

Drug Inventory and Supply Chain Tracking System

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Abstract— Problems that are still being experienced in most healthcare institutions are issues of late delivery, discrepancies in stocks, wastage of drugs, and the frequent shortage of required medicines. These are not the only issues that increase the cost of operations, but they may negatively affect patient safety and continuity of treatment. The paper will examine how the emergence of new digital tools like RFID systems, cloud-based inventory solutions and blockchain systems can increase openness and collaboration in pharmaceutical supply chains. The paper does not focus on the technological alternatives but rather addresses how such tools can solve the inefficiencies that are witnessed within the hospital setting.

Keywords — Medication stock control, pharmaceutical logistics, digital tracking technologies, clear supply chain system, cloud-based hospital inventory, healthcare management.

I. INTRODUCTION

The pharmaceutical supply network is the area of assurance of being able to get the required medicines on time. Correct drug inventory management ensures continuity of treatment, manages the costs of operations, and safeguards patient safety. Although it is important, stock-outs, product gluts, and medication errors are frequent occurrences in the majority of healthcare facilities, which impact the hospitals negatively [1].

A. Drug Inventory Management Significance

Inventory control has a direct relationship with the outcome of patients. In cases where medicines needed are supplied at the appropriate time, the treatment goes on well. On the other hand, the shortages of stock can interfere with the therapy and in worst cases, they can increase the health risks of the patients [2]. On the other hand, overstocking may also lead to wastage particularly in cases where the drugs expire. According to the WHO reports, medication wastage might be reduced by up to 30 percent with improved inventory practices, which improves financial efficiency and the performance of the system [3].

B. Problems in classical Inventory Management

The manual-based inventory control is the traditional inventory control that is prone to human errors and data inconsistencies that tend to create an inaccuracy between the recorded and actual stock quantities [4]. Without the real-time visibility, hospitals are unlikely to plan their procurement accurately or respond promptly to changing demand patterns. A study by Lee and Kim demonstrates that outdated inventory systems contribute to an increase in the rate of medication

errors by up to 15% which explains the reason why more dependable and automated solutions must be embraced [5].

C. Role of Technology

There are more organized systems of controlling pharmaceutical inventories with the help of technological innovations. One of the tools that increase accuracy in tracking and help in ensuring that medicines are checked during dispensing is RFID and barcode systems [6]. Another one is that data-driven solutions like predictive analytics can help make the demand forecasting and inventory planning more accurate. These technologies can help to minimize wastage, increase operational coordination, and patient safety with an effective implementation, but the successful adoption only depends on adequate infrastructure and training [7].

II. LITERATURE REVIEW

Available literature stresses the increased significance of digital change in pharmaceutical supply chains. The technology-based systems help in reducing wastages in the inventory management, improving traceability as well as helping in making superior decisions. Also, in addition to the development of healthcare operations, the tendency to use digital devices to maintain an inventory in real time, facilitate accuracy and patient safety in the process of drug delivery also gains popularity in the institutions.

A. Technology Integration

The integration of technology has been critical in supply chain. As a part of the research, RFID, QR codes, and cloud-based inventory systems positively influence the accuracy of track and facilitate the process of managing stocks [8]. Another application of blockchain enhances the intensity of data security because they offer a tampered transaction record that is risk-free and minimizes the risk of counterfeiting drugs [9]. Once integrated into one platform, communication among hospitals, suppliers and the regulatory agencies will be more effective thus improving the performance of the supply chain.

B. Patient Safety

Inventory measurements have a positive effect on patient safety. The studies have shown that automated systems result in fewer stockouts and medication errors that result in better patient outcomes [10]. RFID and the verification of barcodes enhance the correct dispensing of the products and real-time analytics provide the opportunity to restock in time, minimizing the clinical risks and improving the quality of care [11].

C. Implementation Problems

According to recent studies, the digital technology is slowly gaining importance in improving the pharmaceutical supply chains. The traditional inventory systems are traditionally linked to problems like delays, the lack of availability of information and insufficiency of coordination between hospitals, suppliers, and other interested parties. As the healthcare systems have become more complex, organizations are now employing the latest technological solutions that allow tracking the stocks in real time, have greater accuracy in stocks handling, and patient safety in the process of medication distribution.

D. Traceability and Regulatory Compliance

Regulatory compliance is a measure that must be taken by the pharmaceutical industry to guarantee patient safety and prevent counterfeit drugs. Closer observation and traceability systems will ensure that the drugs will safely and legally pass through different distribution levels, also traceability will be enhanced by blockchain platforms and QR tracking systems that will ensure the maintenance of secure and verifiable records. Their usage also helps to comply with the regulatory frameworks which involve GDP and DSCSA. Studies showed that the effective traceability systems can reduce the distribution of the counterfeit drugs by over 80 percent particularly during the crisis such as the pandemic where the supply chains are likely to be more vulnerable.

E. Role of Data Analytics

Inventory data that is in large amounts is transformed into insights, which can be utilized to plan and make better decisions using data analytics. The predictive tools also help healthcare organizations to forecast the demand of the drugs, monitor their usage, and manage the procurement process effectively and reduce wastage, and avoid shortages. The machine learning models also enhance the accuracy by identifying the seasonal behavior and change in patient demand. On the whole, the data-driven supply chains enhance the efficiency, cost reduction, and reliability.

F. Impact of Supply Chain Interruptions

The recent health crises in the world and the COVID-19 outbreak, in particular, stated that the existing systems have numerous weaknesses. The disruption of transport and supply chain caused the unavailability of needed medicines, which is an unknown supply, proved that a more resilient system is needed. The visibility of suppliers and shipments, as well as stock, has been improved by the cloud solutions and real-time location tracking. These technologies guarantee that supply chain is better-built and capable of overcoming any unforeseen obstacles. G. Environmentally Friendly Approaches to Supply Chain.

G. Environmentally Friendly Methods to Supply Chain

Sustainability is now a topic of concern in healthcare supply chains where organizations are trying to reduce waste and carbon emission. The harm to the environment can be minimized through green logistics practices which involve designing efficient transportation routes, using environmentally friendly packaging and replacing paper records with electronic records, in addition to minimizing costs of operations.

H. Staff Preparation and System Adaptation

Modern inventory systems to be effective need to be supported and properly trained healthcare staff in the

transition process. A good implementation of advanced inventory systems needs to be supported and trained properly.

This is because healthcare staff should be guided regularly to know and be able to use new technologies. Effective communication, involvement of employees and feedback systems will assist in minimising resistance and facilitate an easy implementation. .

III. METHODOLOGY

This part describes the planning of the proposed system, how it was implemented, evaluated and monitored the stock levels of the drugs. The system is based on the combination of blockchain, cloud computing, and predictive analytics to make pharmaceutical inventory and distribution more transparent, secure, and efficient.

A. System Design

The DISCTS is structured into the three layers that include the frontend, backend, and database layer. The frontend will have an interactive dashboard among hospitals, suppliers and authorities. The backend controls the user authentication, data processing and system operations. A cloud-based database and blockchain technology provide the safety and impossibility of altering drug records, and real-time data access and storage are ensured. The other tools allow live shipment tracking and visual data analysis to make it scalable and reliable.

B. Implementation

The implementation phase entailed the construction and the unification of all the significant system modules on one platform. A distinct QR code was allocated to each batch of medicine related to blockchain to allow full traceability. The back-end was hosted on the cloud, which updated the stock levels, orders and deliveries in real-time. Access was restricted by using secure authentication and low stock and expiry notifications were automatically configured. On-site verification and tracking were also done by developing a mobile application. Ultimate testing ensured the absence of stuttering data flow, fast response time, and consistent system performance.

C. Data Collection

The information was gathered using simulated and real-time sources of hospitals, suppliers and distribution centers. All records had information about drug ID, batch number, expiry date, supplier information and blockchain transaction data. History usage was also used to aid in predicting demand. To guarantee the accuracy, consistency, and efficient analysis of all data, all data was safely stored in a cloud-based PostgreSQL database.

D. Data Analysis

The obtained data was analyzed in terms of predictive analytics and time-series forecasting with the purpose to predict the demand in drugs in the future and enhance the decisions related to restocking. Trend analysis was used to determine seasonal patterns whereas anomaly detection was used to identify unusual stock behaviour or delays. The main performance indicators including stock turnover, wastage rate, and delivery efficiency were put on the dashboard to be easily monitored. The constant analysis enhanced planning, minimized mistakes, and enhanced general inventory control.

E. Evaluation

The system was tested on the accuracy, usability, and general efficiency within a healthcare setting. Measurements involved such factors as improvement in stock shortages, transparency tracking, and system performance. Simulated hospital and vendor data pilot testing revealed some apparent improvements with fewer stockouts and enhanced transparency due to blockchain verification. Users found the user-friendly and intuitive interface, such that staff can make faster inventory decisions. The system enhanced the tracking and monitoring of medicine. On the whole, the DISCTS system demonstrated a good level of reliability and scalability and could be deployed on large-scale healthcare.

F. Project Development flowchart

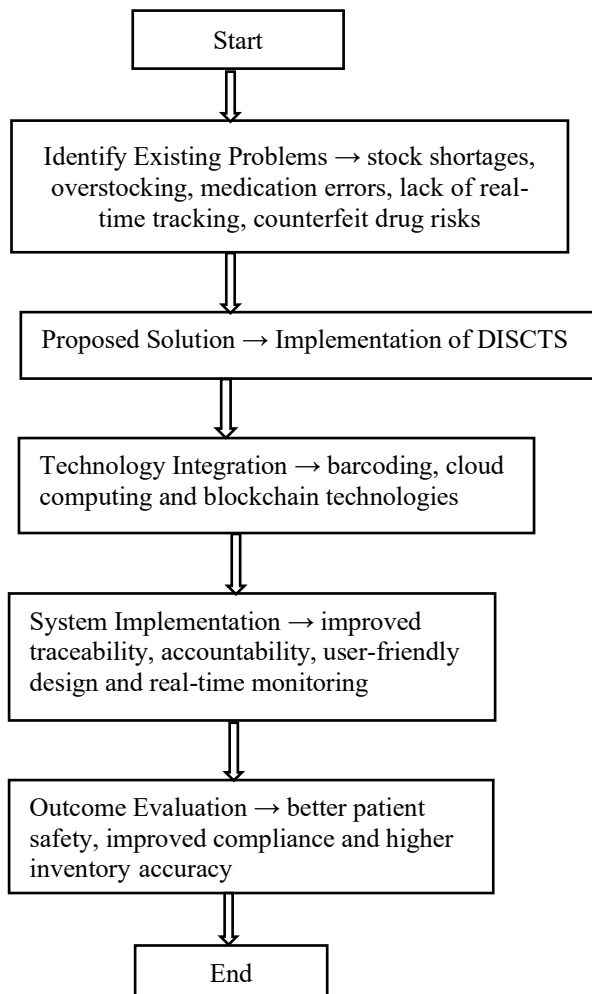


Fig. 1 Depicts the DISCTS workflow for improving

The development of the project begins with defining significant problems in the pharmaceutical management of inventory, and the DISCTS solution was suggested. The secure tracking, transparency, inventory accuracy, compliance, and patient safety were improved with the help of barcoding, cloud computing, and blockchain.

TABLE I. TARGET AUDIENCE TABLE

Target Group	Description	Expected Benefits
Healthcare Professionals	Doctors, nurses and pharmacists who are directly involved in handling patients and medicines	Better visibility of medicine stock, fewer medication mistakes, and overall safer treatment for patients
Pharmacy Staff	People responsible for storing, managing and dispensing medicines in healthcare centers.	Easier inventory handling, reduced shortage situations, less wastage of medicines, and smoother daily workflow
Hospital Administration	Authorities who manage hospital operations, planning and regulatory responsibilities	Improved operational control, better planning of resources, and stronger compliance with healthcare rules
IT Support Teams	Technical professionals managing implementation and maintenance of digital healthcare systems	Easier system maintenance, improved data security, and more organized handling of healthcare information
Patients	Individuals receiving medicines and healthcare services	Better availability of required medicines, improved communication, and safer treatment experience
Regulatory Bodies	Organizations responsible for maintaining healthcare standards and regulations	Improved tracking and monitoring of medicines, better fraud detection, and stronger public health safety

IV. RESULTS AND DISCUSSION

This part is the Home Module, the primary Interface of the Real-Time Drug Inventory and Supply Chain Management, where one can view the activities of the system in real time. It displays crucial information like stock position, order, and delivery information, system alert among others which the users can readily access at any point in time. The user may also find it easy to navigate through the home page where significant updates of the site are displayed like out of stock medicines, shipments, and expired drugs. It is also the one that helps in viewing of reports and helps in monitoring of system performance.

TABLE II. PERFORMANCE COMPARISON METRICS

Key Performance Indicator (KPI)	Before DISCTS Implementation	After DISCTS Implementation	Improvement (%)
Inventory Accuracy (%)	75%	95%	26.67% improvement
Frequency of Stockouts (per month)	10	2	80% reduction
Average Time Required for Restocking (days)	7 days	3 days	57.14% faster
Medication Errors (per 1000 doses)	15	6	67.80% reduction
Weekly time for Inventory Handling(hour)	20hrs	10hrs	50% improvement
Compliance with Regulatory Standards (%)	70%	95%	35.71% improvement



Fig. 2. Homepage

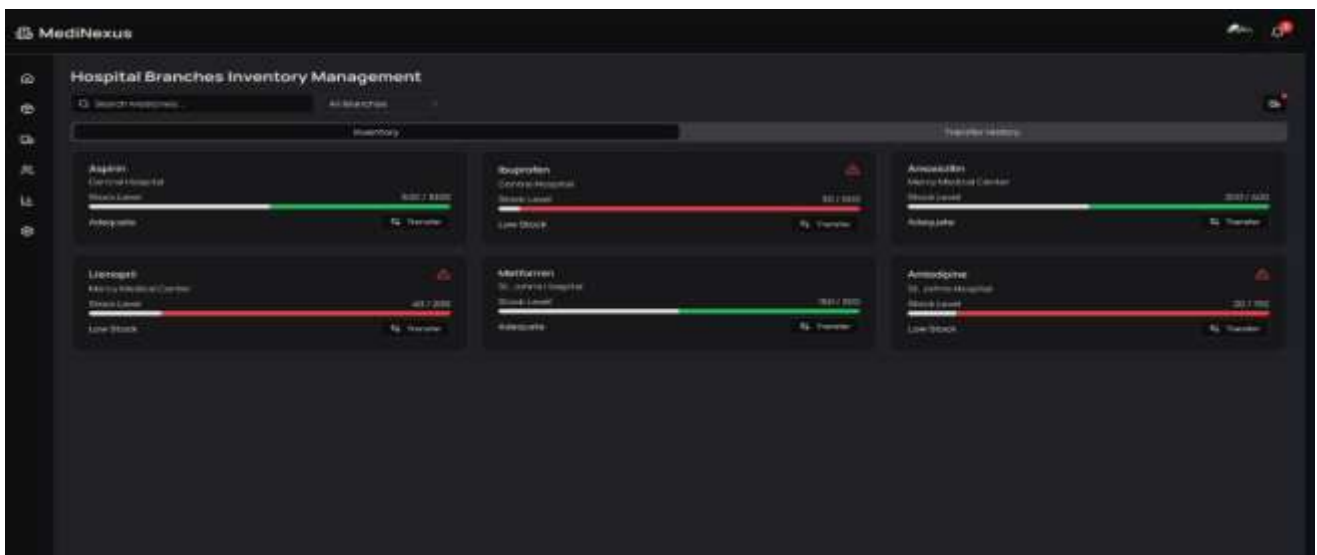


Fig. 3. Stock Updates

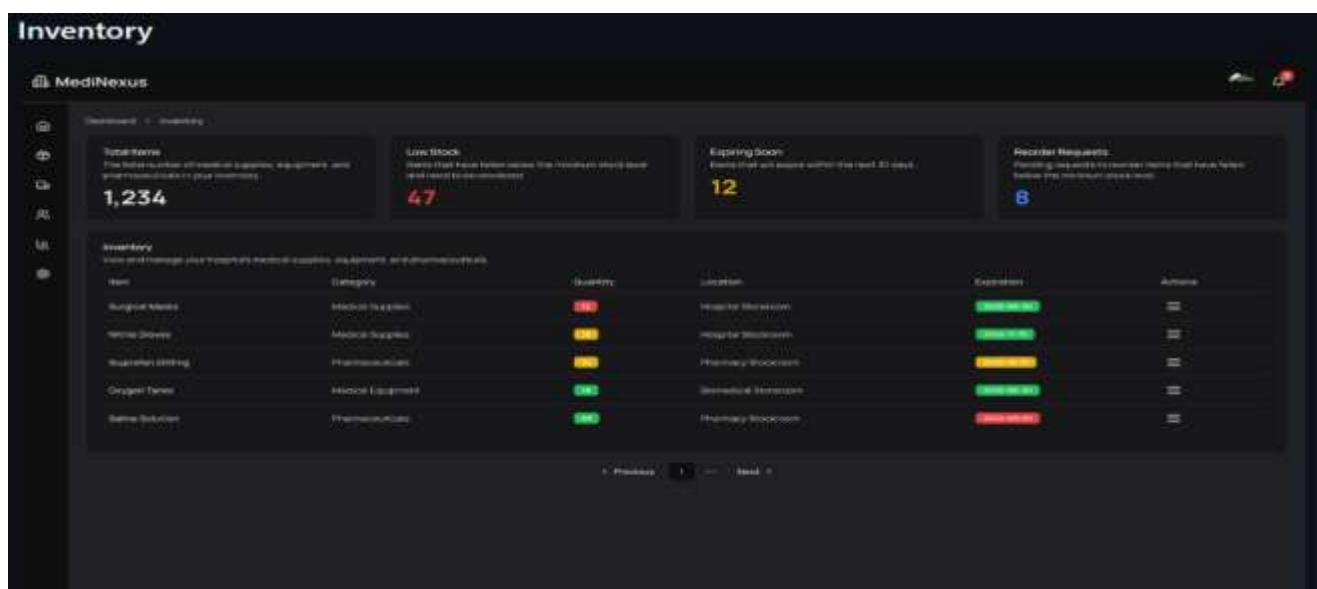


Fig. 4. Inventory

V. CONCLUSION

The proposed idea of DISCTS demonstrates that with the help of innovation and technologies, it is possible to implement a revolution in the existing system and dynamics of drug inventories management. These findings of our research have led us to the conclusion that such technologies that include barcoding, cloud computing, blockchain, and maintaining big chains between hospitals and inventories will result in the domain of high inventory accuracy and measurement, eliminate the cases of stockouts in case of demand, and traceability and availability of pharmaceutical products. Along with the additions to the operational functionality of the management system, they are helpful in refining the health of the patients, too, as the errors in the accounts are reduced, and receiving the required medicine becomes simpler. The introduction of DISCTS (Drug Inventory Tracking and Supply Chain Tracking System) will contribute to the major increase in the accuracy of inventory management and reflected in the results through the increase in the percentage of accuracy and the reduction in the number of stockouts. These results can be observed in the change where the DISCTS is being applied in a large scale. These results prove that it is feasible to account and manage this supply chain with the assistance of the application and indicates that it results in the introduction of the clear and efficient supply chain of pharmaceuticals through the drug inventories which is facilitated by the application of the blockchain technology. Therefore, risks associated with counterfeit drugs are real, however, detection rate of the counterfeit drugs is high, to address this regulation will be achieved as the openness will be known between organizations. It proves healthy to the health cares, who are keen on introducing an improved drug management approach to maintain and run the drugs that minimize system inefficiency that may impinge on the health of the patient. This can also encourage the exploration of the DISCTS and such undertakings in the future which can be attributed to technologies and researches in the future. It will translate to a familiar beneficiary product that principally addresses the need, requirements of the user and whether the user is contented; that is how it will be facilitated by the future scope and technologies, be improving with the emerging technologies such as AI and ML too so that we can manage our pharmaceutical inventories more effectively. In summary therefore, whenever the management of such a drug inventory and the supply chain that ensures the whole distribution of drugs flow in place, is relief when such an application and technology is introduced when it is most needed. It is that we now possess the technologies, and, thus, we will devise ways to ensure that our applications become the source of quality, better, and healthier lives of the patients as the result. So here to draw a conclusion prospectively, the execution of such an application and technology when it comes to the management of these drug inventories and the

supply chain, which manages the entire drug flow distribution, is a relief whenever it comes to encountering the issues which are encountered in the use and adherence of traditional practices. We now possess the technologies, and thus, we will discover ways of ensuring that our applications bring about quality, better and healthier lives of the patients as the fruit.

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