



A REVIEW OF INVENTORY MANAGEMENT PRACTICES IN THE PHARMACEUTICAL INDUSTRY: CHALLENGES AND OPTIMIZATION STRATEGIES

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ABSTRACT

The pharmaceutical supply chain directly influences patient outcomes and healthcare system effectiveness by ensuring the consistent supply of safe and effective medications. Nonetheless, inventory control in this field encounters ongoing issues like stock shortages, purchasing inefficiencies, and excess stock, leading to higher operational expenses and jeopardizing patient care. This study aims to assess existing inventory management practices and identify effective strategies for improving supply chain efficiency. Employing a narrative review approach, recent studies on inventory management methods, technological implementations, and drug supply networks were analysed. Relevant research was systematically reviewed to pinpoint shared difficulties and assess various optimization methods employed in practice. The findings indicate that the primary causes of inefficiencies are insufficient coordination among stakeholders, inaccurate demand predictions, and a deficiency in real-time inventory oversight. The performance of inventory is significantly improved by merging conventional inventory management strategies with advanced digital technologies such as data analysis and automated systems. Enhanced planning, improved integration of information systems, and better coordination were discovered to decrease surplus inventory and avert shortages. The research concludes that implementing a comprehensive and advanced technological method for inventory management can enhance productivity, minimize waste, and ensure a consistent supply of medications. This research is distinctive as it merges traditional and modern methods to provide a thorough framework for enhancing the performance of the pharmaceutical supply chain.

KEYWORDS: Demand forecasting; digital inventory systems; healthcare supply chain; inventory optimization; pharmaceutical logistics; supply chain coordination.

INTRODUCTION

The complex and interrelated pharmaceutical supply chain encompasses the production, storage, distribution, and delivery of drugs from manufacturers to end consumers. It encompasses several entities, such as manufacturers, distributors, wholesalers, and healthcare providers, each of whom plays a vital role in ensuring the consistent and efficient movement of pharmaceutical products. To meet healthcare needs, this system must maintain high levels of quality, safety, and reliability while functioning within strict regulatory guidelines.

The delivery of healthcare depends heavily on the availability of medications since prompt access to necessary medications lowers complications, stops the progression of disease, and enhances patient outcomes. Serious repercussions, such as treatment delays and elevated patient health risks, may result from any disruption in this supply chain (Jaberidoost et al., 2013; Uthayakumar & Priyan, 2013).

The necessity for effective supply chain

management techniques has increased recently due to the growing complexity of global supply networks and the growing demand for pharmaceutical products (Kumar et al., 2021). Despite its importance, inventory management in the pharmaceutical supply chain still faces a number of persistent challenges. Since they immediately affect patient care and render essential pharmaceuticals unavailable, stockouts are among the most severe issues. Procurement inefficiencies are another major problem that can lead to supply disruptions, delays, and increased operating costs. Other problems including product expiration, increased holding costs, and resource waste are also caused by overstocking. These problems are frequently caused by poor supply chain stakeholder coordination, inaccurate demand forecasts, and a lack of real-time inventory visibility (Jha et al., 2018; Saha & Ray, 2022). Inventory management procedures are further complicated by the perishable nature of pharmaceutical products as well as strict handling and storage regulations (Uthayakumar & Priyan, 2013). Despite the fact that numerous research have looked at various facets of

pharmaceutical supply chains, there is still a dearth of thorough knowledge that incorporates these difficulties with contemporary technology developments and useful optimisation techniques. The majority of the literature now in publication concentrates on distinct aspects of inventory management, such as procurement tactics, forecasting methods, or certain technology solutions. Studies that offer a comprehensive viewpoint by fusing conventional inventory control techniques with cutting-edge digital solutions and coordinated supply chain procedures, however, are conspicuously lacking. This disparity emphasises the necessity of a thorough analysis that integrates different aspects of inventory management in order to more successfully eliminate inefficiencies. Furthermore, the contribution of real-time data and integrated systems to better decision-making and supply chain responsiveness has received less attention. Investigating methods that can guarantee inventory management's resilience and efficiency is crucial as pharmaceutical supply chains grow more dynamic and globally integrated. Thus, the goal of this study is to evaluate the pharmaceutical industry's current inventory management procedures critically, pinpoint major issues, and suggest possible solutions. The increasing requirement to improve supply chain performance while guaranteeing continuous access to medications is the driving force behind the study. It seeks to shed light on how enhanced coordination mechanisms, digital inventory systems, and sophisticated forecasting techniques might support more efficient inventory control. This review aims to help create a pharmaceutical supply chain framework that is more integrated and effective by filling in the gaps in the literature. This study, which focused on international pharmaceutical supply chain procedures, was conducted between 2025 and 2026.

MATERIALS AND METHODS

Study Design

The pharmaceutical supply chain's inventory management procedures were examined using a narrative review design. This method was chosen to enable the synthesis and integration of results from many sources, offering a

thorough grasp of intricate supply chain issues and optimisation techniques (Green et al., 2006; Snyder, 2019). The study concentrated on important problems such overstocking, procurement inefficiencies, and stockouts as well as methods for enhancing inventory performance.

Data Sources and Study Area

Numerous scholarly databases, including Scopus, PubMed, ScienceDirect, Google Scholar, and ResearchGate, were used to gather the data. These databases were chosen because they cover a wide range of peer-reviewed research in supply chain management and pharmaceutical sciences. Rather than concentrating on a particular geographic area, the study examined worldwide pharmaceutical supply chain patterns. In order to capture recent advancements in inventory management systems, especially those integrating digital technology and predictive techniques, literature published between 2020 and 2026 was taken into consideration (Mongeon & Paul-Hus, 2016; Carpitella & Izquierdo, 2025).

Search Strategy

To find pertinent material, a methodical search approach was used. Pharmaceutical supply chain, inventory control, stockouts, procurement inefficiencies, overstocking, inventory optimisation, ABC analysis, Just-in-Time, and predictive analytics were among the keywords that were employed. To improve the relevancy of the chosen studies and narrow down the search results, boolean operators like AND and OR were used. To guarantee thorough coverage of the available literature, the search procedure was carried out methodically across all chosen databases (Snyder, 2019).

Data Collection and Sample Characteristics

Based on their emphasis on supply chain management for pharmaceuticals or healthcare, pertinent studies were found and chosen. A methodical methodology was used to retrieve data, including details about supply chain performance, inventory issues, and optimisation strategies. Peer-reviewed journal papers and associated scholarly publications covering both conventional and contemporary inventory management techniques made up the sample that was gathered. A variety of viewpoints,

including theoretical models, analytical techniques, and technology-driven solutions, were represented in the investigations.

Analytical Approach

A qualitative theme analysis approach, which entails uncovering patterns and classifying data into relevant categories, was used to analyse the chosen papers (Braun & Clarke, 2006). Major supply chain issues such as overstocking, procurement inefficiencies, and stockouts were examined, along with variables affecting inventory management systems.

Both contemporary methods like artificial intelligence, optimisation models, and predictive analytics were taken into consideration, as well as more conventional inventory techniques like ABC analysis, Economic Order Quantity, and Just-in-Time systems. This method made it possible to thoroughly assess the many tactics employed to enhance inventory management procedures (Deekshitha et al., 2025; Shriharsha et al., 2025).

Key Analytical Framework

The main supply chain issues and influencing factors served as the framework for the analysis. Stockouts were taken into account in connection to supply disruptions, forecasting constraints, and demand fluctuation. Lead time delays, procurement planning, and supplier cooperation were all considered aspects of procurement inefficiency. Demand estimate errors and inventory control constraints were used to analyse overstocking.

Important elements influencing inventory performance were also taken into account, such as unpredictability in demand, poor connections with suppliers, a lack of information sharing, a lack of internal coordination, and external disruptions like pandemics and supply chain disruptions. These elements ensured a methodical assessment of the literature and served as a guide for the theme classification.

Reliability and Consistency

Several databases were used for data collecting, and a methodical search approach was employed to guarantee dependability. Maintaining consistency throughout the

investigation was made possible by the use of standardised keywords and methodical analysis techniques. The methodical and repeatable nature of the literature evaluation was guaranteed by the topic analysis technique.

RESULTS AND DISCUSSION

The research analyzed indicated that the structure of the supply chain and inventory management methods significantly affect the performance of pharmaceutical systems. Precise demand prediction, efficient stakeholder collaboration, and the integration of digital technology were identified as key factors that improve inventory outcomes. The analysis revealed that businesses employing technology-focused and cohesive strategies enhanced supply chain agility and inventory management (Kumar et al., 2021). A key finding from the reviewed literature was the significance of supply chain resilience in reducing stockouts. Drug shortages were more probable when supply systems showed a lack of redundancy and flexibility. Conversely, utilizing backup suppliers and alternative procurement methods significantly reduced stockout occurrences (Yoseph & Sunitiyoso, 2025). The utilization of data-driven models and predictive analytics emerged as another important discovery. These instruments were found to potentially identify shortages with moderate to high accuracy, allowing companies to implement preventative measures (Shriharsha et al., 2025). This outcome aligns with the increasing adoption of digital technologies such as artificial intelligence and machine learning in supply chain management. Nowadays, the precision of forecasts and the effectiveness of decision-making are more reliant on these technologies. Furthermore, the study revealed that inventory performance benefited from internal integration, strong supplier relationships, and effective information sharing. Companies employing integrated information systems and maintaining strong relationships with suppliers were more capable of managing inventory levels and responding to demand fluctuations (Saha & Ray, 2022). These results support previous studies emphasizing the importance of collaboration and transparency in supply chain operations. It was found that traditional inventory management techniques such as Just-

in-Time systems, ABC analysis, and Economic Order Quantity remained relevant. Nonetheless, when combined with modern digital technologies, their effectiveness was significantly enhanced (Singh, 2023). For instance, forecasting tools enhanced demand precision, resulting in ideal inventory quantities, while Just-in-Time methods helped in minimizing excess inventory. This highlights the importance of integrating traditional and modern approaches to enhance performance.

Additionally, studies indicated that proactive strategies—such as automated inventory management, improved coordination, and real-time tracking—outperformed reactive methods, like emergency procurement (Carpitella & Izquierdo, 2025). Proactive planning improved supply chain responsiveness and lowered risks, whereas reactive strategies often raised operating costs and diminished efficiency.

RESEARCH GAP

There are still a number of important gaps in the vast amount of literature on inventory control and pharmaceutical supply chain management. Previous research has mostly concentrated on individual facets of inventory management, such as demand forecasting, procurement tactics, or the usage of certain inventory control methods like Just-in-Time systems, ABC analysis, and Economic Order Quantity. Nevertheless, there aren't many thorough studies that combine these conventional methods with cutting-edge digital technologies like automated inventory systems, artificial intelligence, and predictive analytics. The complexity of pharmaceutical inventory management is difficult to properly comprehend and handle with this disjointed approach.

Additionally, while numerous studies highlight the need of lowering stockouts and enhancing supply chain effectiveness, managing several issues at once, such as overstocking and inefficient procurement, has received less attention. Instead of examining these problems' links and combined effects on supply chain performance, the majority of study chooses to look at them separately. Because of this, there is not enough data on integrated frameworks that can successfully handle these issues in a coordinated way.

The practical application of cutting-edge technologies is another major gap. There is a dearth of empirical research illustrating the practical use of digital tools like real-time monitoring systems and predictive analytics in pharmaceutical supply chains, despite a number of studies highlighting their promise. The usefulness of many current models in real-world healthcare settings is limited since they are theoretical or based on simulated data. Furthermore, the research has not sufficiently addressed problems with data integration, system compatibility, and organisational readiness.

Furthermore, little is known about the importance of information exchange and stakeholder cooperation. Although cooperation between supply chain actors is acknowledged as crucial, little research has been done on how integrated information systems and real-time data exchange might be successfully applied to enhance inventory performance and decision-making. More research is necessary to fully understand the effects of external disturbances, such as pandemics and uncertainties in the global supply chain, especially when it comes to developing robust and flexible inventory systems.

Thus, by offering a thorough examination of pharmaceutical inventory management procedures, this review seeks to close these gaps. It studies the combined effects of stockouts, procurement inefficiencies, and overstocking and combines conventional inventory control techniques with contemporary digital methodologies. This study advances the creation of a more comprehensive and integrated framework for improving pharmaceutical supply chain performance by emphasising both theoretical insights and practical ramifications.

CONCLUSION

The efficacy of the pharmaceutical supply chain, which affects medication availability, operational effectiveness, and the standard of healthcare delivery, is fundamentally dependent on inventory management, as this review highlights. The analysis shows that major problems, such as overstocking, procurement inefficiencies, and stockouts, are interrelated and frequently result from common underlying

factors like demand uncertainty, poor forecasting techniques, poor coordination, and inadequate visibility of inventory data. The conversation emphasises that while both conventional inventory control techniques and cutting-edge technology-driven strategies help to address these issues, their combined use yields more successful and long-lasting results.

This study's primary finding is that dealing with specific inventory problems alone is inadequate and could have unforeseen repercussions in other supply chain segments. For instance, cost-focused tactics may jeopardise the supply of medications, while attempts to avoid shortages without enhancing procurement strategy or information systems may lead to surplus inventory. As a result, a thorough and integrated strategy that combines precise demand estimation, effective procurement procedures, real-time monitoring technologies, and robust cooperation among supply chain partners is needed.

This strategy guarantees balanced inventory levels, minimises waste, and improves pharmaceutical supply chains' responsiveness and dependability.

This review's distinctive feature is its integrated viewpoint, which offers a comprehensive grasp of pharmaceutical supply chain optimisation by fusing cutting-edge digital technologies with conventional inventory management strategies. This review contributes to a more holistic framework for enhancing inventory performance by combining many factors, such as operational issues, technological improvements, and coordination mechanisms, in contrast to studies that concentrate on specific areas.

The study has certain limitations despite its contributions. The research is predicated on secondary data from previously published literature, which could not accurately reflect the complexities and variances found in various healthcare systems in the real world. Furthermore, the practical use of cutting-edge technology is still restricted, and the generalisability of certain discoveries is constrained by the absence of empirical validation. These drawbacks highlight the need for more investigation based on practical

applications and data-driven assessments. Future studies should concentrate on the real-world application of cutting-edge technology in pharmaceutical settings, such as automated inventory tools and intelligent data systems. Additionally, integrated models that blend conventional techniques with contemporary digital approaches must be created, and these models must be validated through empirical research. Enhancing supply chain resilience should also receive more attention in order to handle outside disturbances and guarantee the effective inventory control, lower operational risks, and guarantee the ongoing availability of necessary medications by implementing such a strategy, which will ultimately enhance healthcare results.

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