

Enhancing Pharmaceutical Supply Chain Efficiency of Medicine Through the Utilization of Lean Practices: A Survey of Hospitals and Clinics in Ndola District, Zambia

Chileya Musamba^{1*}, Dr. Bupe Getrude Mutono Mwanza¹

¹Graduate School of Business, University of Zambia, Lusaka, Zambia

* Corresponding Author

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Abstract

Efficient pharmaceutical supply chains are essential for ensuring timely access to medicines in healthcare facilities. This study assessed inefficiencies in Ndola District's pharmaceutical supply chain and evaluated the impact of lean practices of Value Stream Mapping (VSM), Just-in-Time (JIT), Kanban, and Lean Six Sigma (LSS) using a mixed-methods approach. Findings revealed challenges such as bureaucratic procurement, stock-outs, and poor inventory management. VSM had the strongest positive impact on efficiency ($B = 0.572$, $p = 0.000$), with 74.5% of respondents affirming its effectiveness. LSS improved medication safety and material flow ($B = 0.252$, $p = 0.073$), though with more mixed perceptions. Kanban improved product movement and reduced waste, but 30.9% of respondents were neutral, indicating uneven implementation. JIT showed minimal effect. Overall, lean practices accounted for 47.7% of the variance in supply chain efficiency ($R^2 = 0.477$), with strong internal consistency (Cronbach's alpha = 0.962). Despite demonstrated benefits, barriers such as supplier unreliability, staff resistance, and inadequate training hinder full adoption. Strengthening the implementation of VSM and LSS, alongside policy and infrastructural reforms, is crucial for optimizing pharmaceutical supply chains and improving healthcare delivery in Ndola District.

Keywords: Pharmaceutical supply chain, lean practices, supply chain efficiency, healthcare logistics, Ndola District

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1. Introduction

Pharmaceutical supply chains in Low- and Middle-Income Countries (LMICs), including Zambia, face persistent inefficiencies that hinder timely and equitable access to essential medicines. In districts like Ndola, challenges such as fragmented logistics, poor forecasting, and seasonal health crises like malaria outbreaks continue to disrupt medicine availability (Seidman & Atun, 2017; Vledder et al., 2019). Despite ongoing efforts, stock outs and delayed deliveries remain common. Recently, lean supply chain practices such as Value Stream Mapping (VSM), Just-in-Time (JIT), and Lean Six Sigma (LSS) have gained attention for their potential to enhance efficiency and reduce waste. These methods have shown success in improving pharmaceutical supply chains in LMICs like India, Malaysia, and Tanzania (Dixit et al., 2021; Abideen & Mohamad, 2019; Milulu et al., 2024a). While Zambia has piloted some lean-inspired initiatives, widespread adoption remains limited. Ndola District presents a valuable opportunity to explore how lean practices can be adapted to improve medicine supply and operational efficiency in the local context.

This study aims to examine how the application of lean practices can enhance the efficiency of pharmaceutical supply chains in Ndola District, with a focus on improving the availability and delivery of essential medicines. The findings are expected to provide practical insights for healthcare managers and policymakers, supporting more informed decisions around supply chain improvement initiatives and contributing to stronger, more resilient health systems in Zambia and similar LMIC settings.

1.2. Statement of the Problem

Despite their critical role in ensuring access to essential medicines, pharmaceutical supply chains in Zambia particularly in Ndola District face persistent inefficiencies that compromise healthcare delivery. Internal statistics from the Zambia Ministry of Health (2022) reveal that nearly 40% of health facilities in Ndola experience regular stock-outs of essential medicines such as antimalarials, antibiotics, and vaccines. These stock-outs are often accompanied by delayed deliveries and poor inventory tracking, which negatively affect patient care and treatment outcomes. A 2019 audit by the Zambia Medicines and Medical Supplies Agency (ZAMMSA) reported that only 65% of inventory was accurately tracked, resulting in both overstocking and shortages. These problems intensify during seasonal health emergencies like malaria outbreaks, where demand surges unpredictably (Mekonnen, Worku, & Tefera, 2024).

Existing studies, including those by Argiyantari, Simatupang, & Basri (2020) and Conceição et al. (2020), have demonstrated the benefits of lean supply chain practices—such as Value Stream Mapping (VSM), Just-in-Time (JIT), and Lean Six Sigma (LSS)—in enhancing efficiency in healthcare systems, particularly in high-income countries. However, in Zambia, evidence of successful and sustainable lean implementation in public health facilities remains limited. Factors such as inadequate infrastructure, a constrained healthcare workforce, and erratic demand patterns pose significant barriers to the adoption of these lean practices (Tayyab et al., 2022). Additionally, lean interventions often rely on donor support and external consultants, raising concerns about their long-term sustainability in local settings (Kessy, Salema, & Simwita, 2024).

This study seeks to fill this research gap by focusing specifically on the application of lean practices in the pharmaceutical supply chains of hospitals and clinics in Ndola District. The lack of in-depth understanding of how lean tools can be adapted to Zambia's healthcare context hinders the development of practical and sustainable solutions. Continued inefficiencies in the pharmaceutical supply chain not only result in medicine shortages and resource wastage but also contribute to reduced quality of care and weakened health outcomes. This research aims to provide actionable insights that can inform policy and practice, ultimately enhancing the operational efficiency and reliability of medicine supply systems in Zambia.

1.3. Objectives of the Study

- i. To evaluate the current inefficiencies within the pharmaceutical supply chain of hospitals and clinics in Ndola District.
- ii. To establish the lean practices that are used by hospitals and clinics in Ndola District.
- iii. To assess how the lean practices used in hospitals and clinics can enhance supply chain efficiency.

2. Literature Review

This chapter provides a comprehensive review of existing literature on lean practices in the healthcare sector, particularly within pharmaceutical supply chains (PSCs). It evaluates the application of lean principles, their impact on efficiency, and the contextual factors influencing implementation in low- and middle-income countries (LMICs), especially Zambia. The literature also highlights theoretical gaps, practical limitations, and directions for future research.

2.1 Overview of Lean Practices in Healthcare Supply Chains

Lean is a systematic approach that seeks to maximize value for customers by eliminating waste and improving workflow efficiency. Initially developed in the manufacturing sector, lean principles have since been adapted for use in healthcare and pharmaceutical supply chains. Key tools and techniques include Just-In-Time (JIT) delivery, Value Stream Mapping (VSM), 5S, Kanban systems, and Lean Six Sigma (LSS) (Almeida et al., 2017; Mustafa & Potter, 2009).

In the context of healthcare, lean practices aim to reduce process inefficiencies, ensure timely availability of medicines, minimize stockouts, and improve patient care outcomes. Studies in high-income countries have shown that lean implementation can significantly enhance inventory management, reduce lead times, and improve service delivery (DelliFraine et al., 2010; Mazzocato et al., 2012). However, there is limited empirical evidence on lean application within PSCs in LMICs, where contextual challenges may hinder implementation.

2.2 Application of Lean Practices in Pharmaceutical Supply Chains

Lean tools have been successfully applied in various healthcare environments. For instance, JIT principles can streamline inventory flow, reducing overstocking and expiry of medicines. VSM helps identify non-value-adding activities across procurement, storage, and distribution processes. Kanban systems provide visual cues for stock replenishment, promoting more responsive supply chain operations (Agyapong et al., 2021).

Despite these successes, studies also report challenges related to adapting lean in complex, dynamic, and resource-limited healthcare systems. In many LMICs, including Zambia, hospitals and clinics struggle with weak infrastructure, limited human resources, and fragmented information systems. These factors limit the consistent and effective application of lean strategies (Yadav et al., 2019).

2.3 Contextual Challenges in Resource-Constrained Environments

In Zambia, the pharmaceutical supply chain is characterized by frequent stockouts, poor demand forecasting, and inefficient procurement processes (Mwape et al., 2010). These issues are often exacerbated by centralized decision-making

and a lack of autonomy at the facility level. Additionally, poor data management systems hinder accurate inventory tracking and timely ordering, posing major barriers to lean implementation.

Research suggests that aligning lean strategies with the specific needs and capacities of LMIC healthcare systems is critical for success. Contextual tailoring ensures that interventions are sustainable and responsive to local challenges, including staff shortages, donor dependency, and regulatory gaps (Chigome et al., 2019).

2.4 Enablers and Barriers to Lean Implementation

Human Resources and Training

Successful lean implementation in healthcare settings is often contingent on the availability of well-trained personnel. Continuous professional development, staff engagement, and leadership support are key enablers of lean adoption. Resistance to change, lack of lean knowledge, and limited incentives are common barriers (Abdallah & Phan, 2017).

Technology and Information Systems

Digital innovations, such as Enterprise Resource Planning (ERP) systems, barcode scanning, and electronic logistics management information systems (eLMIS), can support lean PSC operations by improving visibility and coordination. However, adoption of such technologies is often limited in LMICs due to cost, infrastructure, and technical expertise constraints (Sule et al., 2020).

Organizational Culture and Leadership

Embedding lean into organizational culture requires transformational leadership and long-term commitment. This includes promoting a culture of continuous improvement, employee empowerment, and open communication. Without leadership buy-in, lean initiatives may fail to gain traction or deliver sustainable impact (Radnor et al., 2012).

Integration of Lean with Agile and Digital Innovation

Recent studies emphasize the need for hybrid models that integrate lean and agile practices to enhance healthcare system responsiveness. Agile supply chains prioritize adaptability and speed—attributes that complement lean's focus on efficiency. Furthermore, the emergence of Pharma 4.0, characterized by the integration of digital technologies such as AI, IoT, and big data analytics, presents new opportunities to optimize PSC operations (Ismail & Sharifi, 2021).

While these innovations show promise, further research is needed to explore how they can be practically applied in resource-limited settings. In Zambia, digital transformation of the healthcare supply chain remains in its infancy, highlighting a crucial area for exploration and investment.

Cross-Cultural and Contextual Adaptability of Lean

Lean principles must be adapted to reflect local values, capabilities, and constraints. Cross-cultural studies suggest that factors such as governance, community involvement, and institutional trust influence the success of lean interventions. In Africa, lean must often be contextualized to fit decentralized health systems and address informal practices that impact supply chain decisions (Mbohwa & Nyanga, 2016).

2.5 Research Gaps and Future Directions

Based on the review, several areas require further investigation:

- **Long-Term Impact:** More studies are needed on how lean strategies can be embedded into healthcare culture and deliver sustained improvements.
- **Technology Integration:** Research is needed on how AI, IoT, and other emerging technologies can be aligned with lean principles to strengthen PSCs.
- **Hybrid Models:** The integration of lean with agile strategies remains underexplored in healthcare contexts.
- **Human Resources:** The role of training, staff engagement, and leadership in lean success should be studied further.
- **Contextual Adaptation:** There is a need for cross-cultural research to understand how lean principles work in LMICs like Zambia.
- **Quality and Compliance:** Future research should explore how lean can align with digital quality frameworks such as Pharma 4.0.

Contribution of the Current Study

This research, focused on Ndola District, Zambia, addresses critical gaps in understanding how lean practices can be adapted to and implemented within a resource-constrained healthcare context. By exploring lean tools in hospitals and clinics, it aims to generate context-specific insights that support the strengthening of pharmaceutical supply chains and improvement of healthcare delivery in Zambia.

Conclusion

This chapter has examined key literature on lean practices in healthcare and PSCs. While lean offers significant potential for enhancing efficiency, its practical implementation in LMICs faces numerous challenges. The reviewed literature

underscores the need for more context-sensitive, interdisciplinary, and innovation-driven approaches. The next chapter presents the research methodology employed to examine the use of lean practices in the pharmaceutical supply chains of hospitals and clinics in Ndola District.

2.6 Theoretical Framework

This study is grounded in three interrelated theories: Lean Thinking, Lean Supply Chain (LSC), and Supply Chain Management (SCM). Together, these frameworks offer a structured approach to examining inefficiencies and identifying opportunities for improvement within pharmaceutical supply chains in Zambia's public healthcare system.

Lean Thinking Theory focuses on maximizing value by eliminating waste and improving process efficiency. Originating from the Toyota Production System, it emphasizes key principles such as Value Stream Mapping (VSM), Just-in-Time (JIT) inventory, continuous flow, and continuous improvement (Kaizen) (Dixit, Routroy, & Dubey, 2021; Kessy, Salema, & Simwita, 2024). This theory is relevant to the study as it provides tools for identifying bottlenecks, reducing stock-outs, and enhancing medicine availability in public hospitals and clinics in Ndola District.

Lean Supply Chain (LSC) Theory extends lean principles across the entire supply chain, emphasizing waste reduction, demand-driven operations, and collaborative relationships among supply chain actors (Oliveira-Dias, Moyano-Fuentes, & Maqueira-Marín, 2022). LSC theory is particularly useful for exploring how better integration between suppliers, logistics providers, and healthcare facilities can improve responsiveness and reduce inefficiencies in medicine distribution.

Supply Chain Management (SCM) Theory offers a strategic perspective on coordinating end-to-end processes involved in the flow of goods, services, and information (Tayyab et al., 2022; Conceição et al., 2020). It highlights the importance of supplier relationships, data visibility, and process integration to ensure timely and reliable access to essential medicines. In the context of Ndola, SCM theory helps contextualize how systemic issues such as poor data management and fragmented logistics that can be addressed through lean-based strategies.

Together, these theoretical lenses provide a comprehensive foundation for analyzing the challenges in Zambia's pharmaceutical supply chain and for evaluating how lean practices can be adapted to enhance operational performance and healthcare outcomes.

Independent Variables

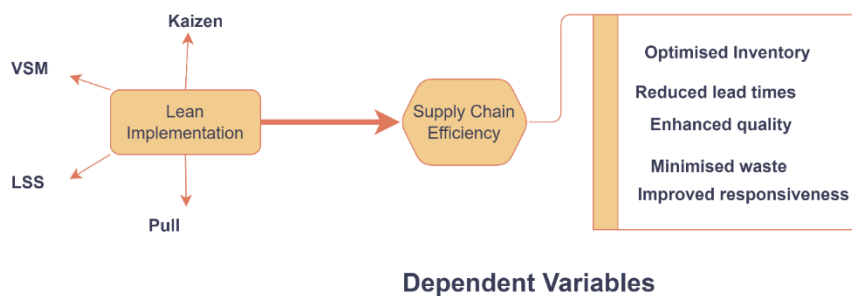


Fig 1: Conceptual Framework

3 Research Methodology

This research adopts a pragmatic philosophy that aligns with a mixed-methods approach. Pragmatism supports combining quantitative and qualitative methods to gain a comprehensive understanding of pharmaceutical supply chain efficiency in Ndola District. This approach facilitates integrating practical numeric data with rich contextual insights from key stakeholders. An exploratory convergent mixed-methods design was employed. Quantitative data were collected via structured questionnaires and supplemented by secondary hospital records. Qualitative data were gathered through semi-structured interviews with pharmacists and supply chain managers. This design allowed for triangulation and provided both a broad and deep perspective on lean practices in the pharmaceutical supply chain.

The study population consisted of pharmacists, pharmacy technologists, healthcare workers, and supply chain managers across 46 health facilities in Ndola District. A multi-stage sampling technique was used; first, all facilities were stratified by type, ownership, and level of care. Then, simple random sampling selected respondents for the quantitative component to ensure representativeness. Purposive sampling was used for the qualitative component to select participants with specialized knowledge relevant to the study. Using Taro Yamane's formula with a 95% confidence level and 5% margin of error, a sample size of 145 was calculated. A total of 136 participants completed the quantitative survey, while 15 participants were purposively selected for qualitative interviews to allow for depth and saturation. Participants included healthcare workers and supply chain managers directly involved in pharmaceutical supply chain processes and willing to provide informed consent. Those not involved in supply chain activities or unwilling or unavailable to participate were excluded.

Quantitative data were collected through structured questionnaires addressing inefficiencies, lean practices, and supply chain efficiency, while secondary data from hospital records supplemented the survey data. Qualitative data were collected via semi-structured interviews focusing on experiences, challenges, and perceptions related to lean practices and

pharmaceutical supply chains. A pilot study was conducted to test the clarity, flow, and relevance of data collection tools, with feedback from healthcare workers and supply chain managers informing revisions to both questionnaires and interview guides. Quantitative data were analyzed using descriptive and inferential statistics, with normality tests determining the appropriate statistical methods. Qualitative data were thematically analyzed to identify patterns and insights related to lean practice implementation and supply chain challenges. Ethical approval was obtained from the University Ethics Committee, and permissions were secured from participating organizations. Voluntary participation, informed consent, confidentiality, anonymity, and participant safety were strictly observed throughout the study.

Validity and Reliability

Reliability in this study was assessed using Cronbach's alpha, with values above 0.7 indicating acceptable internal consistency of the questionnaire constructs. The questionnaire underwent pilot testing to identify and rectify any issues related to item clarity and comprehension. Validity was ensured through several measures including expert review by pharmaceutical supply chain and lean practice specialists, alignment of questionnaire items with established literature, and factor analysis to confirm construct validity. The qualitative component added to validity through triangulation of multiple data sources, member checking where participants reviewed and confirmed interpretations, peer debriefing with external experts providing critical feedback, and maintaining a comprehensive audit trail documenting all research decisions and procedures. Together, these strategies enhanced the credibility, dependability, and overall trustworthiness of the study findings.

4 Results and Discussion

4.1 Demographics

The provided table offers a demographic snapshot of the respondents involved in this study. A majority of respondents (41.2%) were between the ages of 31 and 40, indicating a youthful and dynamic workforce engaged in lean practices in healthcare supply chains. Respondents below the age of 30 made up 31.6%, while those aged 41 to 50 accounted for 22.8%. Only a small proportion (4.4%) of respondents were aged above 51, suggesting limited representation of older professionals in the study.

In terms of job titles, the majority of respondents (80.9%) were pharmacists, reflecting their central role in pharmaceutical supply chains. Health workers constituted 15.4%, supply chain managers 2.2%, and pharmacy technologists a small fraction of 1.5%. This distribution highlights the predominance of pharmacists in healthcare supply chain operations within Ndola district.

Regarding years of experience, 41.2% of respondents had between 6 and 10 years of professional experience, representing a well-established mid-career group. Those with 0 to 5 years of experience accounted for 33.8%, while respondents with 11 to 15 years made up 21.3%. Only 3.7% reported having more than 15 years of experience, indicating fewer senior experts within the sample.

Table 1: Demographic Results

Demographic	Attribute	Frequency	Percentage
Age	Below 30 years	43	31.6%
	31 - 40 years	56	41.2%
	41- 50 years	31	22.8%
	Above 50 years	6	4.4%
Job Title	Pharmacists	110	80.9%
	Health workers	21	15.4%
	Supply chain managers	3	2.2%
	Pharmacy Technologists	2	1.5%
Years of experience	0-5 years	46	33.8%
	6-10 years	56	41.2%
	11-15 years	29	21.3%
	Above 15 years	5	3.7%

4.2 Themes and their Descriptions

The themes for this study were developed through a thorough analysis of responses gathered from healthcare professionals across hospitals and clinics in Ndola District. These insights reflect the practical experiences, challenges, and observations related to the implementation of lean practices in pharmaceutical supply chains. From this analysis, key themes emerged that speak to how lean tools are understood, applied, and evaluated within these institutions.

Awareness and Understanding of Lean Practices.

A significant portion of respondents demonstrated an awareness of lean principles such as Just-in-Time (JIT), Value Stream Mapping (VSM), and 5S. However, the depth of understanding varied among respondents, with many indicating a need for formal training. One participant noted, "We hear about lean during workshops, but we have not been trained in how to use it daily." This highlights a knowledge gap that may affect the effective adoption of lean strategies in health facilities.

Application of Lean Tools in Practice

While there is some evidence of lean tools being applied particularly in areas like inventory management and procurement implementation remains inconsistent. For example, a pharmacist from one of the district hospitals stated, "We use some lean tools like JIT when ordering drugs, but it's not always systematic." This suggests that lean practices are applied informally or in isolation, rather than as part of a structured lean management system.

Benefits Observed from Lean Implementation

Respondents acknowledged several benefits resulting from the partial application of lean tools. These included reduced stock outs, improved efficiency in procurement, and better space utilization in storerooms. One supply chain manager remarked, "Since adopting basic 5S principles, our shelves are better organized, and retrieval time has improved." This demonstrates the potential of lean practices to enhance operational performance even with limited implementation.

Challenges in Implementing Lean Practices

Numerous challenges were cited as barriers to fully adopting lean practices. These include lack of training, resistance to change, limited funding, and inadequate leadership support. A respondent commented, "We often want to improve processes, but there is no budget or management support to do so." This reflects structural and organizational barriers that must be addressed to facilitate effective lean implementation.

Role of Leadership and Policy Support

Leadership engagement was identified as a key enabler of lean practices. In facilities where management actively supported continuous improvement, respondents reported more successful outcomes. Conversely, in settings lacking strategic direction, lean efforts tended to stall. One participant shared, "Our supervisor encourages us to suggest better ways of working, and that has helped us reduce waste." This underscores the importance of top-down commitment in driving lean culture.

Sustainability and Future Prospects

Sustainability of lean practices was a concern for many respondents. While there is a willingness to embrace lean methods, many felt uncertain about the long-term prospects due to irregular support and lack of monitoring systems. A pharmacist from a private clinic explained, "We started using Kanban cards, but it ended after the pilot phase because there was no follow-up." This points to the need for structured evaluation mechanisms and continuous reinforcement of lean strategies.

5 Conclusions and Recommendations

Conclusion

This study has identified several critical inefficiencies affecting pharmaceutical supply chains within healthcare facilities in Ndola District, Zambia. Respondents reported widespread challenges, including delays in supply, frequent stock-outs, inadequate inventory management, poor interdepartmental communication, substandard storage facilities, and medication wastage. These inefficiencies have a direct impact on service delivery, often delaying access to essential medicines and compromising patient care. The findings confirm similar patterns observed in broader literature, reinforcing that logistical and operational shortcomings are common in healthcare supply chains.

In addressing the second objective, the study examined the adoption of lean practices—specifically Value Stream Mapping (VSM), Just-in-Time (JIT), Lean Six Sigma (LSS), and the Kanban system—within pharmaceutical supply chains. Among these, VSM emerged as the most widely adopted, with other practices like JIT and Kanban also seeing notable uptake. These lean tools were employed to streamline processes, reduce waste, and improve inventory flow. However, the study also uncovered challenges impeding the full realization of lean benefits, particularly poor communication, inadequate storage, and insufficient staff training, which limited effective implementation in some facilities.

The assessment of lean practice outcomes revealed a clear potential for enhancing supply chain efficiency. Facilities that adopted lean principles reported better inventory control, reduced stock-outs, and timelier medicine deliveries. Notably, VSM played a pivotal role in identifying process bottlenecks, while JIT and Kanban systems helped optimize inventory levels. LSS further contributed by minimizing errors and promoting continuous improvement. Yet, the success of these interventions varied across institutions, signaling the need for more consistent and supportive implementation strategies. Overall, the study underscores the importance of strengthening lean practice adoption to drive sustainable improvements in pharmaceutical supply chain efficiency. To achieve this, healthcare facilities in Ndola must address key barriers enhancing communication, upgrading storage infrastructure, and equipping staff with adequate training and support. By

fostering a culture of continuous improvement and operational excellence, these facilities can ensure more reliable medicine availability and ultimately contribute to better health outcomes for communities they serve.

Recommendations

To enhance the efficiency and sustainability of pharmaceutical supply chains in healthcare facilities across Ndola District, several strategic interventions are recommended. First, supply chain coordination should be strengthened at the district level by improving collaboration among healthcare facilities, district health offices, and central medical stores. This includes optimizing stock redistribution, enhancing demand forecasting, and implementing emergency supply mechanisms, supported by regular performance reviews and continuous staff training. Second, procurement processes should be improved using Lean tools such as Value Stream Mapping (VSM) and Just-in-Time (JIT) inventory systems, alongside standardizing procurement procedures and engaging multiple reliable suppliers to reduce delays by at least 30% within 12 months. Third, communication among stakeholders should be enhanced through a centralized digital platform that enables real-time updates and minimizes errors, aiming for a 50% reduction in communication-related inefficiencies within 15 months. Fourth, healthcare facilities should upgrade storage systems by investing in climate control, automated inventory tracking, and proper shelving to reduce medication wastage by at least 35% over two years, with government and donor support mobilized for funding. Finally, ongoing staff training in Lean methodologies such as Lean Six Sigma (LSS) and Kanban should be prioritized, ensuring that at least 90% of supply chain personnel are trained within 18 months, with the training's impact regularly assessed to support continuous improvement in pharmaceutical supply chain performance.

Limitations

This study, while offering important insights into pharmaceutical supply chain inefficiencies in Ndola District, has several limitations. First, the findings may not be generalizable to other regions in Zambia due to variations in healthcare infrastructure, policies, and practices across districts. Second, the study relied on self-reported data from stakeholders, which may introduce recall or social desirability biases, potentially affecting the accuracy of the responses. Third, the cross-sectional design limited the ability to assess changes over time or the long-term impact of lean interventions. Despite these limitations, the study provides a valuable foundation for understanding supply chain challenges in Zambian healthcare and highlights areas for future research, including broader geographic studies, longitudinal assessments, and the integration of objective performance data to validate findings.

Conflict of Interest

The authors declare that they have no conflicting interests

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Ethical considerations

The article followed all ethical standards appropriate for this kind of research.

References

- Abideen, A.Z. and Mohamad, F. (2019) 'Supply chain lead time reduction in a pharmaceutical production warehouse – a case study'. *International Journal of Pharmaceutical and Healthcare Marketing*. Available at: [10.1108/ijphm-02-2019-0005](https://doi.org/10.1108/ijphm-02-2019-0005).
- Adeyeye, M.C. et al. (2023) 'Enabling pharmaceutical traceability in the nigerian supply chain using GS1 global standards: lean traceability including In-country serialization of COVID-19 vaccines', *Journal of Regulatory Science*, 11(1), pp. 1–14. Available at: <https://doi.org/10.21423/JRS.REGSCI.111252>.
- Aguirre-Manrique, S. and Chávez-Ugaz, R. (2023a) 'Impact of lean tools in the supply chain: pharmaceutical industry perspective', *International Journal of Innovation, Management and Technology*, 14(3), pp. 108–114. Available at: <https://doi.org/10.18178/ijimt.2023.14.3.946>.
- Aguirre-Manrique, S. and Chávez-Ugaz, R. (2023b) 'Impact of lean tools in the supply chain: pharmaceutical industry perspective', *International Journal of Innovation, Management and Technology*, 14(3), pp. 108–114. Available at: <https://doi.org/10.18178/ijimt.2023.14.3.946>.
- Antonio Rique Roberto, M. and Luiz Reis, D. (2023) 'Proposta de melhoria no processo de picking - estudo de caso em um centro de distribuição farmacêutica na cidade de manaus/am', *Revista Científica Semana Acadêmica*, 11(239), pp. 1–21. Available at: <https://doi.org/10.35265/2236-6717-239-12834>
- Argiyantari, B., Simatupang, T. and Basri, M.H. (2020) 'Pharmaceutical supply chain transformation through application of the lean principle: a literature review', *Journal of Industrial Engineering and Management*. Available at:

<https://doi.org/10.3926/IJEM.3100>.

- Conceição, J.R.B.D. et al. (2020) 'Issues in healthcare supply chain management: from literature to practice', *International Journal of Supply Chain Management* [Preprint]. Available at: <https://www.semanticscholar.org/paper/Issues-in-Healthcare-Supply-Chain-Management%3A-From-Concei%C3%83%C2%A7%C3%83%C2%A3o-Spiegel/0101ac8b48f2a9fd928aa6a44ad51f7235fcd7e3> (Accessed: 6 December 2024).
- Creswell, J.W. and Creswell, J.D. (2023) *Research design: qualitative, quantitative, and mixed methods approaches*. Sixth edition. Los Angeles London New Delhi Singapore Washington DC Melbourne: SAGE.
- De Souza Pinto, J. et al. (2017) 'Proposal the application of DMAIC tools and value stream mapping under the perspective of the lean philosophy for process improvement: a case study', *Brazilian Journal Of Operations And Production Management*, 14(4), pp. 556–566. Available at: <https://doi.org/10.14488/BJOPM.2017.v14.n4.a11>
- Dixit, A., Routroy, S. and Dubey, S. (2021) 'Development of supply chain value stream map for government-supported drug distribution system', *International Journal of Quality & Reliability Management*. Available at: <https://doi.org/10.1108/ijqrm-12-2020-0399>.
- Dixit, A., Routroy, S. and Dubey, S.K. (2022) 'Development of supply chain value stream map for government-supported drug distribution system', *International Journal of Quality & Reliability Management*, 39(5), pp. 1151–1169. Available at: <https://doi.org/10.1108/IJQRM-12-2020-0399>.
- El Midaoui, M., Qbadou, M. and Mansouri, K. (2021) 'Logistics chain optimization and scheduling of hospital pharmacy drugs using genetic algorithms: morocco case', *International Journal of Web-Based Learning and Teaching Technologies (IJWLTT)*, 16(2), pp. 54–64. Available at: <https://doi.org/10.4018/IJWLTT.2021030104>.
- Gohr, C.F., Cabral, N.G.C. and Santos, L.C. (2020) 'Success factors for lean healthcare implementation: an exploratory case study in a brazilian hospital', *RAHIS- Revista de Administração Hospitalar e Inovação em Saúde*, 16(2), pp. 126–138. Available at: <https://doi.org/10.21450/rahis.v16i2.5660>.
- Guedes, R.S. et al. (2024) 'Implementation of lean manufacturing in a pharmaceutical distribution center: a case study', *OBSERVATÓRIO DE LA ECONOMÍA LATINOAMERICANA*. Available at: <https://doi.org/10.55905/oelv22n6-203>.
- Ionel, S. (2024) 'Lean supply chain management', *The Romanian Economic Journal* [Preprint], (88). Available at: <https://doi.org/10.24818/REJ/2024/88/07>.
- Kabera, J.C. and Mukanyangezi, M.F. (2024) 'Influence of inventory management practices on the availability of emergency obstetric drugs in rwandan public hospitals: a case of Rwanda southern province', *BMC Health Services Research*, 24(1), p. 14. Available at: <https://doi.org/10.1186/s12913-023-10459-x>.
- Kamere, N. et al. (2023) 'Supply-chain factors and antimicrobial stewardship', *Bulletin of the World Health Organization*, 101(6), pp. 403–411. Available at: <https://doi.org/10.2471/BLT.22.288650>.
- Kessy, S.S.A., Salema, G.L. and Simwita, Y. (2024) 'Lean thinking in medical commodities supply chains: applicability and success factors for tanzanian health supply chains', *Journal of Humanitarian Logistics and Supply Chain Management*, 14(1), pp. 105–117. Available at: <https://doi.org/10.1108/JHLSCM-05-2022-0058>.
- Lukwa, A.T. et al. (2024) 'Evaluating value-based maternal healthcare in sub-saharan africa: a systematic review', *Women*, 4(3), pp. 226–240. Available at: <https://doi.org/10.3390/women4030017>.
- Mekonnen, B.A., Worku, M.C. and Tefera, B.B. (2024) 'Evaluation of logistics management information system and availability of non-program tracer drugs in public health facilities in bahir dar city, northwest Ethiopia', *PLOS One*. Edited by W. Simegn, 19(4), p. e0302319. Available at: <https://doi.org/10.1371/journal.pone.0302319>.
- Milulu, A., Mwita, S. and Basinda, N. (2024a) 'Electronic Logistic Management Information System in Public Health Facilities and Its Implications for the Medicine Supply Chain in Singida District Council, Tanzania', *Pharmacy* [Preprint]. Available at: <https://doi.org/10.3390/PHARMACY12040112>.
- Milulu, A., Mwita, S. and Basinda, N. (2024b) 'Electronic logistic management information system in public health facilities and its implications for the medicine supply chain in singida district council, tanzania', *Pharmacy*, 12(4), p. 112. Available at: <https://doi.org/10.3390/pharmacy12040112>.
- Mutiara Supatmanto, U. et al. (2023) 'Optimization of the procurement process of pharmaceutical supplies at dr. M goenawan partowidigdo pulmonary hospital with a lean six sigma approach', *BIO Web of Conferences*. Edited by S.A. Kristina et al., 75, p. 5012. Available at: <https://doi.org/10.1051/bioconf/20237505012>.
- Nagaich, R. (2022) 'Lean concept implementation practices in small and medium scale pharmaceutical industry- a case study', *International Journal for Research in Applied Science and Engineering Technology*, 10(1), pp. 213–220. Available at: <https://doi.org/10.22214/ijraset.2022.39811>.

- Ngwuluka, N.C., Akindele, I.M. and Ocheke, N.A. (2021) 'Supply chain of some medicines in health facilities in jos, nigeria: post federal ministry of health mapping survey', *Journal of Pharmacy & Bioresources*, 18(2), pp. 133–146. Available at: <https://doi.org/10.4314/jpb.v18i2.6>.
- Oliveira-Dias, D., Moyano-Fuentes, J. and Maqueira-Marín, J.M. (2022) 'Understanding the relationships between information technology and lean and agile supply chain strategies: a systematic literature review', *Annals of Operations Research*, 312(2), pp. 973–1005. Available at: <https://doi.org/10.1007/s10479-022-04520-x>.
- O'Mahony, L., McCarthy, K., O'Donoghue, J., Teeling, S. P., et al. (2021) 'Using lean six sigma to redesign the supply chain to the operating room department of a private hospital to reduce associated costs and release nursing time to care', *International Journal of Environmental Research and Public Health*. Available at: <https://doi.org/10.3390/ijerph182111011>.
- O'Mahony, L., McCarthy, K., O'Donoghue, J., Teeling, Seán Paul, et al. (2021) 'Using lean six sigma to redesign the supply chain to the operating room department of a private hospital to reduce associated costs and release nursing time to care', *International Journal of Environmental Research and Public Health*, 18(21), p. 11011. Available at: <https://doi.org/10.3390/ijerph182111011>.
- Papalexi, M. et al. (2021) 'Pharmaceutical supply chains and management innovation?', *Supply Chain Management: An International Journal*. Available at: <https://doi.org/10.1108/scm-12-2019-0456>.
- Papalexi, M., Bamford, D. and Dehe, B. (2016) 'A case study of kanban implementation within the pharmaceutical supply chain', *International Journal of Logistics Research and Applications*. Available at: <https://doi.org/10.1080/13675567.2015.1075478>.
- hodology', *British Journal of Multidisciplinary and Advanced Studies*, 4(1), pp. 1–17. Available at: <https://doi.org/10.37745/bjmas.2022.0084>.
- Vledder, M. et al. (2019) 'Improving Supply Chain for Essential Drugs in Low-Income Countries: Results from a Large Scale Randomized Experiment in Zambia', *Health Systems & Reform*, 5(2), pp. 158–177. Available at: <https://doi.org/10.1080/23288604.2019.1596050>.