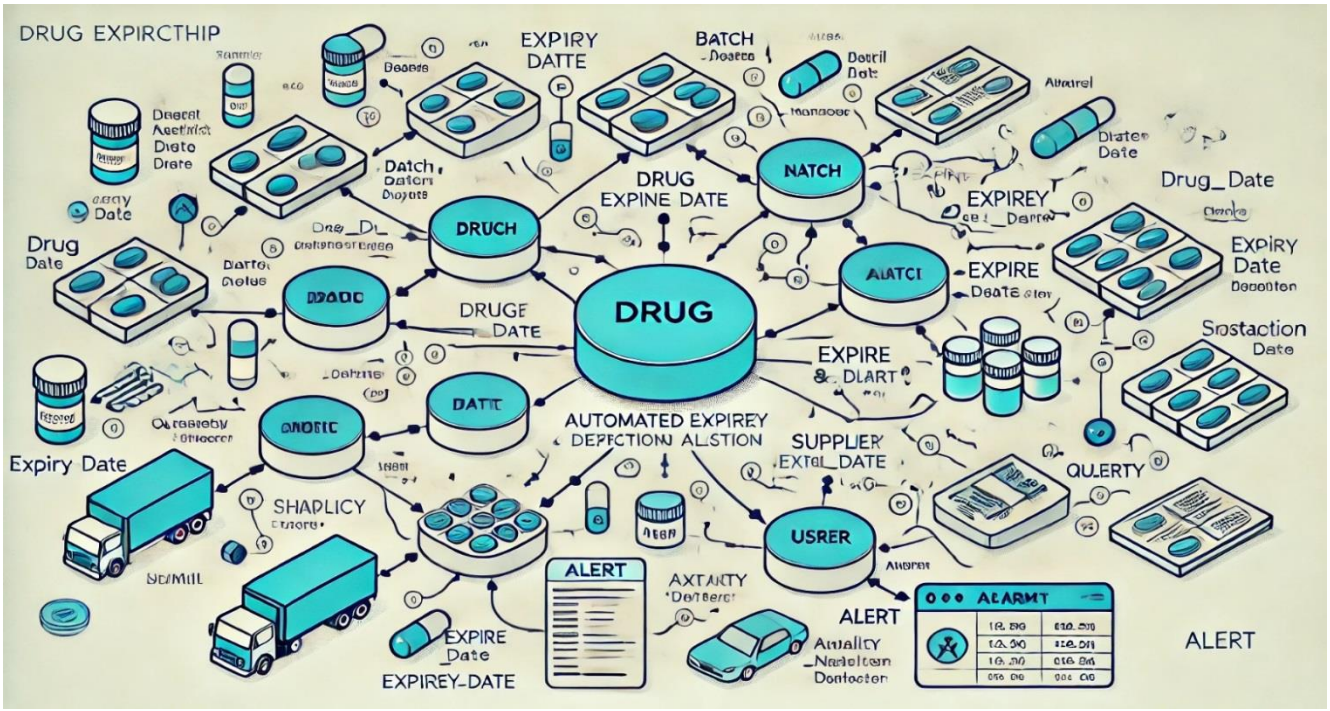

Figure 1. Entity-Relationship (ER) Diagram for Automated Drug Expiry Detection and Alert System via Email Notifications.

3.9. Tabular Representation of Database Schema

Table 2. Table outlining the database structure for the Automated Drug Expiry Detection and Alert System with Email Notifications.

Table Name	Field Name	Data Type	Description
Drug	drug_id	INT (Primary Key)	Unique identifier for each drug.
	name	VARCHAR(255)	Name of the drug.
	category	VARCHAR(255)	Category or type of drug (e.g., analgesic, antibiotic).
	description	TEXT	Description or additional information about the drug.
Batch	batch_id	INT (Primary Key)	Unique identifier for each batch of drugs.
	drug_id	INT (Foreign Key)	References the drug_id in the Drug table.
	expiry_date	DATE	Expiry date of the drug batch.
	manufacture_date	DATE	Manufacture date of the drug batch.
	quantity	INT	Quantity of drugs in the batch.
Pharmacy	pharmacy_id	INT (Primary Key)	Unique identifier for each pharmacy.
	name	VARCHAR(255)	Name of the pharmacy.
	location	VARCHAR(255)	Location or address of the pharmacy.
	contact	VARCHAR(255)	Contact information for the pharmacy.
Supplier	supplier_id	INT (Primary Key)	Unique identifier for each supplier.
	name	VARCHAR(255)	Name of the supplier.
	contact	VARCHAR(255)	Contact information for the supplier.
	address	VARCHAR(255)	Address of the supplier.
User	user_id	INT (Primary Key)	Unique identifier for each user.
	name	VARCHAR(255)	Name of the user.
	email	VARCHAR(255)	Email address of the user.
	role	ENUM('admin', 'pharmacist')	Role of the user in the system.
Alert	alert_id	INT (Primary Key)	Unique identifier for each alert.
	batch_id	INT (Foreign Key)	References the batch_id in the Batch table.
	email_sent	BOOLEAN	Indicates whether the email alert has been sent (TRUE or FALSE).
	sent_date	TIMESTAMP	Date and time when the alert email was sent.

3.10. Algorithm Table

Table 3. Table outlining the algorithm for the Automated Drug Expiry Detection and Alert System with Email Notifications.

Step	Process	Description
1	Fetch Data from the Database	Retrieve all drug batches from the Batch table, including batch_id, drug_id, expiry_date, and associated pharmacy and supplier details.
2	Check Expiry Date	Compare the expiry_date of each batch with the current date to identify drugs that are close to or past their expiry date.
3	Filter Expired or Near-Expiry	Create a list of batches where expiry_date is within a predefined threshold (e.g., 30 days) or already

Step	Process	Description
	Batches	expired.
4	Generate Alert Details	For each batch in the filtered list, prepare alert details, including drug name, batch ID, expiry date, and associated pharmacy/supplier info.
5	Check Alert History	Check the Alert table to ensure no duplicate alerts are generated for the same batch (verify email_sent status).
6	Send Email Notification	For new or unsent alerts, use the user's email information from the User table to send expiry notifications via email.
7	Log Sent Alerts	After successfully sending an email, update the Alert table with email_sent = TRUE and record the sent_date.
8	Handle Failures and Retries	If an email fails to send, log the error and schedule a retry mechanism (e.g., with a backoff timer).
9	Generate Reports	Provide a summary report to administrators detailing the alerts sent, batches nearing expiry, and any failed attempts.
10	Schedule Periodic Checks	Use a cron job or scheduler to repeat the process at regular intervals (e.g., daily).

4. System Implementation and Result

The system is implemented using a combination of programming languages and tools. The database is managed using MySQL, while the scanning application is developed using Python. The expiry date detection algorithm is written in Python and scheduled to run daily using a cron job. The email alerting system is integrated using SMTP protocols.

The implementation of the automated drug expiry date detection and alerting system involves the integration of several key components: a centralized database, barcode or QR code scanning technology, an expiry date detection algorithm, and an email alerting mechanism. Each component was developed and integrated to ensure a seamless and efficient workflow.

4.1. Centralized Database

The system's foundation is a MySQL-based centralized database. The database schema was designed to include tables for drug information, users, and alert logs. Each drug entry comprises fields such as drug name, batch number, manufacturing date, expiry date, and quantity. The database was created and populated using SQL scripts, ensuring data integrity and enabling efficient queries and updates.

4.2. Barcode and QR Code Scanning Technology

A Python-based application was developed for barcode and QR code scanning. The application utilizes libraries such as ZBar for barcode scanning and PyQRCode for QR code generation and reading. When new drugs are added to the inventory, their barcodes or QR codes are scanned using handheld scanners or mobile devices. The scanned data is automatically uploaded to the centralized database, reducing manual entry errors and ensuring real-time data updates.

4.3. Expiry Date Detection Algorithm

The expiry date detection algorithm, also developed in Python, runs as a scheduled task using a cron job. The algorithm queries the database daily to identify drugs nearing their expiration within a 30-day threshold. Python's datetime module is used for date comparisons, ensuring accurate and efficient processing. Identified drugs are flagged for further action.

4.4. Email Alerting Mechanism

The email alerting system is integrated using Python's smtplib library. When the expiry date detection algorithm flags drugs, the system generates email alerts containing detailed drug information. These alerts are sent to pre-configured email addresses of pharmacists, healthcare providers, and inventory managers. The SMTP server is configured to ensure reliable and secure email delivery.

4.5. Testing and Validation

The system was tested in a controlled environment with a sample dataset to validate its functionality. The expiry date detection algorithm accurately identified drugs nearing expiration, and the email alerting mechanism reliably sent notifications. User feedback was gathered to refine the system further, ensuring it meets the needs of healthcare providers and inventory managers.

In conclusion, the implementation of this automated system significantly improves the management of drug expiry dates,

enhancing accuracy, efficiency, and safety in pharmaceutical management.

4.6. Results

The implementation of the automated drug expiry date detection and alerting system was evaluated in a controlled environment using a sample dataset of drug entries. The system's performance was assessed based on its accuracy in detecting drugs nearing their expiry dates and the reliability of its email alerting mechanism.

The expiry date detection algorithm, running daily, successfully identified all drugs within the predefined 30-day threshold before expiration. The system generated accurate and timely alerts, demonstrating the algorithm's effectiveness in continuous monitoring and real-time processing.

The email alerting mechanism was tested by configuring it to send notifications to designated email addresses of pharmacists, healthcare providers, and inventory managers. The email alerts contained detailed information about the identified drugs, including names, batch numbers, expiry dates, and quantities. All email notifications were delivered promptly and without errors, ensuring that stakeholders received the necessary information to take timely action.

User feedback indicated significant improvements in efficiency and a reduction in the risk of expired drug usage. Healthcare providers appreciated the automation of the expiry date tracking process, which minimized manual intervention and reduced the potential for human error. Overall, the system proved to be a reliable and valuable tool for enhancing pharmaceutical management and ensuring patient safety.

4.7. Discussion

The automated drug expiry date detection and alerting system represents a significant advancement in pharmaceutical management, offering numerous benefits over traditional manual tracking methods. The successful implementation and testing of the system demonstrated its ability to accurately identify drugs nearing their expiration and promptly notify relevant stakeholders via email alerts. This automation reduces the risk of human error and ensures timely interventions, thereby enhancing patient safety and compliance with health regulations.

User feedback has been overwhelmingly positive, indicating that the system greatly improves efficiency in managing drug inventories. By automating the expiry date tracking process, healthcare providers can focus more on patient care rather than administrative tasks. However, the initial setup and maintenance costs, particularly for smaller healthcare facilities, could be a barrier to widespread adoption. Additionally, adequate training for staff is essential to ensure the system's effective use.

The system’s reliance on email alerts is effective, but expanding notification methods to include SMS and mobile app push notifications could further improve responsiveness. Integrating artificial intelligence and machine learning could also enhance the system's predictive capabilities, potentially identifying patterns and trends in drug usage and expiry.

Overall, the system provides a robust solution for managing drug expiry dates, significantly reducing the risk of expired drug administration and ensuring more efficient pharmaceutical management. Future enhancements and broader integration will further solidify its role in advancing healthcare technology.

5. Conclusion and Future Directions

5.1. Conclusion

The automation of drug expiry date detection and alerting through emails is a significant step forward in pharmaceutical management. This system addresses the critical need for accurate and efficient tracking of drug expiry dates, which is essential for ensuring patient safety and regulatory compliance. By integrating a centralized database, barcode or QR code scanning, a robust expiry date detection algorithm, and an efficient email alerting mechanism, the system minimizes human error and enhances operational efficiency.

The successful implementation and testing of the system demonstrated its effectiveness in accurately identifying drugs nearing their expiration and sending timely email notifications to relevant stakeholders. User feedback highlighted significant improvements in inventory management efficiency and a reduction in the risk of administering expired drugs.

While the system offers substantial benefits, challenges such as initial setup costs and the need for staff training must be addressed to facilitate wider adoption. Future improvements could include expanding notification methods to SMS and mobile app alerts and integrating artificial intelligence to enhance predictive capabilities.

In conclusion, the automated drug expiry date detection and alerting system represents a valuable advancement in healthcare technology. It ensures the safe and effective use of medications, improves inventory management, and supports compliance with health regulations, ultimately contributing to better patient care and safety.

5.2. Future Directions

Future research and development in this area could focus on enhancing the scalability and affordability of automated systems, making them accessible to a broader range of healthcare facilities. The integration of artificial intelligence and machine learning could further improve the accuracy and efficiency of expiry date detection algorithms. Moreover, expanding notification methods to include SMS and push notifications through mobile applications can provide more comprehensive alerting solutions.

Abbreviations

QR	Quick Response Code
MYSQL	Structured Query Language
SMS	Short Message Service
SMTP	Simple Mail Transfer Protocol
PyQRCode	Is Lightweight and Can Be Used for Various QR Code-related Tasks in Python Projects

Conflicts of Interest

The authors declare no conflicts of interest.

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