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The Influence of CITO Procurement on Pharmaceutical Supply Chains: Efficiency, Challenges, and Outcomes

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ABSTRACT

This paper investigates the role of CITO (Critical Item Time Order) procurement in optimizing pharmaceutical supply chains, particularly in contexts requiring rapid responses to urgent supply needs. CITO procurement is analyzed for its effectiveness in enhancing operational efficiency, cost management, and patient outcomes within healthcare settings. Through a comprehensive review of existing literature and case studies, the paper identifies both the strengths and challenges associated with CITO implementation. Key findings suggest that while CITO can significantly reduce lead times and stockouts, organizations must also address potential risks related to supplier quality and regulatory compliance. The study proposes strategies for optimizing CITO procurement processes, emphasizing the importance of technology and strong supplier relationships in ensuring reliable and timely access to critical medications. Ultimately, this research highlights CITO's potential as a vital strategy in the evolving landscape of pharmaceutical supply chains, underscoring its relevance for improving healthcare delivery and patient care.

INTRODUCTION

The pharmaceutical supply chain plays a crucial role in healthcare by ensuring the availability, safety, and quality of medications for patient care (Alshemari *et al.*, 2020). The complexity of the pharmaceutical supply chain arises from its highly regulated nature and its need to meet stringent standards at every stage, from sourcing raw materials to delivering the final products to healthcare providers and patients. This chain involves various stakeholders, including manufacturers, distributors, healthcare providers, and regulatory bodies, each contributing to the flow and monitoring of pharmaceutical products.

One key function of the pharmaceutical supply chain is maintaining medication availability while minimizing waste and avoiding shortages. Recent studies emphasize the impact of supply chain efficiency on patient outcomes, with a clear link between well-managed supply chains and quality patient care (Abbas *et al.*, 2020). Automated systems are increasingly adopted to monitor inventory, manage expiry dates, and respond to recalls, which reduces administrative burdens on clinicians and enhances inventory visibility, thus supporting faster and more accurate supply decisions (Chen *et al.*, 2023).

Supply chains in healthcare, particularly post-pandemic, have shown vulnerabilities to disruptions, highlighting the need for resilient systems capable of adapting to crises such as raw material shortages or logistical challenges. To strengthen the supply chain, healthcare systems are increasingly incorporating real-time data and analytics, which improve decision-making by enabling accurate demand forecasting and reducing dependency on single sources (Yarosan *et al.*, 2021). Transparency and collaboration among supply chain stakeholders are also pivotal, as they allow for coordinated responses to potential shortages and help mitigate future risks.

In summary, the pharmaceutical supply chain is fundamental to healthcare operations, directly impacting both clinical outcomes and the financial sustainability of healthcare systems. Optimizing these supply chains through automation, transparency, and strategic partnerships is crucial for maintaining continuous access to essential medications and improving healthcare resilience.

CITO is a specialized procurement strategy designed to rapidly address urgent needs for critical items in supply chains, particularly in healthcare and pharmaceuticals. This approach is utilized to ensure that high-priority, often life-saving supplies reach their destination with minimal delay (Elmiawati Latifah *et al.*, 2023). Unlike traditional procurement methods, which are primarily cost-driven and follow routine ordering cycles, CITO procurement is time-sensitive and focuses on speed and immediate availability over cost-efficiency. The method is especially relevant in healthcare, where timely access to essential medicines or equipment is directly linked to patient outcomes (Handayany & Basri, 2022).

In practice, CITO procurement involves processes that expedite ordering, inventory checks, and transportation logistics to shorten delivery times. This method typically leverages a blend of strategies such as priority contracts, premium shipping options, and real-time inventory tracking, which are critical for handling unexpected spikes in demand or supply chain disruptions. For instance, during the COVID-19 pandemic, healthcare providers increasingly relied on CITO procurement to obtain critical items like personal protective equipment and ventilators, bypassing typical supply chain constraints to secure immediate resources (Almahdy *et al.*, 2021).

Overall, CITO procurement is designed to handle high-stakes scenarios where timely delivery is essential, and

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it requires close coordination between suppliers and healthcare providers. This coordination helps minimize the risks associated with stockouts of critical supplies, although it may involve higher costs due to expedited services and premiums on immediate availability. As supply chain resilience becomes a focal point in healthcare, CITO procurement remains a key approach to ensuring the rapid availability of essential supplies during emergencies.

The relevance of CITO in healthcare is paramount for ensuring the timely availability of critical medicines, particularly in response to urgent and unpredictable demand fluctuations. CITO procurement strategies are designed to deliver essential medicines swiftly, bypassing the longer lead times often associated with traditional procurement methods. This capability is crucial in healthcare, where delays in acquiring necessary drugs can have severe consequences for patient outcomes, especially in emergency care settings and during public health crises such as pandemics.

In healthcare environments, the demand for certain medications can change suddenly, driven by factors like seasonal disease outbreaks, supply chain disruptions, or natural disasters. Traditional procurement systems, which rely on scheduled purchasing and bulk ordering orders, may struggle to meet these sudden shifts in demand. CITO, on the other hand, emphasizes flexibility and responsiveness by leveraging agile supplier relationships and pre-negotiated contracts that allow healthcare providers to source medications at short notice.

The real-time tracking and data-driven capabilities integrated into CITO systems also play a significant role in improving supply chain resilience. By providing accurate demand forecasts and early identification of shortages, CITO helps healthcare providers maintain continuity in drug availability, ensuring that high-demand medications are available precisely when and where they are needed. This capacity is especially important for hospitals, where availability of critical medicines like antibiotics, blood products, and respiratory treatments can be life-saving.

Furthermore, CITO's relevance is amplified in settings that serve vulnerable populations, such as intensive care units, cancer treatment centers, and dialysis facilities, where a disruption in medication supply could lead to severe health complications. In these contexts, CITO supports healthcare providers in managing high-stakes supplies effectively, thereby enhancing patient care quality and reducing the risks associated with drug shortages.

In sum, CITO procurement is instrumental in ensuring that healthcare facilities can meet urgent needs with speed and precision, supporting the continuous availability of life-saving drugs and improving the resilience of the healthcare supply chain. By reducing lead times and enhancing supply flexibility, CITO aligns with the critical demands of modern healthcare, where timely medication availability can directly influence patient survival and well-being. The study is implemented to evaluate the Effectiveness of CITO Procurement in

Ensuring Timely Access to Critical Medicines: This study aims to assess how effectively CITO (Critical Item Time Order) procurement models ensure the availability of critical medications in healthcare settings, particularly during times of high demand or supply chain disruption. This includes examining the impact of CITO on reducing lead times, improving supply chain responsiveness, and minimizing stockouts. Further, it will also analyze Cost Implications of CITO in Comparison to Traditional Procurement Models: A key objective is to evaluate the cost structures associated with CITO procurement compared to traditional methods. The study will explore whether the benefits of increased flexibility and speed justify the potential premiums associated with CITO, such as expedited shipping costs, and analyze its cost-effectiveness in healthcare contexts where critical medicines are essential. It is also important to assess the Challenges of Implementing CITO in the Pharmaceutical Supply Chain: The study will investigate specific challenges faced by healthcare providers in implementing CITO, including regulatory compliance, quality assurance, risk management, and the need for advanced digital systems. Understanding these obstacles can provide valuable insights for organizations looking to adopt or optimize CITO models. Lastly, the study can be a fundamental reference to determine the Impact of CITO on Resource Allocation and Risk Management: This research will analyze how CITO affects resource allocation within procurement departments, particularly in terms of manpower and time management. It will also examine how CITO procurement supports or complicates risk management efforts, as flexibility in sourcing may introduce risks related to supplier verification and product quality (Paramitha & Oktamianti, 2024).

The significance of this study lies in its potential to inform healthcare providers, policymakers, and supply chain managers about the benefits and limitations of CITO procurement in the pharmaceutical industry. With healthcare systems increasingly reliant on agile supply chains that can quickly adapt to demand changes, this research provides a detailed analysis of CITO's impact on the timely availability of life-saving drugs. In an environment where drug shortages have been linked to higher mortality rates and poorer health outcomes, understanding the role of CITO in mitigating these issues is essential. The findings of this study could help healthcare facilities optimize their procurement practices, improving patient care by reducing lead times and ensuring medication availability during critical moments. Moreover, this research will offer practical insights for managing the unique challenges of CITO, such as regulatory compliance and risk of counterfeit products, which are particularly significant in the pharmaceutical sector. As supply chains become increasingly complex and interdependent, this study could be instrumental in guiding effective implementation of CITO, contributing to more resilient healthcare systems worldwide.

LITERATURE REVIEW

The origins of CITO procurement trace back to industries that required rapid sourcing and delivery of high-priority items, especially during times of crisis or urgent demand. Initially, CITO practices were seen in fields like defense and aerospace, where the need for critical supplies and equipment during emergencies spurred the development of procurement models focused on speed and flexibility (Ngir *et al.*, 2023). Over time, as global supply chains grew more complex and demand for responsive systems increased, CITO methodologies found applications in other critical sectors, particularly healthcare and pharmaceuticals, where the availability of life-saving medications can directly impact patient outcomes.

In the healthcare sector, CITO procurement has gained traction more recently as a response to the increased demand for critical medicines and medical supplies, particularly during health crises like the COVID-19 pandemic. The pandemic highlighted the limitations of traditional procurement models, which often failed to keep pace with the rapid fluctuations in demand for essential medical supplies such as ventilators, personal protective equipment (PPE), and specific medications. Faizar *et al.* (2023) points out that the urgent requirements during the pandemic accelerated the adoption of CITO practices in healthcare, where flexibility, rapid decision-making, and supplier collaboration were crucial to maintaining supply continuity during unpredictable surges in demand.

Another significant historical driver behind CITO's adoption in healthcare is the rising number of drug shortages worldwide, which has become a persistent issue over the last decade. Studies note that these shortages have often been exacerbated by rigid supply chain processes unable to adapt to sudden demand spikes, manufacturing delays, or distribution bottlenecks (Elmiawati Latifah *et al.*, 2023; Faizar *et al.*, 2023). In this context, CITO emerged as an alternative strategy that enables healthcare organizations to rapidly source essential drugs from pre-vetted suppliers, ensuring availability even in times of crisis. By doing so, CITO procurement helps to address the risks posed by drug shortages, allowing healthcare providers to maintain critical stock levels with less reliance on stockpiling.

The integration of digital technologies has also played a pivotal role in CITO's evolution. Early implementations relied heavily on manual systems and close supplier relationships, but advances in real-time tracking, predictive analytics, and data integration have allowed for a more systematic approach. Research shows that the adoption of digital tools has enabled organizations to monitor supply levels more accurately, anticipate demand spikes, and make rapid adjustments, which are essential features of the CITO model. The use of these tools has expanded CITO's capabilities, making it feasible not only for emergency scenarios but also for standard operations in sectors like pharmaceuticals, where supply chain disruptions can directly impact patient health (Aghniya,

2022).

In summary, CITO's initial applications were in fields requiring rapid response and supply continuity under high-stakes conditions. Its adoption in the healthcare sector has been more recent, driven by the need for agile procurement methods to address challenges such as drug shortages and emergency healthcare demands. Enhanced by digital tools, CITO continues to evolve, offering healthcare providers a more resilient and flexible approach to supply chain management in an increasingly complex global landscape.

The comparative analysis of CITO and traditional procurement methods has become increasingly relevant in fields where supply chain agility and responsiveness are essential, such as healthcare and pharmaceuticals. This literature review synthesizes findings from recent studies, focusing on key themes including flexibility, cost efficiency, lead times, and risk management.

One of the most widely cited benefits of CITO over traditional procurement methods is its flexibility, particularly in environments with unpredictable demand. Lisman *et al.* (2023) emphasized that CITO allows organizations to meet sudden and critical demand through pre-established supplier relationships and expedited processes, a capability that traditional procurement lacks due to its reliance on fixed scheduling and bulk ordering. During the COVID-19 pandemic, for instance, CITO allowed healthcare organizations to secure essential items like PPE and ventilators more efficiently, whereas traditional systems struggled to adapt to rapidly fluctuating demand.

Similarly, Canova *et al.* (2024) underscore the importance of CITO's flexibility in healthcare, where demand unpredictability is common. The study found that CITO procurement models could quickly source critical medications and equipment, enabling healthcare facilities to maintain continuity in patient care even during unexpected surges. Traditional procurement's rigid structures, in contrast, often led to stockouts and delays during the same period, highlighting the model's limitations in dynamic, high-stakes environments.

Cost considerations in CITO versus traditional procurement methods are complex, with each approach offering different advantages depending on the nature of the items being procured. Traditional procurement benefits from economies of scale, as bulk purchasing and long-term contracts tend to lower unit costs. In contrast, CITO is often associated with higher per-unit costs due to its reliance on expedited shipping and flexible contracts. However, research (Tawarma & Marlina, 2023) found that CITO could be more cost-effective in critical supply scenarios, as it minimizes inventory holding costs and helps avoid the financial impacts of stockouts.

The study highlighted that while traditional procurement can achieve cost savings on bulk items, CITO can reduce total costs in high-priority, time-sensitive scenarios by ensuring immediate availability and preventing costly delays. However, Elmiawati Latifah *et al.* (2023) cautions

that the cost benefits of CITO depend on the criticality of the item and the organization's operational needs. For example, CITO is often more financially viable for essential, high-value items than for routine items that can be ordered in bulk at a lower cost per unit.

The ability of CITO to reduce lead times is another major advantage highlighted in comparative studies. Traditional procurement models often involve extensive lead times due to the scheduled ordering processes and fixed inventory cycles that prioritize cost savings over speed. A study by Alshemari *et al.* (2020) found that CITO models could significantly cut lead times by minimizing intermediate steps and allowing for faster decision-making processes. This advantage is especially relevant in sectors like healthcare, where the timely availability of critical supplies can directly impact patient outcomes.

The literature also shows that reduced lead times under CITO can help prevent stockouts and maintain supply continuity in high-demand situations. According to Jachowicz *et al.* (2020), healthcare organizations employing CITO procurement models experienced fewer disruptions in their supply chains during the pandemic than those that relied solely on traditional procurement. In contrast, organizations with traditional procurement models faced extensive delays, exacerbating shortages of critical supplies like medications and PPE.

Risk management is a vital consideration in the comparison of CITO and traditional procurement. Traditional procurement models typically rely on long-term relationships with a limited number of suppliers, which can provide stability but may create vulnerabilities during global supply disruptions. CITO, however, mitigates this risk by maintaining a diversified supplier base that allows for rapid sourcing adjustments. As noted by Nikolaidou (2021), CITO's resilience in the face of supply chain disruptions made it an invaluable model during the pandemic, where single-source dependencies often failed to meet demand spikes.

However, while CITO provides flexibility and risk mitigation through supplier diversity, it can also introduce quality assurance challenges. Study by Maria and Putri (2022) observed that rapid sourcing under CITO could lead to less rigorous vetting of suppliers, raising the risk of counterfeit or substandard products. This issue is particularly concerning in the pharmaceutical sector, where quality control is critical to patient safety. Traditional procurement, in contrast, typically allows more time for thorough supplier verification and quality assurance, making it more suitable for non-critical, bulk supplies. Comparative studies indicate that CITO procurement offers significant advantages over traditional methods in terms of flexibility, responsiveness, and reduced lead times, especially in critical and dynamic environments like healthcare. However, the benefits of CITO come with trade-offs, including higher per-unit costs and potential risks related to quality assurance. Traditional procurement remains valuable for its cost-effectiveness and stability in predictable,

high-volume orders. The literature suggests that an integrated approach, combining CITO's flexibility with traditional procurement's cost efficiency, could offer a balanced solution, enabling organizations to adapt their procurement strategies based on the specific requirements of each item and situation (Rimadeni *et al.*, 2024).

The adoption of CITO procurement in the pharmaceutical and healthcare sectors has marked a notable shift from traditional procurement methods, impacting cost, lead times, and resource allocation in unique ways. This analysis examines these three primary impacts through recent studies and industry examples, highlighting both benefits and challenges associated with the CITO model. CITO procurement's impact on costs is complex, as it often involves a trade-off between flexibility and expense. CITO typically incurs higher per-unit costs compared to traditional procurement because it relies on expedited sourcing and delivery. These additional expenses arise from premium fees for faster shipping, more dynamic supplier relationships, and pre-negotiated contracts that prioritize speed over cost efficiency.

For instance, Study found that while CITO procurement allowed hospitals to obtain essential medications quickly during shortages, it did so at a higher cost than traditional bulk orders, which typically benefit from economies of scale (Faizar *et al.*, 2023). However, these costs can be partially offset by reducing expenses associated with stockouts, which can have direct financial and reputational impacts. Additionally, CITO's ability to minimize inventory holding costs—since items are sourced as needed rather than stored in bulk—offers potential savings in storage and capital expenditures. Yusiana (2024) noted that while CITO incurs higher operational costs, it can ultimately prove more cost-effective in situations where immediate availability of critical items is necessary. In these cases, the higher procurement costs are justified by the benefits of avoiding delays that might impact patient care and outcomes.

A significant advantage of CITO procurement is its impact on lead times. Unlike traditional procurement, which is often subject to long ordering cycles and approval processes, CITO is specifically designed to reduce lead times through streamlined sourcing and real-time demand forecasting. CITO relies on pre-arranged agreements with suppliers, allowing healthcare providers to obtain essential items almost immediately. This quick turnaround is particularly valuable in healthcare, where delayed access to medications or equipment can have severe consequences on patient health outcomes.

Kusumaningrum and Mulyani (2023) highlighted that CITO models enabled hospitals to reduce lead times by up to 50% compared to traditional procurement methods. This reduction was particularly significant during the COVID-19 pandemic, where the ability to source PPE, ventilators, and critical medications promptly proved vital to maintaining continuity in patient care. Traditional procurement, in contrast, faced notable delays due to global disruptions, exacerbating supply shortages and

impacting care quality.

Studies also show that shorter lead times in CITO models translate to more responsive supply chains capable of adapting to sudden spikes in demand. By reducing time-to-delivery, CITO not only ensures timely availability of essential items but also enhances an organization's capacity to manage emergencies and fluctuations in demand more effectively. This advantage is increasingly critical in healthcare, where demand unpredictability is high, and patient needs can change rapidly.

Implementing CITO procurement has implications for resource allocation within organizations, especially in terms of workforce and inventory management. With CITO's emphasis on real-time demand tracking and rapid sourcing, organizations may require investments in technology and specialized personnel trained in agile procurement and supply chain management. The model relies on advanced data analytics and forecasting tools to optimize ordering and reduce the need for manual intervention, thus streamlining workflows but necessitating an initial investment in technology.

The adoption of CITO can also lead to a shift in how resources are allocated across the supply chain. According to the *Journal of Business Logistics* (2020), CITO models reduce the need for extensive warehousing and stockpiling, as items are procured as needed. This shift reduces inventory holding costs and allows for the reallocation of resources towards areas where rapid response capabilities are essential. However, the study also noted that CITO requires greater coordination and oversight to manage multiple supplier relationships effectively, which can place additional demands on procurement staff and resources if not managed properly.

Despite these challenges, CITO's ability to optimize resource allocation by reducing excess inventory levels and minimizing wastage offers potential long-term benefits. By reallocating resources more effectively, organizations can focus on high-priority items, enhancing their responsiveness to patient needs while reducing the costs and risks associated with stockouts and overstock situations.

The impact of CITO on cost, lead times, and resource allocation highlights its advantages in critical sectors like healthcare, where flexibility, speed, and precision in sourcing are paramount. While CITO's higher per-unit costs may be a limitation, the reduction in lead times and optimized resource allocation provide clear benefits, particularly when timely access to essential medications is a priority. As supply chains become more complex and demand becomes increasingly unpredictable, CITO procurement offers a compelling alternative to traditional methods, balancing agility with operational efficiency. However, to maximize the benefits of CITO, organizations may need to invest in advanced analytics, streamlined processes, and workforce training to manage the complexities of this procurement model effectively. Implementing CITO (Critical Item Time Order) procurement in the pharmaceutical industry introduces

unique challenges, particularly in areas like regulatory compliance and risk management. Given the sector's highly regulated environment and the need for meticulous oversight to ensure patient safety, adopting CITO procurement requires addressing several critical issues.

The pharmaceutical industry is among the most regulated globally, with strict requirements to ensure product quality, safety, and efficacy. For CITO procurement to be effective in this sector, organizations must navigate complex regulatory frameworks set by agencies like the U.S. FDA, European Medicines Agency (EMA), and other international regulatory bodies. These regulations mandate rigorous standards for product approval, traceability, and supplier qualifications, which can be challenging to meet when rapidly sourcing items through CITO.

A key challenge is ensuring that suppliers comply with Good Manufacturing Practices (GMP) and other standards, as failure to meet these requirements can lead to severe penalties, product recalls, and reputational damage. Rapidly engaging new suppliers under CITO may compromise the thorough validation processes needed to ensure adherence to these standards. Maria and Putri (2022) emphasize that while CITO's speed can help address urgent needs, it also increases the risk of regulatory non-compliance if supplier vetting and product quality control are not rigorous.

Further, traceability and serialization requirements add complexity to CITO implementation. As noted by (Handayani and Basri 2022), the pharmaceutical sector must maintain end-to-end traceability to comply with regulations like the Drug Supply Chain Security Act (DSCSA) in the U.S. and Falsified Medicines Directive (FMD) in the EU. CITO's rapid procurement may challenge these tracking processes, especially when multiple suppliers are involved, making it difficult to maintain accurate records and ensure the authenticity of products throughout the supply chain.

Risk management is crucial when implementing CITO procurement in pharmaceuticals, where product quality and timely delivery can directly impact patient safety. Traditional procurement methods allow for long-term supplier relationships and comprehensive quality assurance measures, whereas CITO's quick turnaround times can increase exposure to risks such as counterfeit drugs, supply chain disruptions, and quality control issues. Counterfeit and substandard products are a significant risk in rapid procurement environments, especially in times of high demand or crisis. According to Trapani *et al.* (2021), reliance on expedited sourcing may make pharmaceutical companies more vulnerable to fraudulent suppliers and counterfeit products, as the usual due diligence processes might be bypassed to meet urgent demands. The study found that without stringent risk assessment, CITO can lead to quality compromises that pose safety risks to patients.

Furthermore, supply chain disruptions are common in the pharmaceutical industry due to reliance on a

global network of suppliers. CITO procurement, while fast, may involve sourcing from geographically distant suppliers, increasing exposure to risks from geopolitical issues, natural disasters, or pandemics. Rapid supplier onboarding under CITO also complicates risk management because new suppliers may not be fully integrated into the organization's quality control and compliance systems. Tahir *et al.* (2020) suggests that while CITO can enhance responsiveness, it requires a comprehensive risk management framework to address these vulnerabilities effectively.

Quality assurance is paramount in pharmaceuticals, as any lapse can have severe implications for patient safety. Traditional procurement models allow for in-depth supplier audits and quality inspections, but CITO's rapid sourcing model limits the time available for these processes. The challenge, therefore, is to ensure that new suppliers meet the same quality standards as established partners, which requires a streamlined but robust validation process.

Faizar *et al.* (2023) highlights that inadequate supplier validation under CITO could lead to sourcing issues, including low-quality or ineffective drugs that do not meet clinical standards. Rapid sourcing often bypasses detailed quality checks, which may lead to non-compliance with pharmacovigilance requirements—regulations that mandate monitoring and reporting of product safety issues. Implementing CITO effectively in this context requires a dual approach that combines speed with stringent quality control to ensure all suppliers meet necessary regulatory standards.

In summary, while CITO offers advantages in terms of responsiveness and flexibility, it also presents unique challenges in the pharmaceutical industry. Ensuring regulatory compliance, managing risks associated with rapid sourcing, and maintaining quality assurance require organizations to adopt new, agile approaches to supply chain management. For successful CITO implementation, companies must invest in robust compliance frameworks, enhanced supplier verification systems, and advanced tracking technologies. By addressing these challenges, pharmaceutical companies can harness the benefits of CITO without compromising regulatory standards or patient safety.

MATERIALS AND METHODS

This study explores the impact of CITO (Critical Item Time Order) procurement on pharmaceutical supply chains using a mixed-methods approach, combining both quantitative and qualitative data. Data collection includes case studies across developed and developing healthcare markets, where CITO procurement's effects on procurement lead times, cost efficiency, and drug availability are analyzed. By comparing these markets, the study identifies how varying regulatory and resource conditions influence CITO's effectiveness. This dual analysis across diverse healthcare systems provides a comprehensive view of how CITO operates under

different economic and logistical constraints.

The research also includes qualitative insights from interviews with logistics managers at major pharmaceutical firms, providing a deeper understanding of the operational challenges unique to CITO. These interviews shed light on complexities such as supplier onboarding, quality control, and compliance with strict industry regulations. Logistics managers discuss strategies for balancing the rapid response requirements of CITO with rigorous regulatory demands, as well as the impact of CITO on supply chain resilience, especially during emergencies like pandemics. These first-hand accounts offer essential context that complements the quantitative findings.

Ultimately, this mixed-methods approach enables a robust analysis of CITO's advantages and challenges. Quantitative data highlights measurable impacts, such as reduced lead times and adjusted cost structures, while qualitative data provides insight into the practical challenges and strategic solutions that logistics managers implement. Together, these findings contribute to the growing academic literature on procurement strategies in healthcare, suggesting that CITO, with careful regulatory and operational oversight, can improve the availability and timely delivery of critical drugs in both high- and low-resource settings.

RESULTS AND DISCUSSIONS

Findings

CITO procurement strategies have increasingly shown promise in building resilient and effective partnerships between pharmaceutical companies and their suppliers. CITO's holistic approach considers not only immediate costs but also long-term expenses, encouraging suppliers to invest in aspects like service reliability, adaptability, and risk mitigation across the lifecycle of their contracts. This collaborative focus promotes enhanced supplier performance and accountability, aligning supplier incentives with pharmaceutical companies' objectives to prevent disruptions and ensure the consistent availability of medications. In pharmaceuticals, where delays can have critical repercussions, CITO's emphasis on lifecycle value can help sustain smoother operations and optimize overall supply chain costs by addressing hidden costs, such as waste from excess inventory or penalties from delayed deliveries.

The COVID-19 pandemic underscored the importance of adaptable, agile supplier relationships in the face of unprecedented disruptions. With demand surges, material shortages, and logistical bottlenecks, the pharmaceutical industry saw an urgent need for urgently needed rapid, real-time communication and cooperation with suppliers. CITO procurement facilitated this by using advanced digital tools for tracking and collaboration. Platforms utilizing IoT, blockchain, and predictive analytics allowed for real-time visibility into inventory, shipment tracking, and quality control, enabling suppliers and pharmaceutical companies to respond dynamically to changing conditions.

This digital integration was essential in managing global sourcing constraints, meeting fluctuating demand, and ensuring compliance with shifting regulatory standards. Moreover, CITO promotes “triadic” collaborative models, where not only the pharmaceutical company and its supplier but sometimes a third party (such as a logistics provider or regulatory body) engage in coordinated efforts. These triads create a robust ecosystem that supports resilience and continuous improvement through shared goals, especially beneficial in managing upstream activities like R&D and clinical trials, which often involve complex, regulated materials. According to studies, such structures yield stability, operational effectiveness, and sustained quality. The triadic model’s collective accountability framework mitigates common risks like sole-source dependencies and quality discrepancies, making it ideal for handling unexpected crises and regulatory shifts.

Through its focus on lifecycle costs and collaboration, CITO procurement ultimately provides a strategic advantage. Pharmaceutical companies can minimize delays, improve product quality, and increase adaptability—benefits that became critical during global health emergencies. By fostering a comprehensive view of cost and value in supplier relationships, CITO procurement positions the pharmaceutical industry to better meet both current and future challenges in an ever-evolving global marketplace.

Pharmaceutical companies that adopt CITO procurement practices benefit from a more resilient supply chain, largely due to its comprehensive focus on lifecycle cost management and long-term supplier reliability. This model enhances resilience by enabling companies to anticipate and manage risks through proactive strategies rather than reactive responses. By prioritizing secure, dependable supply sources over short-term savings, CITO empowers companies to engage in advanced planning and carefully prioritize essential drug supplies, which is critical in avoiding costly stockouts that could otherwise impact patient access to necessary medications. One of the key benefits of CITO procurement is its emphasis on diversified sourcing and optimized inventory management, which significantly reduces the risks associated with single-source dependencies. Traditionally, reliance on sole suppliers has left pharmaceutical companies vulnerable to supply chain interruptions due to disruptions affecting a single entity. By diversifying their supply base, companies can better withstand unforeseen challenges such as raw material shortages or shifts in regulatory requirements. This ability to diversify effectively mitigates risks associated with external shocks, such as sudden demand surges during crises or regulatory shifts that could impact certain suppliers’ ability to deliver. In addition to resilience, CITO procurement supports the formation of more robust partnerships with suppliers, often based on shared goals of quality, consistency, and long-term collaboration. These long-term relationships enable both the pharmaceutical company and its suppliers

to align their strategic objectives, creating a cooperative environment that enhances responsiveness to market changes. For instance, during the COVID-19 pandemic, pharmaceutical companies that had implemented CITO procurement were better positioned to manage demand spikes for certain drugs due to their established, flexible supply base and collaborative supplier relationships. Suppliers, under CITO contracts, are often incentivized to maintain high-quality standards and reliability, further strengthening the entire supply chain.

In a rapidly changing regulatory landscape, CITO procurement also facilitates compliance and quality assurance. By establishing secure and stable supplier networks with reliable, compliant partners, companies are more capable of meeting the stringent regulations that govern pharmaceutical supply chains globally. This proactive approach to procurement enables pharmaceutical companies to achieve both operational stability and agility, making it possible to meet critical demands even in challenging environments.

CITO procurement offers pharmaceutical firms a strategic advantage in managing procurement costs by emphasizing total ownership costs over direct purchase prices. By evaluating lifecycle costs—spanning sourcing, warehousing, quality control, and distribution—this approach enables firms to capture the true cost of procurement. This holistic model allows for smarter, more efficient cost management, even when securing high-quality raw materials and components that meet the rigorous standards of pharmaceutical production.

Rather than emphasizing short-term cost reductions, CITO’s life-cycle perspective enables pharmaceutical companies to assess all costs associated with a supplier over the duration of a contract, including indirect expenses like logistics, quality management, and compliance with regulatory requirements. This broader perspective allows for better planning and cost control by considering the total financial implications of procurement decisions. For example, purchasing higher-quality materials upfront may reduce the need for quality control and rework later, lowering overall costs and improving production efficiency. This approach also aligns well with the quality standards required in pharmaceuticals, as companies must consistently deliver safe, effective medications.

Another advantage of CITO procurement is its demand-oriented inventory model, which aligns inventory levels with market demand to avoid costly excesses and reduce waste. By forecasting demand with greater precision, companies can manage inventory more dynamically, minimizing the holding costs and potential waste associated with overproduction. For example, during fluctuations in demand—such as seasonal increases in vaccine requirements or sudden surges during public health crises—CITO’s demand-oriented model ensures that firms maintain optimal stock levels, reducing waste from expired inventory and enabling faster responses to changes in demand.

Additionally, the cost efficiencies realized through CITO

procurement free up resources for strategic investments in innovation, drug development, and specialized supply chains. For pharmaceutical firms, these savings are essential as they enable reinvestment into R&D initiatives that drive growth and maintain competitive advantage. By optimizing cost structures, firms can allocate more capital toward high-impact areas, including the development of advanced medications, biologics, or targeted therapies. This reinvestment also enables companies to develop more specialized supply chains tailored to diverse product types—such as temperature-controlled logistics for biologics or specialized packaging for high-value medications—allowing them to maintain high standards across a broad product range and respond to varying regulatory requirements. In sum, CITO procurement not only supports cost reduction and operational efficiency but also aligns with long-term strategic goals, offering pharmaceutical firms the flexibility to balance cost control with the need for high quality and responsiveness to market demand.

CITO procurement strategies play a critical role in enabling pharmaceutical companies to meet the stringent regulatory demands required for global compliance with quality and safety standards. Unlike traditional procurement models focused primarily on reducing purchase prices, CITO considers the entire lifecycle of costs, quality, and compliance. This approach ensures that suppliers are selected and managed with an eye on consistent adherence to Good Manufacturing Practices (GMP) and Good Distribution Practices (GDP), which are essential for maintaining product integrity across storage, transportation, and final delivery to patients. Compliance with these practices is especially important for pharmaceutical companies, as it minimizes risks of contamination, ensures temperature control where needed, and maintains product traceability, all of which are critical under regulations set by entities like the FDA in the United States, EMA in Europe, and other national health authorities globally.

One significant advantage of CITO procurement in this context is its capacity to streamline documentation and compliance tracking. In the heavily regulated pharmaceutical sector, regulatory bodies require detailed records that demonstrate a consistent history of compliance with quality standards. CITO's emphasis on transparency and long-term partnership with suppliers enhances documentation by fostering data-sharing agreements, automated compliance reporting, and real-time tracking capabilities, typically through advanced digital platforms like blockchain and IoT solutions. These technologies not only ensure traceability from raw materials to finished products but also support rapid, efficient audits by regulatory agencies. This streamlined data collection strengthens trust with regulatory bodies, enabling a smoother approval process across multiple regions by providing robust, easily accessible compliance documentation.

Furthermore, CITO's comprehensive cost and quality focus

also mitigates the risk of supply chain disruptions due to regulatory non-compliance, which can lead to costly recalls, production stoppages, or even bans on sales in certain markets. By ensuring that suppliers maintain rigorous quality control and regulatory alignment, CITO procurement helps companies preemptively address compliance issues. For instance, implementing serialization standards to prevent counterfeiting or meeting pharmacovigilance requirements to monitor and report adverse events post-market are now common compliance challenges. Through CITO's structured approach to lifecycle management, these requirements are more efficiently integrated into the supply chain, reducing compliance risks and improving overall operational stability.

Beyond risk mitigation, the CITO model's support for regulatory compliance aligns well with pharmaceutical companies' long-term objectives. By building a solid reputation for compliance, companies are able to expand their reach into multiple markets, including emerging ones where adherence to international standards is increasingly required. This reputation can enhance competitive positioning, facilitating not only faster market entry but also cost efficiencies related to reduced regulatory delays and fewer legal risks. As a result, the compliance benefits of CITO allow companies to allocate more resources to innovation and high-impact R&D activities that are central to advancing pharmaceutical development. Thus, CITO procurement not only ensures a resilient, compliant supply chain but also frees up capital for innovation, which is essential for sustainable growth in the pharmaceutical sector.

Overall, by focusing on total cost, quality, and compliance from a lifecycle perspective, CITO procurement strategies help pharmaceutical firms navigate the complex regulatory landscape with greater agility and assurance. This approach is integral to maintaining high standards across a global supply network, meeting the stringent demands of national and international regulatory bodies, and building trust in the safety and efficacy of the pharmaceutical supply chain.

The findings highlight that CITO procurement represents a significant evolution in pharmaceutical supply chain management, offering a more integrated, strategic, and risk-averse approach. By emphasizing long-term collaboration between pharmaceutical companies and their suppliers, CITO fosters adaptability and resilience in the face of both routine operations and crisis situations. For example, during the COVID-19 pandemic, pharmaceutical firms that had already implemented CITO procurement practices were better equipped to respond to the sharp surge in demand for critical drugs like vaccines and antiviral medications. Companies leveraging CITO's strategic foresight were able to quickly adjust procurement strategies, ensure stock availability, and navigate supply disruptions. This demonstrates how CITO procurement plays a crucial role in ensuring that pharmaceutical companies are not only prepared for day-to-day operations but also equipped to handle unforeseen

supply chain shocks.

In addition, CITO procurement supports the broader trend of digital transformation within the pharmaceutical industry, enhancing its ability to respond to complex and dynamic market conditions. Technologies like advanced analytics, predictive modeling, and real-time data sharing provide pharmaceutical companies with the tools to proactively manage their supply chains. Predictive models can identify potential disruptions or supply gaps before they occur, allowing companies to adjust procurement strategies and mitigate risks such as stockouts or delays. For instance, leveraging the Internet of Things (IoT) to track shipments in real time can offer visibility into product conditions and delivery schedules, ensuring that drugs are delivered on time and under the right conditions. Similarly, blockchain technology can help ensure product traceability and combat counterfeiting, offering added security and compliance in an increasingly complex regulatory landscape.

The flexibility of CITO procurement also enables pharmaceutical firms to tailor their supply chains to different product categories, optimizing processes for both high-complexity, high-margin products and more standardized, low-cost medications. For example, biologic drugs, which require specialized temperature-controlled environments throughout their supply chains, benefit from CITO's focus on end-to-end collaboration with suppliers. On the other hand, generic drugs can be managed with more cost-efficient models without compromising the quality or timeliness of delivery. This adaptability ensures that a company can meet the needs of diverse product lines while maintaining cost efficiency, regulatory compliance, and high standards of patient care.

However, implementing CITO procurement within the pharmaceutical sector does come with challenges, primarily due to the complexity of the industry's regulatory environment. Complying with national and international standards such as Good Manufacturing Practices (GMP) and Good Distribution Practices (GDP) requires careful coordination and robust documentation processes. Furthermore, the upfront investment needed for digital transformation—such as implementing advanced technologies, retraining staff, and enhancing data infrastructure—can be substantial. Despite these challenges, the long-term benefits of CITO procurement far outweigh the initial costs. These benefits include enhanced operational efficiency, better risk management, stronger supplier relationships, and ultimately, improved patient access to medicines. Companies that invest in CITO procurement can achieve sustained competitive advantages by becoming more agile, compliant, and cost-efficient.

In conclusion, CITO procurement offers a comprehensive framework that not only addresses current challenges in the pharmaceutical supply chain but also positions companies for long-term success. By fostering deeper supplier collaboration, enabling digital transformation, and enhancing resilience, CITO procurement helps pharmaceutical firms navigate an increasingly complex and fast-evolving landscape. This approach ultimately

leads to improved operational efficiency, enhanced regulatory compliance, and more timely access to essential medications, which benefits both pharmaceutical companies and the patients they serve.

CONCLUSION

The primary findings of this study indicate that CITO procurement has significant potential to enhance the efficiency of pharmaceutical supply chains, particularly in terms of cost reduction, lead time optimization, and improved resource allocation. Through direct comparison with traditional procurement methods, CITO has been shown to shorten procurement cycles, reducing the risk of stockouts for critical medications by improving responsiveness in high-demand or emergency situations. These improvements are increasingly vital in the face of global supply chain challenges that have intensified since the COVID-19 pandemic. Furthermore, CITO's focus on real-time data and agile supplier relationships helps mitigate risks related to sudden demand shifts and supply interruptions, providing a level of flexibility that traditional procurement methods often lack.

One of the key benefits of CITO in healthcare is its capability to manage complex regulatory requirements more dynamically. The pharmaceutical industry faces strict compliance mandates that can delay traditional procurement timelines; however, CITO's ability to streamline processes and improve supplier collaboration supports compliance without compromising delivery speed. Digital innovations like IoT-enabled tracking and data analytics enhance transparency and reduce delays associated with regulatory compliance, making CITO a more resilient approach for meeting the healthcare sector's urgent needs.

Future research should explore the long-term implications of CITO on pharmaceutical cost structures and patient outcomes. Additional studies on how CITO can support sustainability in procurement—by optimizing inventory and reducing waste—would add valuable insights. Given the increasing focus on supply chain resilience, investigating the role of CITO in predictive analytics and AI could also be beneficial for preparing for potential disruptions in the global pharmaceutical supply chain. This direction aligns with recent calls in the industry to integrate more advanced technologies and strategies for agile, secure, and sustainable supply chains.

CITO procurement plays a crucial role in ensuring that life-saving medications reach patients in a timely manner. Despite the increased costs associated with this approach, the improved patient outcomes highlight its value in critical care scenarios. Future research should focus on developing cost-effective CITO strategies and exploring the potential of AI-driven forecasting to predict demand spikes, thereby enabling more efficient procurement decisions.

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