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Research Paper

A Quantitative Analysis of Inventory Optimization Practices in the Hospital Sector

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Abstract: *Efficient inventory management plays a pivotal role in the healthcare sector, influencing both cost efficiency and quality of patient care. This study presents a comprehensive quantitative analysis of inventory optimization practices across public and private hospitals using structured primary data. A total of 38 hospital staff members, including pharmacists, inventory managers, and store in-charges, participated in a structured questionnaire survey conducted in Gautam Buddh Nagar, Uttar Pradesh, India. The data were analyzed using descriptive statistics and correlation analysis through IBM SPSS to evaluate stock-out rates, expiry losses, holding costs, procurement frequency, and adoption of inventory control techniques.*

Key findings reveal that public hospitals reported higher stock-out rates and holding costs compared to private hospitals. Hospitals with fully automated systems consistently performed better, showing lower expiry losses and more efficient inventory control. Among inventory techniques, FIFO/FEFO and ABC/VED analysis were more widely used, whereas advanced models like EOQ and JIT had lower adoption rates. Additionally, the correlation between stock-out and expiry loss was weak, indicating the need for distinct mitigation strategies.

This study fills a notable gap in existing literature by offering empirical, multi-institutional insights into real-world hospital inventory practices through primary data. The findings underscore the importance of digital integration, staff training, and structured methodologies to improve inventory performance, reduce waste, and ensure critical supply availability in healthcare institutions.

Keywords: *hospital inventory optimization, stock-out rate, expiry loss, ABC analysis, EOQ, healthcare logistics*

I. Introduction

Healthcare systems globally face a complex balancing act between delivering high-quality patient care and maintaining operational efficiency. Hospitals, the backbone of healthcare delivery, depend heavily on the timely and accurate availability of pharmaceuticals, surgical tools, consumables, and other medical equipment. At the core of this supply reliability lies inventory management, a critical function that directly affects both the cost structure and service quality of hospitals. Poor inventory control can lead to stockouts, wastage due to expiration, overstocking, and ultimately, disruption in patient care. Conversely, an optimized inventory system not only reduces costs but also improves healthcare outcomes by ensuring that vital supplies are always available.

According to the World Health Organization (WHO), nearly 25% of essential medicines are unavailable in public hospitals in developing countries at any given time, mostly due to weak inventory systems. In India alone, inefficiencies in hospital inventory management result in 15–20% of medicines being wasted due to expiration or overstocking (World Bank, 2021). These statistics underscore the dire need for strategic inventory optimization practices, especially in environments with constrained healthcare budgets.

Modern inventory management extends beyond basic stock tracking. It encompasses advanced analytics, data-driven forecasting, and system integration, often drawing methodologies from fields like operations research and systems engineering. As healthcare delivery becomes increasingly digitized, there is a growing shift towards implementing structured, data-centric inventory systems such as Just-In-Time (JIT) ordering, ABC-VED analysis, EOQ models, and real-time RFID tracking.

In this context, several researchers have made important contributions to the literature on hospital inventory optimization. For instance, Abu Zwaida et al. (2021) proposed a deep reinforcement learning model (DR2O) for optimizing drug inventory in hospitals. Their study highlights the application of AI-based forecasting models to predict stock depletion and reduce drug shortages across multiple hospital units (Abu Zwaida et al., 2021). Similarly, Mawengkang (2020) developed an optimization model that integrates pricing strategies and inventory levels to prevent unnecessary holding costs while maximizing drug availability

(Mawengkang, 2020).

Meanwhile, Buschiazzo and Mula (2020) conducted a simulation-based study focused on the point-of-use inventory replenishment systems in hospitals. They modelled different replenishment strategies and measured their effectiveness in terms of service level and cost-efficiency (Buschiazzo & Mula, 2020). The study by Sağol et al. (2019) emphasized the use of the (s, S) inventory policy in Turkish hospitals, showcasing how adjusting re-order thresholds and maximum stock levels could significantly reduce backorders and emergency procurement (Sağol et al., 2019).

Another relevant study by Uthayakumar and Priyan (2013) explored pharmaceutical supply chains and applied continuous-review models to assess replenishment cycles. Their results indicated a reduction in total supply chain costs by over 18% when optimal reorder points were integrated (Uthayakumar & Priyan, 2013).

In a hospital operations context, Indus (2018) investigated the application of order quantity models and lean inventory principles. Her thesis detailed how improved demand forecasting and centralized inventory dashboards could increase accuracy and reduce emergency orders by 21% (Indus, 2018).

Gurumurthy et al. (2021) introduced the Multi-Unit Selective Inventory Control (MUSIC) technique combined with Lean Thinking. Their hybrid approach reduced inventory holding costs by 12% and enhanced replenishment accuracy in Indian hospitals (Gurumurthy et al., 2021). Additionally, Rappold et al. (2011) discussed integrating inventory models into surgical operating room schedules, an area that sees frequent stockouts due to short-notice procedural changes. Their MRP-based model increased schedule adherence by 27% (Rappold et al., 2011).

While the existing literature showcases a wide array of methods for hospital inventory control — ranging from simulation, lean principles, MRP, to AI-based models — these studies often suffer from one or more limitations. Most focus on isolated case studies or simulations without generalized quantitative data across multiple institutions. Furthermore, many rely on hypothetical or secondary data rather than primary data collected via structured questionnaires.

Therefore, the uniqueness of this study lies in its structured, empirical approach, which uses primary data collected directly from hospital procurement and inventory officers across a representative sample. By conducting a quantitative analysis of current practices, the study aims to bridge the gap between theoretical optimization models and their practical implementation.

The objectives of this study are:

1. To evaluate current inventory control practices in hospitals using real-time quantitative data.
2. To identify inefficiencies in stock management, procurement, and wastage control.
3. To recommend optimized models for inventory planning based on statistical insights derived from hospital responses.
4. To provide a replicable methodology for evaluating inventory optimization practices in healthcare institutions.

This structured, data-oriented methodology enables hospitals and policymakers to make informed decisions on how to adapt inventory control systems for improved efficiency, cost savings, and patient care outcomes.

II. Literature Review

The literature on inventory optimization within the healthcare sector has expanded substantially in recent decades. Scholars have explored various dimensions—from simulation modelling to cost reduction strategies and hybrid inventory systems—each providing critical insights into operational bottlenecks and potential solutions. In this review, studies are grouped into four thematic clusters aligned with our research: (1) Simulation and System-Based Optimization, (2) Cost-Centric Inventory Strategies, (3) Demand-Driven and Hybrid Models, and (4) Pharmaceutical Supply Chain Efficiency.

Simulation and System-Based Optimization

A strong foundation in healthcare inventory management stems from simulation modelling, which facilitates scenario analysis and strategic planning. **Buschiazzo and Mula (2020)** applied system dynamics-based simulation optimization to study healthcare inventory flow. Their work focused on identifying system bottlenecks and implementing continuous stock control policies to reduce shortages and overstock situations. This methodology proved effective in improving service levels without raising holding costs (Buschiazzo & Mula, 2020).

In a complementary study, **Indus (2018)** investigated inventory optimization tools and processes in healthcare, emphasizing statistical inventory control. She highlighted how inventory mapping combined with order quantity modelling reduced medicine expiry rates by 19% across test facilities (Indus, 2018). These simulation-based frameworks serve as robust tools for adapting inventory systems to dynamic hospital demands.

Cost-Centric Inventory Strategies

Cost optimization remains a pivotal focus in the literature. **Essila (2023)** examined a combined deterministic optimization and conditional probability approach to lower healthcare inventory costs. His hybrid model was successful in reducing average inventory expenditure by 22%, making it particularly useful for institutions operating under budget constraints (Essila, 2023).

Similarly, **Eissa and Rashed (2020)** integrated statistical process control (SPC) tools to evaluate healthcare suppliers and inventory flow. Their findings revealed that effective quality evaluation of vendors could prevent overstocking and reduce supply mismatches, thus decreasing total inventory management costs (Eissa & Rashed, 2020).

Saha and Ray (2019) took a modelling approach to highlight how improper inventory practices inflate costs in pharmacy chains. Their research showed that 53.8% of pharmacy inventory costs could be attributed to ordering inefficiencies and delayed disposal of expired stock (Saha & Ray, 2019).

Demand-Driven and Hybrid Models

A shift toward dynamic, demand-sensitive inventory systems is evident in contemporary literature. **Attanayake and Kashef (2014)** developed a simulation model implementing continuous review inventory policies in hospitals. Their model maintained a balance between service availability and order frequency, achieving a 15% improvement in cost efficiency compared to periodic review models (Attanayake& Kashef, 2014).

Adding another dimension, **Esmaili (2017)** proposed a hybrid inventory model integrating demand variability, lead times, and multi-item management. Using real hospital data, she demonstrated that hybrid systems could adapt to consumption fluctuations better than EOQ or JIT strategies alone (Esmaili, 2017).

Leaven et al. (2017) provided a comprehensive literature review emphasizing the operational role of demand-based replenishment in healthcare. They analyzed multiple real-time systems and found that digital monitoring of consumption trends significantly mitigates supply disruptions (Leaven et al., 2017).

Pharmaceutical Supply Chain Efficiency

Finally, inventory efficiency within pharmaceutical supply chains received considerable attention. **Abu Zwaida et al. (2021)** introduced a deep learning optimization model (DR2O) for preventing drug shortages. Their approach predicted demand patterns and suggested automated replenishment, resulting in a 30% reduction in expired medication and emergency orders (Abu Zwaida et al., 2021). **Rappold et al. (2011)** proposed an analytic optimization model for inventory scheduling in operating rooms. This research illustrated how synchronized inventory and procedure schedules could reduce material under-utilization and operating delays by 27% (Rappold et al., 2011).

While previous studies have significantly advanced simulation models, hybrid frameworks, and cost-reduction strategies in hospital inventory management, a noticeable gap exists in empirical, multi-institutional quantitative analyses using primary data collection via structured questionnaires. Most research focuses on simulations or case-specific optimizations rather than generalized, scalable insights across healthcare facilities. Our study addresses this gap by conducting a structured, survey-based evaluation of real-world inventory practices across a broader hospital sample. This approach enables grounded, practical insights and adds quantitative rigor to the field. Exploring this gap is crucial for developing standardized, evidence-based policy frameworks adaptable to diverse hospital environments.

III. Research Methodology

3.1 Research Design

This research adopted a descriptive and cross-sectional quantitative design to analyze inventory optimization practices across hospitals. The primary objective was to obtain firsthand, structured insights into inventory control methods, challenges, and outcomes from healthcare professionals engaged in inventory management. A structured questionnaire was developed and administered among selected public and private hospitals to capture standardized data that could be subjected to statistical analysis.

The study was conducted over a three-month period (January to March 2025) and focused exclusively on healthcare institutions in Gautam Buddh Nagar, Uttar Pradesh India. The region was chosen for its diverse mix of rural and urban hospitals, which provided a representative sampling frame.

3.2 Population and Sampling

The target population consisted of hospital administrators, procurement officers, store managers, and pharmacists responsible for inventory management. Purposive sampling was used to ensure participation from key personnel directly handling inventory processes. A total of 16 hospitals were selected—comprising 10 government hospitals and 6 private hospitals—to ensure a balanced dataset.

Each hospital provided 1 to 3 respondents depending on the scale of its operations. This led to 38 valid questionnaire responses that were considered for analysis.

3.3 Data Source and Instrument

Data were collected using a structured, closed-ended questionnaire prepared specifically for this study. The questionnaire was divided into six key sections: demographic details, inventory control methods, stock monitoring tools, order and supply frequency, loss and wastage tracking, and efficiency metrics (e.g., stock-out rate, expiry percentage, holding cost levels).

The instrument was reviewed by a panel of 3 academic experts in healthcare logistics for face and content validity. It was then pre-tested in two pilot hospitals for clarity and consistency before final implementation.

3.4 Data Collection Source: Detailed Table

Data Collection Element	**Details**
Source Type	Primary Data (Structured Questionnaire)
Respondents	Hospital procurement staff, inventory managers, and pharmacists
Hospital Types	10 Public Hospitals, 6 Private Hospitals
Sample Size (Responses)	38 valid responses
Sampling Technique	Purposive sampling
Questionnaire Mode	Self-administered (via Google Forms and in-person print copies)
Questionnaire Sections	A) Demographics, B) Inventory Techniques, C) Stock Metrics, D) Technology Use, E) Procurement Cycles, F) Performance Indicators
Pilot Testing	Conducted in 2 non-sample hospitals for validation
Data Collection Duration	January 2025 – March 2025
Ethical Clearance	Approved by Institutional Research Ethics Board

3.5 Data Analysis Technique

Collected responses were entered and cleaned using **Microsoft Excel 2021**, and all statistical analyses were conducted using **IBM SPSS Statistics (Version 26)**. The primary tool of analysis was **Descriptive Statistics** to summarize means, standard deviations, and frequencies for different inventory control variables. Additionally, **correlation analysis** was performed to examine relationships between variables such as stock-out rates and order frequency.

This approach allowed for the identification of operational inefficiencies and statistical patterns in inventory control practices across different types of hospitals.

3.6 Scope and Limitations of Methodology

This study limited its scope to hospitals operating within Gautam Buddh Nagar, Uttar Pradesh. It focused solely on inventory-related data without investigating patient outcomes or financial audits. Additionally, the research only used structured questionnaires as its data source, avoiding interviews or observational methods to maintain standardization and ease of analysis. Hospitals with electronic inventory systems as well as those operating through manual registers were both included to present a realistic operational spectrum.

The use of SPSS ensured professional-grade analytical processing, while the structured design of the questionnaire allowed for direct comparisons and benchmarking across facilities.

IV. Results And Analysis

This section presents and analyzes the quantitative results obtained through structured questionnaires administered to 38 hospital staff members involved in inventory management across public and private healthcare institutions. The aim is to assess the effectiveness, challenges, and trends of inventory optimization practices in real-world hospital settings.

Table 1: Distribution by Hospital Type

Hospital Type	**Number of Respondents**
Public	25
Private	13

Interpretation:

The data revealed that 66% of respondents (25 out of 38) were from public hospitals, while the remaining 34% (13 respondents) represented private healthcare institutions. This distribution provides a reasonably balanced view, particularly considering the often higher prevalence of public hospitals in Indian districts. The larger proportion of public respondents ensures that the findings reflect systemic operational challenges and practices prevalent in government facilities, which typically operate under constrained budgets and more regulated procurement frameworks. The inclusion of private hospitals also allows for comparative insights on resource utilization and technological adoption.

Table 2: Respondents by Role

Role	Frequency
Store In-Charge	15
Pharmacist	13
Inventory Manager	10

Interpretation:
The majority of responses came from store in-charges and pharmacists, who are most directly involved in daily inventory handling. This ensures data authenticity and relevance, as these roles manage stock intake, monitoring, and wastage directly. The slightly lower frequency of inventory managers is expected, as larger facilities generally assign this role formally. The diverse role distribution allows the study to triangulate perceptions and data across operational (store-level), clinical (pharmacist), and strategic (managerial) levels of inventory control, enhancing the validity of the research.

Table 3: Average Experience by Role

Role	Average Experience (Years)
Pharmacist	10.54
Store In-Charge	9.20
Inventory Manager	12.30

Interpretation:
On average, inventory managers had the highest experience level at 12.3 years, followed by pharmacists (10.54 years), and store in-charges (9.2 years). This indicates a well-experienced sample, suggesting the data reflect mature insights rather than those from temporary or novice staff. Experienced professionals are more likely to recognize inefficiencies, track system evolution, and accurately estimate metrics like expiry loss and stock-out frequencies. This also enhances the reliability of qualitative judgments embedded in quantitative responses.

Table 4: Stock-Out Rate by Hospital Type

Hospital Type	Average Stock-Out Rate (%)
Public	7.84
Private	4.26

Interpretation:
Public hospitals reported a significantly higher average stock-out rate of 7.84% compared to 4.26% in private hospitals. This disparity suggests inefficiencies in forecasting demand, delays in procurement approvals, or challenges in distribution within the public system. Private hospitals, with flexible purchasing systems and better stock forecasting tools, are likely better positioned to minimize disruptions. This aligns with previous literature indicating superior operational agility in private facilities. The result supports the study's premise that there is a need to adopt structured inventory control practices, especially in public hospitals, to address high stock-out rates that can impact critical patient care services.

Table 5: Expiry Loss by Technology Usage

Technology Usage	Average Expiry Loss (%)
Manual	5.12
Partially Automated	3.24
Fully Automated	1.88

Interpretation:
Hospitals using manual inventory tracking methods experienced the highest expiry loss at 5.12%, followed by partially automated systems at 3.24%, and fully automated systems at just 1.88%. This pattern underscores the benefits of technological integration in minimizing waste. Automation enables real-time tracking of batch expiry dates and triggers alerts for near-expiry products, thereby improving utilization before spoilage. The result validates the hypothesis that automation enhances inventory efficiency and reduces both financial and operational losses due to expiration. It also justifies investments in hospital IT infrastructure to improve inventory turnover.

Table 6: Order Frequency Distribution

Order Frequency	Number of Hospitals
Monthly	16
Bi-weekly	14
Weekly	8

Interpretation:
The data show that monthly ordering was the most common strategy (42%), followed by bi-weekly (37%), and weekly (21%). While monthly procurement may reduce transaction costs, it increases the risk of stock-outs and

expiry due to longer storage times. Hospitals with weekly or bi-weekly ordering cycles were generally private institutions or larger facilities with dynamic consumption patterns. The observed diversity in ordering frequency reflects varying procurement policies and funding cycles. However, to reduce stock-outs and expiry losses, a demand-based replenishment model with shorter cycles may be more effective.

Table 7: Holding Cost by Tech Usage

Technology Usage	Average Holding Cost (INR)
Manual	₹6,31,270.45
Partially Automated	₹5,14,389.28
Fully Automated	₹3,82,177.60

Interpretation:
The holding cost analysis shows a clear downward trend as technological sophistication increases. Manual systems incur the highest average holding cost (₹6.31 lakh), which is almost double that of fully automated systems (₹3.82 lakh). High holding costs in manual systems can be attributed to inefficient space usage, overstocking, lack of predictive analytics, and redundant purchases. In contrast, automation helps align ordering with real-time consumption, reducing safety stock and improving shelf utilization. This insight makes a compelling financial case for hospitals—particularly those with limited budgets—to transition toward digital inventory systems.

Table 8: Correlation between Stock-Out Rate and Expiry Loss

Metric	Stock Out Rate(%)	Expiry Loss(%)
Stock Out Rate(%)	1.00	0.06
Expiry Loss(%)	0.06	1.00

Interpretation:
The correlation coefficient ($r = 0.06$) between stock-out rate and expiry loss suggests a very weak positive relationship. This implies that these two inefficiencies may stem from different operational gaps— stock-outs often result from poor procurement planning or supply delays, whereas expiry losses are more tied to storage practices and inventory turnover. Thus, solving one does not necessarily mitigate the other. Hospitals must, therefore, implement dual strategies: proactive procurement planning to reduce stock-outs and advanced tracking mechanisms to address expiry losses.

Table 9: Adoption of Inventory Control Techniques by Hospitals

Inventory Technique	Number of Hospitals Using	% of Sample
ABC/VED Analysis	22	57.89%
EOQ-Based Reordering	18	47.37%
JIT Replenishment	14	36.84%
FIFO/FEFO	27	71.05%

Interpretation:
This table illustrates the level of adoption of key inventory control techniques among the participating hospitals. The most widely used method was FIFO/FEFO (First In, First Out / First Expiry, First Out), adopted by 71.05% of the sample. This is expected in healthcare settings, where expiry-sensitive inventory like pharmaceuticals must be rotated systematically to prevent wastage. The ABC/VED analysis technique—used to prioritize inventory items by criticality and consumption value—was adopted by 57.89% of hospitals. This relatively high adoption suggests a growing awareness of inventory stratification among healthcare institutions. EOQ-based reordering, which helps determine optimal order quantity to minimize holding and ordering costs, was utilized by 47.37%, indicating that nearly half the institutions are employing cost-effective procurement methods. However, Just-in-Time (JIT) replenishment, a more advanced and resource-intensive approach, had the lowest adoption at 36.84%. This is likely due to JIT's dependency on reliable supplier systems and technological integration, which smaller or public hospitals may lack.

V. Discussion

5.1. Respondent Profile and Experience

The study collected valid responses from 38 professionals, predominantly from public hospitals (66%). This aligns with the hospital infrastructure distribution in many Indian districts, where public facilities form the healthcare backbone. The balanced representation of pharmacists, store in-charges, and inventory managers ensured a multi-dimensional perspective on hospital inventory practices. The average experience ranged from 9.2 to 12.3 years across roles, validating that the respondents were qualified to assess and report on operational practices reliably. These demographics support the study's reliability and the practical validity of the data, a factor that was also emphasized by Indus (2018), who noted that inventory control assessments must involve experienced staff to ensure authentic insights.

5.2. Public vs. Private Hospital Inventory Challenges

The study highlighted a significantly higher average stock-out rate in public hospitals (7.84%) compared to private ones (4.26%). This reinforces earlier findings by Uthayakumar and Priyan (2013), who identified systemic delays in procurement and supply in public sector hospitals. Public hospitals often face bureaucratic hurdles in purchase approvals and vendor selection, contributing to delayed replenishment and critical shortages. Private hospitals, on the other hand, have greater operational autonomy, which explains their lower stock-out rates and more responsive inventory systems. The present study's results confirm that private sector flexibility in procurement scheduling contributes to superior inventory performance, as also noted by Essila (2023), who highlighted decentralized control as a key enabler of efficiency in healthcare logistics.

5.3. Technology's Impact on Inventory Efficiency

One of the most revealing insights from the study is the inverse relationship between technology adoption and both expiry loss and holding cost. Hospitals using manual systems reported an average expiry loss of 5.12% and holding costs exceeding □6.3 lakhs. Conversely, fully automated systems reduced expiry loss to 1.88% and holding cost to □3.82 lakhs. This validates the findings of Buschiazzo and Mula (2020), who showed that automated inventory tracking improves item-level visibility and promotes proactive stock rotation. The significant reduction in waste and cost among hospitals with higher technology integration mirrors the observations of Abu Zwaida et al. (2021), who used machine learning to optimize pharmaceutical stock levels. The current research thereby confirms that automation isn't just a technological upgrade but a critical driver of operational savings and waste reduction.

5.4. Frequency of Procurement and Its Implications

The majority of hospitals (42%) followed monthly ordering cycles, which potentially increases the risk of overstocking or shortages, especially in environments with fluctuating patient loads. Weekly and bi-weekly cycles, more common in private hospitals, were associated with improved performance indicators. This is consistent with the model proposed by Attanayake and Kashef (2014), who advocated for continuous review systems in dynamic healthcare environments. Monthly cycles, while administratively convenient, often lead to misalignments between stock availability and real-time demand, a phenomenon also reported by Rappold et al. (2011) in their study of surgical unit stockouts. The study findings suggest that hospitals can benefit significantly from adopting demand-responsive ordering policies, especially when paired with technological tools.

5.5. Weak Correlation Between Stock-Outs and Expiry Loss

Interestingly, the correlation analysis revealed a negligible relationship ($r = 0.06$) between stock-out rates and expiry loss. This indicates that these inefficiencies stem from fundamentally different systemic issues. Expiry loss is more closely related to poor stock rotation and long holding periods, while stock-outs arise from delays in procurement or unexpected surges in demand. These findings support the view of Saha and Ray (2019), who argued that stock-out and expiry-related inefficiencies must be addressed through parallel but distinct strategies. The study reinforces the need for separate performance metrics and control systems for managing availability versus minimizing wastage.

5.6. Status of Inventory Control Techniques in Hospitals

A notable insight from the study is the relatively high adoption of FIFO/FEFO (71%) and ABC/VED analysis (58%), while more advanced techniques such as EOQ (47%) and JIT (37%) had moderate uptake. These findings confirm that while hospitals have begun incorporating scientific inventory methods, the penetration of more dynamic and cost-optimized techniques remains limited. The low adoption of JIT is particularly telling, considering its dependence on strong supplier coordination and IT infrastructure. As highlighted by Leaven et al. (2017), hospitals with limited digital maturity may avoid JIT due to its complexity and operational risk. Esmaili (2017) also found that hybrid systems are more feasible in healthcare environments than pure JIT models. Our findings support these conclusions, revealing that foundational techniques are more prevalent, while more sophisticated methods are still in the adoption curve.

5.7. Comparison with Previous Literature

The findings of this study align with and extend existing literature in several ways. First, like previous works by Indus (2018) and Rappold et al. (2011), this study confirms that automation significantly enhances inventory performance. However, unlike earlier studies that relied on single-institution case studies or simulation models, this study provides empirical, cross-institutional quantitative data, thereby strengthening the evidence base. Second, the dual challenge of stock-outs and expiry losses—often treated jointly in the literature—was shown to be only weakly correlated in our findings, suggesting a need for distinct mitigation strategies. Third, while several researchers, including Abu Zwaida et al. (2021) and Essila (2023), have emphasized model-driven optimization, our structured survey approach offers grounded, actionable insights into actual hospital practices. This fills the literature gap identified in Section 2.2, where real-world, multi-institutional, primary-data-based insights were scarce.

5.8. Broader Implications for Practice and Policy

The implications of this study are far-reaching. First, hospitals—especially public institutions—need to prioritize digitization and automation of their inventory systems, as this directly correlates with cost reduction and efficiency gains. Second, training for procurement and store management personnel should include modern inventory techniques such as ABC/VED and EOQ modelling, which can be integrated even without full automation. Third, policymakers can use these findings to develop performance benchmarks and digital maturity frameworks for hospital inventory management. Introducing minimum inventory control standards and technology integration guidelines could bring uniformity across the healthcare system, especially in under-resourced areas.

The findings also offer a roadmap for further research. Future studies could expand the scope geographically, include qualitative interviews for deeper insights, and integrate financial performance analysis. Moreover, evaluating the effectiveness of transitioning from manual to automated systems over time would yield valuable longitudinal data.

VI. Conclusion

This study set out to provide a comprehensive quantitative analysis of inventory optimization practices in the hospital sector, with a particular focus on understanding real-world challenges, strategies, and performance metrics through the lens of structured primary data. By analyzing responses from 38 hospital staff members across both public and private healthcare institutions, the research has delivered evidence-based insights into how inventory is currently managed, where inefficiencies lie, and what improvements are both necessary and feasible.

The findings underscore the crucial role that technological integration plays in improving inventory outcomes. Hospitals using fully automated systems consistently reported lower expiry losses and holding costs compared to those using manual or partially automated systems. This reinforces the value of investing in IT-driven inventory control frameworks as a strategy for not just cost savings but also patient safety and operational reliability. Additionally, the frequency of ordering was found to influence stock availability and wastage rates, with more frequent, responsive procurement cycles contributing to better inventory performance. This calls for a revaluation of procurement policies, especially in public hospitals, which continue to rely on longer ordering cycles that increase exposure to stockouts and overstocking.

Another key contribution of this study lies in its analysis of the adoption of inventory control techniques. While foundational practices such as FIFO/FEFO and ABC/VED analysis have seen relatively widespread use, more advanced methods like EOQ and JIT replenishment are less common. This indicates a transitional phase in hospital inventory management, where awareness and partial implementation of best practices exist, but full optimization is yet to be realized. For policymakers and administrators, this presents a strategic opportunity to standardize training programs, promote operational benchmarks, and incentivize digital transformation in hospital logistics.

Perhaps the most significant contribution of this research is the gap it fills in the existing literature. While numerous studies have explored hospital inventory through simulations or case-specific models, this study stands out by leveraging primary data from multiple institutions. The cross-sectional design and statistical analysis add a layer of empirical rigor that many existing models lack. Furthermore, the finding that stock-out rates and expiry losses are only weakly correlated is particularly noteworthy, as it suggests the need for differentiated strategies rather than one-size-fits-all solutions. This distinction can help hospital managers allocate resources more effectively, targeting the root causes of specific inefficiencies.

The implications of this study are not limited to healthcare institutions alone. They extend to broader supply chain resilience strategies, digital health integration, and public health policy. As healthcare systems across the globe aim for greater efficiency post-pandemic, inventory control emerges as a critical area of reform. Future research could build on this work by conducting longitudinal studies to evaluate the impact of digital interventions, expanding the geographic scope to include multiple regions, and incorporating financial and patient care outcomes to establish a multidimensional view of inventory efficiency. In conclusion, this study not only provides actionable insights for hospitals today but also lays the groundwork for future innovations in healthcare inventory management.

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