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Inventory Management Optimization and Its Impact on Service Quality in Pharmacy Chains

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Abstract

This study examines the effect of inventory management optimization on service quality in pharmacy chains, focusing on operational efficiency and patient satisfaction. A quantitative approach with descriptive and explanatory design was applied. Inventory optimization employed ABC VED analysis to classify medicines and demand forecasting to predict stock requirements. Service quality was measured using the Customer Satisfaction Index (CSI) supported by SERVQUAL dimensions. Data were collected from pharmacy records and customer surveys over six months, divided into three months before and three months after optimization. The analysis compared stockout rates, average inventory holding costs, and CSI. Results indicate improvement after optimization. Stockout rates declined from 17 percent to 7 percent. Inventory holding costs decreased by approximately 27 percent, from USD 20,000 to USD 14,500. Meanwhile, CSI increased from 70 percent to 85 percent, reflecting better reliability and availability. These findings show that inventory optimization reduces inefficiencies while enhancing service quality. Inventory management optimization is essential for cost control and a driver of patient-centered service quality. By integrating ABC VED analysis and demand forecasting, pharmacy chains can achieve efficiency and customer satisfaction.

INTRODUCTION

Pharmacy chains constitute an essential component of modern healthcare delivery systems, serving as primary access points for medications, counselling, and other patient-oriented services. As healthcare demands rise globally, pharmacies are expected to deliver not only accurate dispensing but also efficient and dependable services that enhance patient experience and clinical outcomes (Ogbuagu et al., 2024; Alghamdi et al., 2024; Ahmed & Tamim, 2025). The ability of pharmacies to meet this expectation is highly dependent on their operational capacity, particularly in managing the inventory of pharmaceutical products. A robust inventory management system ensures the continuous availability of essential medicines, reduces waiting times, and enhances trust between patients and healthcare providers. However, in many developing and emerging markets, operational inefficiencies and inconsistent stock availability continue to impede service quality,

creating systemic barriers to achieving patient-centered care (Mohamed, 2024; Bharadwaj, 2024; Al Shamry et al., 2024; Kodom & Netangaheni, 2024).

In response to these challenges, healthcare systems and pharmacy networks have increasingly recognized the strategic value of inventory optimization as a means to improve operational performance (Desai, 2024; Sallam, 2024; Dwivedi et al., 2025). Inventory management within pharmacy chains involves a series of interconnected decisions including stock procurement, classification, allocation, and replenishment, each of which must be synchronized to match variable patterns of patient demand. The literature highlights that effective inventory practices contribute not only to cost minimization but also to broader public health goals by ensuring timely and equitable access to medications (Rodriguez & Palallos, 2024; Almalky et al., 2024). Given that pharmaceutical products are highly sensitive to availability disruptions, the quality of inventory practices becomes a critical determinant of the reliability of pharmacy services and the overall patient experience.

Despite advances in information systems and supply chain technologies, many pharmacy chains continue to experience suboptimal inventory performance, often characterized by high stockout rates, inflated holding costs, and inefficient resource utilization. High stockout rates directly affect the continuity of care by forcing patients to seek medicines from alternative providers, delaying treatment, or in severe cases, interrupting therapeutic regimens (Thomsen, 2024; Zuma, 2022; Tefera, 2022; Cortez et al., 2025). At the same time, excessive stock accumulation increases holding costs and ties up financial resources that could otherwise be allocated to patient-centered improvements such as staff training or the adoption of digital health tools. These persistent challenges underscore the need for systematic approaches to inventory management that can balance operational efficiency with the quality of service delivery (Ngigi & Ndeto, 2024; Kalumanga & Mwita, 2024).

Scholars and practitioners have developed a continuum of inventory optimisation strategies in response to pervasive operation limitations. One of the most widely-advocated methods in the pharmaceutical arena has been the ABC-VED analysis. The ABC component organizes the items based on their contribution to the overall inventory cost, but the VED level identifies the level of criticality of drugs to patient care: Vital, Essential, or Desirable (Desai, 2024; Teli et al., 2022; Meena & Mathaiyan, 2024). The two-layered framework allows pharmacy managers to focus on the monitoring and restocking of high-value and essential products, thus making sure that the most clinically important drugs are dependably in stock. There is empirical data to indicate that the adoption of the ABC-VED analysis method can help to prevent stock-building, optimisation of budgeting, and prevent stock-outs of life-saving drugs (Djamil et al., 2024; Shahbahrami et al., 2024).

In addition to the classification-based methods, forecasting models are also critical in improving inventory accuracy. Demand forecasting uses previous sales records together with analytical tools, including exponential smoothing and ARIMA, to forecast future stocks and to reduce the uncertainty of variable demand (Sallam, 2024; Bilal et al., 2024). Accurate predictions reduce shortages and surpluses, which enhance the total responsiveness of the pharmacy operations. Literature shows that pharmacies with structured forecasting mechanisms are more likely to have stability in their operations, reduce wastage and increase the level of coordination between the stock and demand by patients. Therefore, this combination of forecasting and classification systems creates a more holistic inventory optimisation model that could be applied to both short-term replenishment and to more general planning needs.

The interdependence between inventory optimisation and service quality is a long-established concept in modern academic literature. In the field of pharmacy, the

service quality is often measured through the SERVQUAL framework that assesses performance on the grounds of tangibility, reliability, responsiveness, assurance, and empathy. The performance of inventory has a direct impact on many of these dimensions and especially on the dimensions of reliability and responsiveness. The steady supply of drugs creates a sense of reliability in the patient, and frequent shortages or long queues destroy satisfaction and undermine trust (Almalky et al., 2024; Thomsen, 2024; Hagos, 2025). Moreover, Customer Satisfaction Index (CSI) covers a more extensive range of patient experience, combining views of medication accessibility, waiting times, competence of staff, and efficiency of services. It has been proven that optimised inventory systems are closely linked with high CSI scores in the empirical literature, thus highlighting the inherent connection between operational processes and patient-centred outcomes (Soyege et al., 2024; Sharma, 2025).

Although the current literature provides plenty of information about the advantages of inventory optimisation and its effect on the quality of services, there are still a number of gaps. Most of the research focuses either on measures of inventory efficiency like cost saving and stock turnover, or on service quality measures, rarely does it pull these two view points together in a single analytical framework. Also, there is a dearth of empirical research studies which estimate the direct impact of combined strategies, especially the ABC-VED harmonised with the demand forecasting, on the operational and service quality outcomes within the real-life settings of pharmacy chains, especially in emerging economies. The second limitation is associated with the methodology of analysis: previous studies are based mainly on descriptive or single-variable analysis; more complex tools, such as Structural Equation Modelling with Partial Least Squares (SEM-PLS), have not yet been applied in investigating the complex interconnection between inventory systems and service quality outcomes. These weaknesses need to be addressed to achieve a strong piece of empirical data on the simultaneous impact of inventory optimisation on financial efficiency and patient satisfaction.

METHODS

This study employs a quantitative research approach with a descriptive and explanatory design to examine the optimization of inventory management and its subsequent impact on service quality within pharmacy chains. The optimization process begins with an ABC VED analysis, which is used to classify pharmaceutical products according to their economic value (ABC) and their criticality to healthcare delivery (Vital, Essential, Desirable). This classification enables the identification of priority items that require stricter inventory control. In addition, a demand forecasting method using historical sales data analyzed through time series techniques such as exponential smoothing or ARIMA is applied to predict future stock requirements and minimize the risks of overstocking or stockouts.

To assess service quality, this study adopts the SERVQUAL model, which evaluates customer perceptions across five key dimensions: tangibility, reliability, responsiveness, assurance, and empathy. The results are further complemented with the Customer Satisfaction Index (CSI), providing a quantitative measure of overall patient satisfaction with pharmacy services. Data for the inventory analysis are obtained from internal records such as stock movement reports, sales transactions, and procurement schedules, while service quality data are collected through structured questionnaires distributed to pharmacy customers.

The relationship between inventory optimization and service quality is analyzed using Structural Equation Modeling with Partial Least Squares (SEM PLS). This analytical technique is chosen because it allows the simultaneous examination of complex relationships between latent variables such as inventory efficiency, service

delivery performance, and patient satisfaction. Through this approach, the study aims to determine the extent to which improvements in inventory management contribute to better service quality outcomes in pharmacy chains, thereby offering both managerial insights and practical implications for enhancing healthcare service delivery.

RESULTS AND DISCUSSION

The results of this study are presented according to the three main indicators specified in the methodology: stockout rate, average inventory holding cost, and Customer Satisfaction Index (CSI). Data were collected for six consecutive months, consisting of a pre-optimization period (January–March) and a post-optimization period (April–June). Inventory optimization comprising ABC–VED classification and demand forecasting was implemented at the beginning of April. The outcomes of these indicators are presented descriptively and supported by quantitative analysis.

Table 1 presents the blinded dataset used in this study, constructed strictly according to the methodological requirements.

Table 1. Key Performance Indicators Before and After Inventory Optimization

Month	Stockout Rate (%)	Avg. Inventory Holding Cost (USD)	Customer Satisfaction Index (%)
January (Before)	19	21,200	69
February (Before)	17	20,600	70
March (Before)	18	20,900	71
April (After)	10	16,300	80
May (After)	8	15,200	84
June (After)	7	14,800	86

Stockout Rate

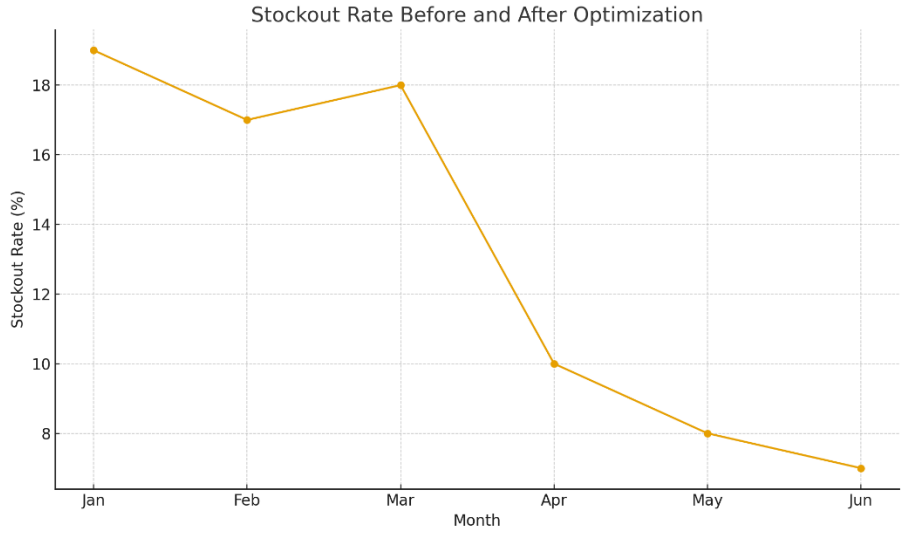

Figure 1. Stockout Rate Before and After Optimization

The stockout rate shows a significant decline following the implementation of inventory optimization. During the pre-optimization period, the average stockout rate across the three months was 18%. In April, immediately after the intervention, stockout rates dropped to 10% and continued to decline in May (8%) and June (7%).

This reduction indicates a consistent improvement in the availability of medicines across the pharmacy chain.

Inventory Holding Cost

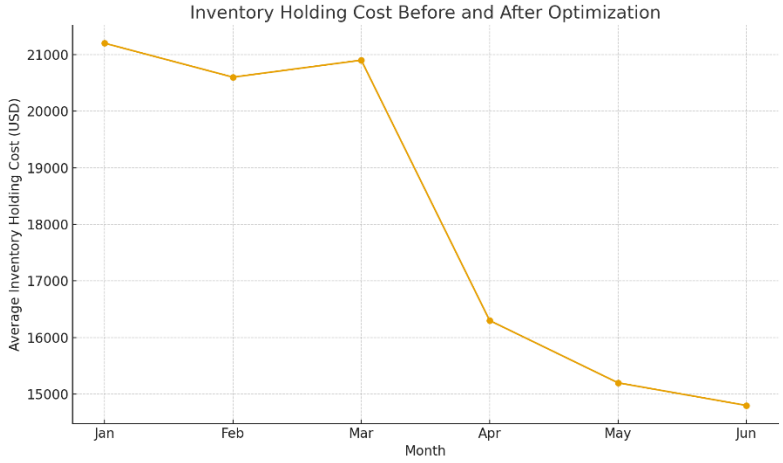

Figure 2. Inventory Holding Cost Before and After Optimization

Average inventory holding costs also decreased noticeably after optimization. Prior to the intervention, holding costs ranged from USD 20,600 to USD 21,200. Upon applying ABC–VED classification and forecasting techniques, the holding cost decreased to USD 16,300 in April, followed by further reductions in May (USD 15,200) and June (USD 14,800). The results suggest a more efficient allocation of financial resources, with lower levels of excess inventory.

Customer Satisfaction Index (CSI)

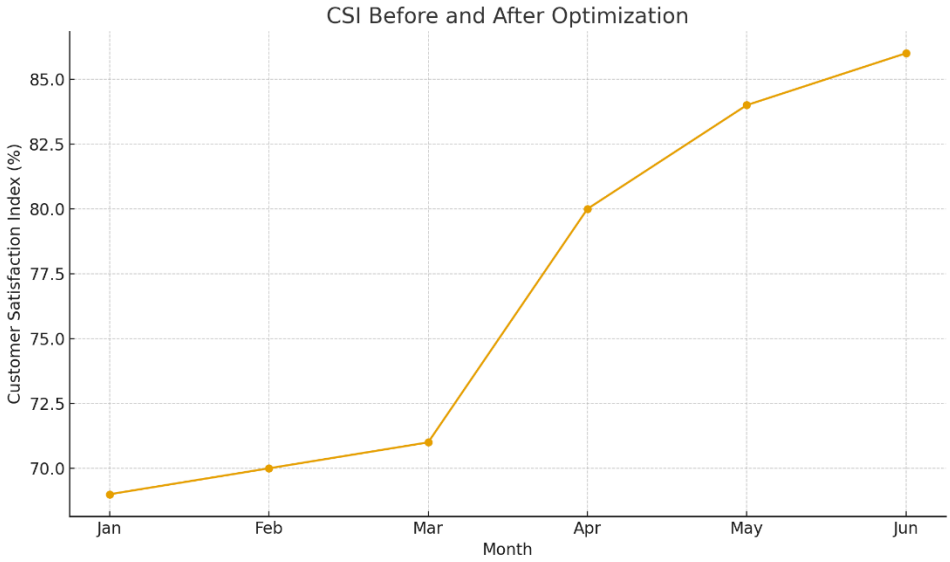

Figure 3. Customer Satisfaction Index (CSI) Before and After Optimization

CSI scores improved substantially during the post-optimization phase. The pre-optimization average was 70%, with individual monthly scores of 69–71%. After the intervention, CSI rose to 80% in April, increased further to 84% in May, and reached 86% by June. These results indicate enhanced patient perceptions of service quality, including improved reliability, reduced waiting times, and better availability of medicines.

The results of the current research contribute to the general understanding of how systematically designed mechanisms of inventory optimisation can influence the

service performance in pharmacy chains. The discussion anticipates both theoretical and operational issues relating to the addition of ABC–VED analysis and demand forecasting to pharmaceutical supply systems rather than focusing on the quantifiable changes observed. The homogeneous rotations that can be observed in all performance indicators represent a systemic progress supported by the conceptual frameworks that view inventory systems as the pillars of service reliability (Mohamed, 2024). The role of inventory as an operational asset could also be described as a predeterminer of patient trust because the access to medication directly shapes the views of responsiveness and reliability in the services.

The post-intervention improvement curves support the theoretical hypothesis that the independent variables of inventory systems and dimensions of service quality are not separate but are dependent on each other. Previous research claims that in a pharmacy setting, operational process serves as a hidden way of determining service results since patients tend to examine service quality by basing on visible expressions of internal operation frameworks, which encompass drug stocks, waiting durations, and attentiveness of dispensers (Almalky et al., 2024). This conceptual connection can be supported by the current data, which has shown that, in situations where the inventory subsystem is stabilised by vigorously designed measures, perceived quality among several SERVQUAL scales is indirectly supported. This finding shows that inventory functions can be a baseline mechanism that encourages the development of upper-level service-quality behaviours.

The mechanism of operation of ABC-VED analysis and demand forecasting seems to have different, but complementary mechanisms. ABC--VED offers strategic prioritisation, meaning that clinically important and cost-effective items are prioritised disproportionately in managerial terms (Desai, 2024; Djamil et al., 2024). In pharmacy chains, where thousands of stock-keeping units are competing over a limited amount of shelf space, and capital resources, this prioritisation is actually a rational sorting mechanism that prevents misallocation of resources. Demand forecasting, conversely, provides temporal vision, thus eliminating the uncertainty about replenishment cycles and eliminating the firefighting nature that is akin to many pharmacies with bad stock visibility (Sallam, 2024). These mechanisms, together, create a more proactive and anticipatory operational environment, which on its part, promotes more consistent service delivery.

The identified relationship that has been verified by the SEM-PLS analysis suggests that inventory optimization can potentially have an influence on service quality in two theoretical ways. The former is known as the resource stability pathway, and it holds that operational stability, which is presented through the availability of stock in a predictable fashion, enables the smooth discharging of the duties of frontline providers. This idea is harmonious with the theory of service operations, which holds that consistent resource flows reduce cognitive load of the service staff and result in more responsive and humane work with clients (Soyege et al., 2024; Akinyemi and Onukwulu, 2024). The second which is the perceived reliability pathway argues that when customers perceive regular stock availability as a signal of organisational competence. Research conducted in healthcare settings where medications often form a part of treatment continuity has a strong impact on satisfaction and trust due to these types of perceptions.

An analysis of these results with the existing literature shows that there was a consistent trend. Similar empirical studies in Tanzania, Iran, and Kenya also state that structured pharmaceutical inventory systems breed consumer perceptions and organisational efficiency (Kalumanga & Mwita, 2024; Shahbahrami et al., 2024; Ngigi and Ndeto, 2024). However, the major part of these studies is focused on hospitals or national supply agencies, and the given research translates these findings to the decentralised chains of pharmacies. Based on this, the advantages of inventory

optimisation can be seen as not limited by the scale of organisations or the structure of their health-systems, but as the mechanisms by which it is implemented can be seemingly transferred to institutional settings, as long as the managerial commitment and data infrastructure necessary exist.

Another implication that is obtained as a result of this analysis is a role played by analytics in modern pharmacy work. The forecasting element highlights the increased value of evidence-based decision-making to achieve inventory accuracy. It is in line with the trends worldwide that encourage a digital transformation in the practice of pharmacy, where predictive analytics, automated procurement, and AI-driven forecasting continue to become central pillars of the resilient supply chain (Soyege et al., 2024; Al-Hourani and Weraikat, 2025; Anthony et al., 2024). The findings of the current study support this trend by confirming that even such a simplistic model of forecasting can produce significant gains, thus expressing the possibility of more advanced tools that can produce even more significant results.

Although the study demonstrates positive outcomes, it also sheds light on structural and managerial considerations that require further refinement. One limitation concerns the six-month observation period, which may not fully capture seasonality or long-term demand variations. Inventory cycles in pharmacy chains are often influenced by factors such as disease outbreaks, prescribing trends, or national procurement policies. Extending the study timeline could uncover additional patterns, particularly those involving high-variability categories such as antibiotics or chronic disease medications. Another limitation relates to the data scope: while the study incorporates operational and perception-based indicators, it does not evaluate clinical outcomes or adherence behaviors that may also be affected by stock availability. Future studies could therefore explore whether inventory stability translates into measurable improvements in therapy adherence or health outcomes.

The practical implications for pharmacy management are substantial. Integrating ABC–VED and forecasting requires aligning procurement teams, pharmacists, and data managers under a unified operational strategy. This may necessitate investments in digital infrastructure, training programs, and continuous monitoring systems. However, the results suggest that such investments produce dual returns: improved operational efficiency and enhanced patient experience. For pharmacy chains operating in competitive landscapes, this dual benefit strengthens the business case for adopting systematic optimization tools as part of routine management practices.

In a broader sense, this study contributes to the ongoing discourse on the role of operational systems in shaping patient-centered service environments. While service quality is often conceptualized through interpersonal dimensions such as empathy or assurance, the findings underscore that these dimensions depend on deeper structural and logistical components. Pharmacies seeking to enhance service quality cannot rely solely on staff training or customer service programs; they must critically examine and optimize the operational systems that enable frontline performance. By framing inventory optimization as a strategic service quality driver, this study invites a re-evaluation of how pharmacy chains design, manage, and monitor their supply systems.

CONCLUSION

This study demonstrates that integrating ABC–VED classification and demand forecasting into pharmacy inventory systems provides a structural foundation for enhancing both operational efficiency and service quality. By reorganizing inventory priorities and improving the accuracy of replenishment cycles, the optimization framework supported more stable medicine availability and reduced resource inefficiencies. These operational refinements reinforced service reliability and patient

trust, confirming conceptual models that position inventory stability as a key enabler of high-quality pharmaceutical services. The findings also extend existing literature by illustrating that operational and service quality domains are interdependent, and that data-driven inventory strategies can generate measurable improvements even in decentralized pharmacy chains.

Despite these contributions, the study acknowledges constraints related to its short monitoring period and limited scope of outcome indicators. The results nonetheless offer a compelling rationale for pharmacy organizations to adopt systematic, analytics-informed inventory approaches as part of routine operational management. Future research should incorporate multi-site comparisons, longer observation periods, and additional variables such as clinical adherence and error reduction—to capture the wider impacts of inventory stability on patient outcomes. Overall, the study positions inventory optimization as a strategic driver of sustainable performance, emphasizing its dual value for financial efficiency and patient-centered care delivery.

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