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Analysis of Challenges of the Medical Supply Chain – A Case of Zambia Medicines and Medical Supplies Agency

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ABSTRACT
Medical supply chains play a vital role in delivering essential health commodities and ensuring the availability of medicines and medical supplies, especially in developing countries. Recent technological, organizational, and economic advancements in healthcare systems have provided increased access to treatment for patients. Therefore, the availability of the right medicine with the right composition for the right patient in the right quantity at the right time is essential for the patient's safety and recovery. This paper aims to analyse the supply chain operations of the Zambia Medical Stores (ZAMMSA). The study adopted a descriptive study design and employed a mixed research approach. The population comprised of Third-Party Logistics providers, ZAMMSA facilities supported by Third-Party Logistics partners and the health facilities. The study used simple random sampling technique and data was collected with the help of structured questionnaires. Quantitative data was analysed using descriptive statistics and regression analysis while qualitative data was analysed using thematic analysis. The study revealed that, there are persistent operational challenges like procurement delays, incomplete tracking visibility, and inadequate storage capacities. The study also revealed that, strengthened communication channels, collaborative regulatory compliance efforts, contingency planning for disruptions, feedback mechanisms on product issues, transportation route optimization and provider training were the main strategies needed for improving challenges at each supply chain stage.

Keywords: *essential medicines, efficiency, primary health care, inventory, supply chain*

I. INTRODUCTION

Recent technological, organizational, and economic advancements in healthcare systems have provided increased access to treatment for patients. Despite these advances, improvement in healthcare infrastructure and supply chain management is inevitable. Therefore, the availability of the right medicine with the right composition for the right patient in the right quantity at the right time is essential for the patient's safety and recovery (Imran, et al., 2018).

ZAMMSA formerly known as Medical Stores Limited (MSL) is another autonomous government agency established by an act of Parliament with the express objective of furnishing to the nation good quality drugs and medical equipment at accessible prices (Competition and Consumer Protection Commission, 2022). ZAMMSA is a statutory agency responsible for the procurement, storage and distribution of medicines and medical supplies across the whole of the country's public health sector, representing 80% of the country's total medical products. The 2,600 facilities that ZAMMSA serves range from University Teaching Hospital in Lusaka with over 1,700 beds to rural health posts that are a little over 1 cubic meter in size. Jones (2022), stated that the public health sector faces challenges that are common across the developing world; First, demand for essential medicines far exceeds supply. Second, demand is significantly affected by seasonality, with malaria and other common illnesses becoming more prevalent in the rainy season. Third, supply is challenging, with remote health posts hard to reach, particularly after poor weather. In order to achieve the purpose of this study, the study was guided by the following specific objectives:

- To analyse the medical supply chain for ZAMMSA.
- To identify the challenges at each stage of the supply chain of ZAMMSA.
- To establish strategies for improving the identified challenges at each supply chain stage.

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II. LITERATURE REVIEW AND CONCEPTUAL FRAMEWORK

2.1 Medical Supply Chain from a Global Perspective

According to Yu, et al., (Pharmaceutical supply chain in China: Current issues and implications, 2010), China has a population of 1.3 billion, which is serviced by 298,408 health facilities including 19,852 public hospitals. Previously, under a centrally planned economy, all the pharmaceutical products were distributed by a state-owned monopoly company (first-tier wholesaler) to several regional wholesalers (second-tier wholesalers) who would then distribute the products to local wholesalers (third-tier wholesalers). Hospitals at different levels usually purchased drugs only from different wholesalers. The advantages of the old supply chain included greater regulation on drug quality and price. However, such a regulated chain lacked competitive mechanisms, and can result in bureaucratic behaviours, inefficiencies and an imbalanced supply. Due to the changing economic system, the Chinese government has reformed its pharmaceutical distribution network. It has been changed from a centrally controlled supply system to a market-oriented system. The competitive mechanism has been introduced into the pharmaceutical market, which improves the availability of pharmaceuticals.

2.2 Medical Supply Chain from a Continental Perspective

Lugada, et al, (Health supply chain system in Uganda: current issues, structure, performance, and implications for systems strengthening, 2022) explained the health supply chain system in Uganda, it was composed of both public and private stakeholders. The MoH, through the Department of Pharmaceuticals and Natural Medicines, were charged with providing oversight over policy development and implementation and coordination of the pharmaceutical sector. The health supply chain system in Uganda was a four-tier system including the central level, tier II composed of sub-national level entities, tier III composed of government-managed health facilities and tier-IV composed of private health facilities. The system was composed of a network of public, and private actors, development partners and Non-Governmental Organizations GHSC-PSM. The MoH managed the public sector health supply chain system through the Department of Pharmaceuticals and Natural Medicines.

Lugada, et al, (Health supply chain system in Uganda: current issues, structure, performance, and implications for systems strengthening, 2022) further explained that the health supply chain system in Uganda was based on a tiered system structured around the different levels of administration in the country. The structure was designed to fit within the different administrative levels of the health system and not the technical considerations of the elements that influence the capacity and performance of the supply chain system. However, this was yet to be effectively implemented to ensure the optimum performance of the system. Failure to structure and formalize the supply chain structures had several implications for accountability for decision-making and performance across the different administrative levels in the country. Furthermore, it contributed to disruptions often witnessed across several supply chain functions including forecasting, inventory management, warehouse and stores management, stock management, and failed to address the commodity needs of end users (health facilities). These structural inefficiencies aggravated other supply chain challenges including insufficient coordination, inadequate financing, lack of incentivization, and schemes for supply chain personnel.

2.3 Medical Supply Chain in Zambia

The Ministry of Health (2021), updated its Health Sector Supply Chain Strategy & Implementation Plan (HSSCS) for the 2019 -2021 period to ensure equitable access to medicines, vaccines, and medical supplies for all Zambian citizens. The diagram below shows Zambia's National Health Supply Chain process. According to the Zambia Ministry Health, as depicted in figure 3 above (2022-2026 National Health Strategic Plan, 2023), the existing national health system comprises promotive, preventive, curative, palliative and rehabilitative services. The health service delivery structures are established at different levels. These health services are organized along a pyramidal structure, with Primary Health Care (PHC) services at the community level (Health Posts, Health Centres, and Mini-Hospitals) at the base, followed by the first and second-level hospitals at district and provincial levels respectively, third-level (tertiary) and fourth-level (specialized) hospital services at the national level. These levels of care are linked by a referral system intended to provide citizens with access to the health services they need.

Furthermore, the health services in Zambia are provided by the public, private, faith-based, and civil society-owned not-for-profit health facilities. Alternative health services are also provided by traditional health practitioners and herbal health services providers at community levels. The system is also supported by disease-specific programmes, service statutory institutions, regulatory statutory institutions, and training institutions, each with specific roles and responsibilities. These include Disease-Specific Programmes, Service Statutory Institutions, Regulatory Statutory Institutions, Health Training Institutions

According to a study conducted by Vledder, el al., (Improving Supply Chain for Essential Drugs in Low-Income Countries: Results from a Large Scale Randomized Experiment in Zambia, 2019), they explained that despite increased investments in procurement of essential medicines, their availability at health facilities remains extremely low in many low-

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and middle-income countries. They further explained that lack of a well-functioning supply chain for essential medicines is often the cause of this poor availability. They examined the optimal number of levels in a distribution system depending on geographical factors, demand at each service point, and frequency of shipment, storage space availability, and transport cost structure. According to them, many scholars had studied these problems and had emphasized the need of better information integration between the levels in the distribution system. Incentive problems may arise in multi-tiered distribution systems when decisions are delegated to decentralized sites that have intimate knowledge of their immediate surroundings. And the common solution that has been used is cross-docking which involves the direct transfer of ready shipments from inbound transport/truck trailers (or railroad car) and the loading of these materials either directly onto outbound trucks, trailers, or rail cars, or loading after minimal storage but in either event with no layaway inventory. Concluded that the direct flow of demand and order information from health facilities to ZAMMSA reduced the problem of diffuse accountability. Higher reporting rates in turn contributed to better visibility of health facility-level demand at the central distribution centre (ZAMMSA) leading to better planning and lower stockouts.

2.4 Challenges in the Supply Chain Management

John (2022) examined supply chain management in 200 healthcare facilities in Indonesia, identifying issues such as stockouts, poor storage conditions, high shipping costs, and a lack of standardized systems. Smith (2021) reviewed global challenges in pediatric medicine supply chains, highlighting inadequate forecasting, weak coordination, poor infrastructure, and inefficient procurement. Johnson (2022) assessed these challenges in 500 low- and middle-income health facilities, noting limited data access, fragmented supply chains, weak infrastructure, and storage issues, recommending improved systems and personnel capacity.

In Sub-Saharan Africa, Smith et al. (2019) conducted a systematic review, finding stockouts, inadequate storage, poor forecasting, and inefficient distribution systems as key challenges in pediatric medication supply chains. Kasekende et al. (2018) focused on Uganda, identifying inconsistent medication supply, inadequate storage, insufficient trained staff, and poor data management as significant issues. Ogunmodede et al. (2018) assessed tertiary health facilities, revealing inadequate monitoring, poor coordination among departments, and inventory control problems, leading to frequent stockouts.

Mwansa et al. (2018) studied 16 health facilities in Zambia, finding stockouts of essential pediatric antiretroviral drugs, limited formulations, inadequate storage, poor forecasting, weak coordination, and training gaps. Scott et al. (2017) evaluated 118 Zambian health institutions, highlighting poor coordination, high stockout rates, long order lead times, and insufficient supervision, which impacted the availability of pediatric antiretroviral drugs. Mutale et al. (2018) assessed 89 health facilities, district health offices, and central institutions in Zambia, identifying stockouts, long lead times, inadequate storage, lack of accurate data, and poor supervision and coordination as major challenges affecting pediatric medicine availability and care.

2.4 Strategies for Improving the Identified Challenges at Each Supply Chain Stage

Supply chain management plays a critical role in the success of any organization, enabling efficient flow of products, services, and information from suppliers to end customers. However, challenges often arise at each stage of the supply chain, including procurement, production, distribution, and customer service. This literature review aims to examine the strategies available to address these challenges and improve supply chain performance. The procurement stage involves sourcing raw materials, negotiating with suppliers, and ensuring quality supplies. Several strategies have been proposed to improve procurement challenges: supplier Relationship Management (SRM): SRM focuses on building strong partnerships and collaborative relationships with suppliers. Research suggests that a robust SRM approach leads to better responsiveness, trust, and improved supply chain performance (Caniels, Gelderman, & Semeijn, 2016).

The inclusion of diverse suppliers has gained attention due to its positive implications for innovation, competitive advantage, and risk management. Diverse suppliers bring in new ideas, perspectives, and capabilities, ultimately enhancing supply chain performance (Weer, 2016). Utilizing electronic platforms for procurement processes improves efficiency, transparency, and reduces costs by streamlining workflows and automating processes (Bechtold & Niedereichholz, 2020). Effective risk management in procurement involves identifying and mitigating potential risks associated with suppliers. Literature emphasizes the importance of proactive measures, such as conducting supplier audits and developing backup suppliers, to minimize disruptions (Wagner & Bode, 218).

The production stage focuses on optimizing manufacturing processes and ensuring high-quality output. Strategies to improve production challenges include: Lean principles have been widely adopted to eliminate waste, improve efficiency and quality, and enhance value creation. Studies indicate that implementing lean manufacturing practices positively impacts productivity, reduces costs, and results in enhanced customer satisfaction (Kumar, Antony and Singh, 2017).

Collaboration between different departments, such as production, product design, and engineering, is crucial for identifying and implementing process improvements. A collaborative approach enables efficient communication, reduces errors, and enhances product quality (Pfohl, Köhler, & Thomas, 2010). Implementing QMS frameworks, such as Six Sigma

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and Total Quality Management (TQM), provides structured methodologies for defect identification and reduction. Studies show that effective QMS implementation leads to improved product quality, reduced defects, and enhanced customer satisfaction (Maskell, 2006).

The distribution stage involves delivering finished goods to end customers in a timely and cost-effective manner. Strategies for addressing distribution challenges include: Optimizing the supply chain network layout, including the placement of distribution centers, can significantly reduce costs and improve customer service levels. Research suggests that strategic network design decisions, involving factors like demand patterns and transportation costs, positively impact overall supply chain performance (Melo, Nickel, & Saldanha-da-Gama, 2009).

Effective inventory management is crucial for reducing costs while ensuring adequate stock availability. Techniques like Just-in-Time (JIT) and Vendor-Managed Inventory (VMI) minimize inventory holding costs, reduce stockouts, and improve order fulfillment rates (Sridharan, Caines, & Patterson, 2005). Utilizing transportation management systems (TMS) and route optimization tools helps streamline logistics operations, reduce transit times, and increase on-time delivery rates. Studies indicate that effective transportation management positively impacts customer service levels and overall supply chain success (Ballestero, Melo, & Nickel, 2016).

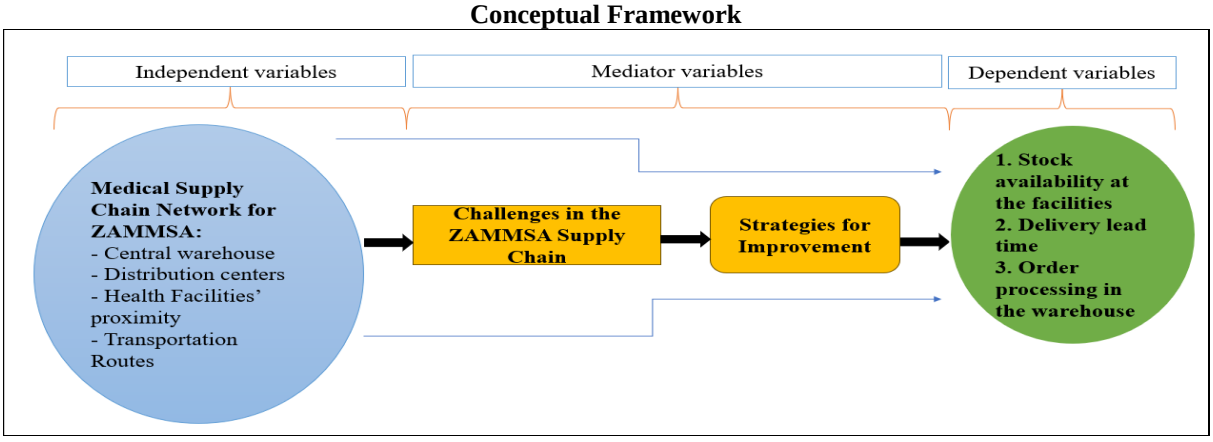
Reverse logistics, involving the management of returned products, recycling, and disposal, has gained importance from an environmental and economic perspective. Studies emphasize the benefits of robust reverse logistics processes, such as reduced waste, improved sustainability, and enhanced customer satisfaction (de Brito & Dekker, 2004). The customer service stage focuses on post-purchase interactions and satisfaction. Strategies to improve customer service challenges include: Customer Relationship Management (CRM): Implementing CRM systems helps organizations effectively capture, track, and analyze customer interactions, enabling personalized and timely support. Research highlights the positive impact of CRM on customer satisfaction, loyalty, and retention (Chen & Popovich, 2003).

Omni-Channel Retailing: Providing customers with a seamless shopping experience across multiple channels, including physical stores, e-commerce platforms, and mobile applications, enhances convenience and customer satisfaction. Literature emphasizes the need to integrate channels and ensure a consistent brand experience (Verhoef et al., 2018).

Service Level Agreements (SLAs): SLAs formalize service expectations, response times, and issue resolution processes, helping organizations manage customer inquiries effectively. Research suggests that well-defined SLAs improve complaint handling, response times, and overall customer service quality (Padaki and Kumar, 2019).

Continuous Improvement: Gathering and analyzing customer feedback allows organizations to identify areas for improvement and promptly address issues. Literature emphasizes the need for organizations to cultivate a culture of continuous improvement to enhance customer satisfaction and loyalty (Diaz-Rainey et al., 2018).

Conceptual Framework



Research Hypotheses

Based on the relationships depicted in the conceptual framework above, the following Hypotheses guided the research and helped to determine whether there were significant relationships or differences in the variables.

Null Hypothesis (H0): *The challenges encountered at different stages of the ZAMMSA medical supply chain network do not have an impact on the elements of the supply chain.*

Alternative Hypothesis (H1): *The challenges encountered at different stages of the ZAMMSA medical supply chain network have an impact on the elements of the supply chain.*

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III. RESEACRH METHODOLOGY

This study employed a pragmatic research philosophy, which emphasized practical solutions and real-world applicability (Schwartz-Shea & Yanow, 2020). Pragmatism allowed for a flexible approach, integrating both quantitative and qualitative data to address complex issues within Zambia's medical supply chain. By focusing on actionable strategies and recognizing the system's complexity, the pragmatic approach ensured context-specific interventions that were both useful and relevant (Rashid, 2023). The research design was convergent parallel, involving the collection and analysis of quantitative and qualitative data separately before comparing results to draw comprehensive conclusions (Tegan, 2021).

The study's target population included the medical supply chain in Zambia, specifically ZAMMSA facilities and their associated Third-Party Logistics (3PL) providers. With a population of about 1,033, including hospitals, clinics, and ZAMMSA hubs, the sample size was determined to be 288 using a margin of error of 5% (McCombes, 2023). Judgmental sampling, specifically purposive sampling, was used to select participants based on their relevant expertise and knowledge (Creswell & Poth, 2018). Data collection involved closed-ended and open-ended questionnaires and interviews, to ensure comprehensive coverage. Quantitative data were analyzed using descriptive statistics in SPSS, while qualitative data were assessed through thematic analysis. Regression and correlation analyses were employed to explore relationships and test research hypotheses (Zohrabi, 2013; Clark, 2013).

IV. RELIABILITY AND VALIDITY

The collected data was reliable given that it was gathered from a cross section of ZAMMSA's Supply Chain. To ensure reliability and validity, the researcher used multiple data sources to the research questions. Further, to ensure that the content of the questionnaires accurately reflected the construct the researcher sought to measure, this study was established through expert reviews and pilot testing.

V. ANALYSIS OF THE RESULTS

5.1 Response rate

The data was collected from 288 respondents from ZAMMSA's Supply Chain.

5.2 Test for Instrument Reliability

Table 1 below shows the outcomes of the reliability test performed on the research instruments. The internal consistency and reliability of the instrument were evaluated using Cronbach's alpha, where a value of 0.70 or higher indicates satisfactory reliability.

Table 1: Reliability Test

Variable	Cronbach's Alpha
Medical Supply Chain	0.82
Challenges at Each Stage of the Supply Chain	0.75
Strategies for Improving the Identified Challenges	0.79

Source: Author, (2024)

5.3 Descriptive Statistics

The mean score interpretation scale provided a framework for understanding the average responses of participants and their perceptions of the variables under investigation. The scale ranges from 1 to 5, with corresponding labels to help interpret the responses. A mean score interpretation scale was utilized to aid in the interpretation of the mean scores related to the medical supply chain at ZAMMSA with the intent of establishing the challenges. The scale provided a structured framework for categorizing and understanding the median score, allowing for a more comprehensive analysis of the obtained mean scores. By categorizing the mean scores into different levels, the scale facilitated a contextualized interpretation of the findings. This approach enhanced the understanding of the medical supply chain at ZAMMSA with the intent of establishing the challenges based on the calculated mean scores.

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Table 2: Mean Score Interpretation Scale

Category	Response	Mean Score Range
High	Strongly Agree	4.50 – 5.00
	Agree	3.50 – 4.49
Medium	Neutral	2.50 – 3.49
Low	Disagree	1.50 – 2.49
	Strongly Disagree	1.00 – 1.49

Source: Moraga (2012)

The mean score interpretation scale presented in Table 2 categorizes the total mean scores into three distinct categories: low, moderate, and high. This scale provides a framework for interpreting the results obtained from the study in a more meaningful way. By assigning specific categories to the mean scores, it allows for a quick assessment of the overall level of the measured construct.

5.4 Findings from Transporters

The analysis of the ZAMMSA medical supply chain indicated generally positive perceptions but also highlighted areas requiring attention. The respondents viewed the efficiency of the current information systems positively, with an average score of 4.20, suggesting agreement on their effectiveness. Communication among stakeholders was highly regarded with a score of 4.45, indicating strong consensus on the effectiveness of coordination. However, transportation methods received a moderate score of 3.90, reflecting some disagreement on their adequacy. The supply chain's resilience to unforeseen challenges was rated at 4.15, showing a reasonably consistent view of its adaptability. Overall performance met stakeholders' expectations with a score of 4.35, showing a high level of satisfaction. Collaboration and coordination among different stages were viewed positively with a score of 4.10. Technology infrastructure supporting the supply chain was considered up-to-date and reliable, with a score of 4.25.

Challenges faced at each stage of the ZAMMSA supply chain revealed several key issues. Delays in procurement processes were seen as impactful with a mean score of 3.75, indicating a shared concern but with some variability in opinions. Transportation bottlenecks were a recurrent problem, scoring 3.80, reflecting general agreement but some differences in severity perception. Communication gaps in distribution were identified with a score of 3.60, showing moderate consensus but varied opinions on the extent of the problem. Inventory management issues were a notable challenge with a mean score of 3.85, suggesting a relatively consistent recognition of this issue. Quality control problems in production scored 3.70, indicating moderate acknowledgment with some variability. Regulatory compliance challenges were viewed as significant with a score of 3.95, showing a high level of agreement. External disruptions, like adverse weather, were noted with a mean score of 3.55, indicating some consensus but with a range of opinions on the impact. Information asymmetry was perceived as a hindrance with a score of 3.65, reflecting varied views on its effect on smooth functioning.

To address these challenges, several strategies were proposed. Implementing advanced technology solutions was highly recommended, with a score of 4.20, showing a generally positive view but some variability in opinion. Strengthening collaboration and communication channels was considered crucial, receiving a high score of 4.40, with a strong consensus on its importance. Regular training programs for staff were seen as beneficial with a score of 4.10, indicating a consistent view on their effectiveness. Establishing a robust quality control system was deemed essential with a score of 4.30, reflecting general agreement on improving product standards. Developing contingency plans for external disruptions was recommended with a score of 4.15, showing moderate agreement. Streamlining regulatory compliance procedures was viewed positively with a score of 4.25, indicating strong support for improved operations. Investing in a more reliable transportation network was suggested with a score of 4.05, reflecting some variability in opinions. Conducting regular audits for inventory management was advocated with a score of 4.30, indicating a consistent view on its importance. Real-time tracking and monitoring systems were highly recommended with a score of 4.35, showing strong consensus on enhancing visibility.

Regression analysis of the data showed that the predictor variables collectively explained a substantial portion of the variability in the dependent variable, with an R-squared value of 0.56. This meant that 56% of the variability in the dependent variable was explained by the model. The Adjusted R-squared value of 0.52, which accounted for the number of predictors, indicated that 52% of the variability was explained after adjusting for model complexity. The Standard Error of 0.87 reflected the average deviation between observed and predicted values. The F-statistic of 42.68 with a significance value of 0.001 suggested that the model was statistically significant, meaning that at least one of the predictors significantly affected the dependent variable.

Examining the coefficients for each predictor, the constant term (1.52) indicated the expected value of the dependent variable when all predictors were zero. The Medical Supply Chain predictor had an unstandardized coefficient of 0.72, suggesting that a one-unit increase in this predictor was associated with a 0.72 increase in the dependent variable. This positive

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relationship, supported by a standardized coefficient of 0.35 and a significant t-value of 5.56, highlighted its importance. Challenges at Each Stage of the Supply Chain had an unstandardized coefficient of -0.28, indicating that a one-unit increase in challenges was associated with a decrease of 0.28 in the dependent variable. The negative standardized coefficient of -0.15, with a t-value of -2.34, showed that increased challenges were associated with a decrease in the dependent variable. For Strategies for Improving Challenges, the unstandardized coefficient was 0.45, suggesting that a one-unit increase in this predictor was associated with a 0.45 increase in the dependent variable. The positive standardized coefficient of 0.25 and a t-value of 3.75 emphasized the importance of these strategies.

Overall, the analysis indicated that while the ZAMMSA supply chain was generally viewed positively, there were areas for improvement. Effective communication, resilience, and overall performance were strong points, but challenges related to transportation, inventory management, and external disruptions required targeted strategies. The regression results underscored the significant impact of the Medical Supply Chain and Strategies for Improvement on the dependent variable, emphasizing the need for ongoing enhancements to address these challenges effectively.

5.5 Findings from Health Facilities

The evaluation of health facilities' perspectives on the ZAMMSA medical supply chain revealed a generally positive outlook but also highlighted several areas of concern and variability in perceptions. Health facilities viewed the accuracy and timeliness of information received from ZAMMSA favorably, reflecting a mean score of 4.2. This suggested that most respondents believed the information provided was reliable, although the standard deviation of 0.6 indicated some differences in opinions among them. When it came to accessing a diverse range of medical products through ZAMMSA, the mean score was 3.8, suggesting moderate satisfaction but also indicating variability in how facilities experienced product availability. Communication between health facilities and ZAMMSA was also rated positively with a mean score of 4.0, though the higher standard deviation of 0.7 showed a range of opinions about the effectiveness of these communication channels. The quality of medical supplies received was highly rated, with a mean score of 4.5 and a low standard deviation of 0.4, demonstrating strong agreement on the standards being met. Transportation methods were perceived as moderately reliable with a mean score of 3.9 and a standard deviation of 0.6, reflecting some disagreement about their effectiveness. Overall satisfaction with the ZAMMSA supply chain stood at 4.1, but the higher standard deviation of 0.8 indicated varied levels of contentment among facilities. Technology integration for tracking and monitoring medical supplies was well-regarded with a mean score of 4.3 and a standard deviation of 0.5, showing general agreement on the benefits of technological advancements. Collaboration in addressing supply chain issues was seen with moderate approval, as evidenced by a mean score of 3.7 and a standard deviation of 0.7, reflecting a range of opinions about the effectiveness of these efforts.

The challenges faced at each stage of the ZAMMSA supply chain were also documented, highlighting significant issues impacting health facilities. Delays in procurement processes emerged as a notable challenge with a mean score of 2.9 and a high standard deviation of 0.8, indicating varied opinions on how these delays affected supply availability. Transportation bottlenecks causing shortages were reported with a mean score of 3.2, suggesting a moderate consensus on the impact of these issues, as reflected by a standard deviation of 0.6. Communication gaps with ZAMMSA were seen as contributing to distribution challenges, with a mean score of 3.0 and a standard deviation of 0.7, revealing differing views on the extent of this problem. Difficulties in inventory management were a significant challenge, with a mean score of 3.4 and a low standard deviation of 0.5, indicating a more consistent view of this issue. Quality control problems in the production of healthcare supplies were highlighted with a mean score of 3.1 and a standard deviation of 0.6, reflecting moderate agreement on the impact of these issues. Regulatory compliance challenges received a mean score of 2.8 and a standard deviation of 0.7, showing varied opinions on the obstacles these challenges created. External factors, such as adverse weather, disrupting supply regularity were acknowledged with a mean score of 2.7 and a standard deviation of 0.6, suggesting some consensus on the impact of these disruptions. Information asymmetry impeding smooth supply chain functioning was rated with a mean score of 3.0 and a high standard deviation of 0.8, indicating diverse perceptions of this challenge. Receiving medical supplies close to expiration dates was identified as a challenge with a mean score of 3.3 and a standard deviation of 0.7, reflecting moderate agreement on the impact of this issue. The cumbersome process for returning or replacing defective supplies was recognized with a mean score of 2.5 and a high standard deviation of 0.8, suggesting varied opinions on the severity of this problem. Challenges in managing demand fluctuations were noted with a mean score of 3.5 and a standard deviation of 0.6, indicating some consensus on the difficulties associated with this issue.

Strategies proposed to address these challenges included various measures aimed at improving the supply chain. Providing regular training to health facility staff on inventory management was suggested with a mean score of 4.0, indicating varied opinions on its effectiveness, as shown by a standard deviation of 0.7. Strengthening communication channels between ZAMMSA and health facilities was recommended with a mean score of 3.8, reflecting a moderate level of agreement on this approach's potential benefits. Advanced technology solutions for inventory tracking were highly recommended, with a mean score of 4.2 and a low standard deviation of 0.5, demonstrating strong agreement on the effectiveness of technological advancements. Collaborative efforts to streamline regulatory compliance received a mean score of 3.9, indicating diverse

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opinions on the effectiveness of these strategies, as reflected by a standard deviation of 0.7. Developing contingency plans for external disruptions was proposed with a mean score of 4.1 and a standard deviation of 0.6, showing moderate agreement on the importance of resilience planning. Regular audits and assessments were suggested with a mean score of 3.7, indicating varied opinions on the effectiveness of this strategy, as evidenced by a standard deviation of 0.8. Establishing a feedback mechanism for reporting issues was highly recommended, with a mean score of 4.3 and a low standard deviation of 0.5, reflecting strong agreement on the benefits of feedback for improving the supply chain. A proactive approach to managing and preventing shortages was proposed with a mean score of 3.6, indicating varied opinions on its effectiveness. Optimizing transportation routes to minimize delays was suggested with a mean score of 3.8, showing moderate agreement on the potential benefits of improved transportation planning. Participation in demand forecasting by health facilities was recommended with a mean score of 4.0 and a higher standard deviation of 0.7, reflecting diverse opinions on the advantages of joint forecasting efforts. Establishing clear guidelines for returning or replacing defective supplies was proposed with a mean score of 3.9, indicating some consensus on the effectiveness of clear return policies.

Regression analysis of the model assessing these predictors revealed that the predictor variables (Medical Supply Chain, Challenges at Each Stage of the Supply Chain, and Strategies for Improving the Identified Challenges) collectively explained a substantial portion of the variance in the dependent variable, with an R value of 0.75, indicating a strong positive correlation. The R-squared value of 0.56 showed that 56% of the variability in the dependent variable was accounted for by these predictors. The Adjusted R-squared value of 0.52 suggested that 52% of the variability was explained after adjusting for the number of predictors in the model. The standard error of 0.52 reflected average variability between observed and predicted values. The F statistic of 8.21 and a significance value of 0.002 indicated that the model was statistically significant, implying that at least one of the predictor variables significantly affected the dependent variable. Coefficients for the predictors showed that while the Medical Supply Chain and Strategies for Improving the Identified Challenges had positive associations with the dependent variable, the Challenges at Each Stage of the Supply Chain had a negative association.

5.6 Analysis of Qualitative Data

The interviews were conducted to capture perceptions about ZAMMSA's medical supply chain, the stakeholders involved, the system employed, the collaboration between partners, and the challenges within the supply chain. The respondents indicated that ZAMMSA's medical supply chain involved key stakeholders including the Ministry of Health, health facilities, and international partners such as USAID, UN agencies, and the Global Fund. The Ministry of Health provided essential governance, setting policies and regulations, while health facilities placed orders and delivered services. External partners contributed funding, commodities, infrastructure, and technical assistance, facilitating smooth operations. ZAMMSA sourced medical supplies through annual consumption forecasts combined with flexible ad-hoc orders to manage both regular and unexpected demands. The distribution process used both owned and hired fleets, with central warehouses dispatching orders to regional hubs or directly to facilities, and District Health Offices aiding deliveries in rural areas. Inventory management employed Warehouse Expert software and an Electronic Proof of Delivery system, though these technologies were not yet fully integrated. Key challenges included insufficient material handling equipment, manual sorting, and rising stock levels. Proposed solutions included investing in electronic sorting systems, acquiring additional equipment, and improving resource allocation at regional hubs. Timeliness of deliveries was guided by a Distribution Schedule with around 70% adherence due to transport and other delays; efforts were underway to optimize this schedule. ZAMMSA collaborated with Charz through the Global Fund and USAID for technical assistance and infrastructure support, which improved supply chain efficiency. In emergencies, the Ministry of Health, particularly the Provincial Health Office, directed ZAMMSA on priorities and quantities needed, ensuring swift responses to crises. Future plans included expanding storage capacities at health facilities to cover up to three months of supply and exploring innovations like prefabricated and mobile warehouses to enhance storage and reduce delivery frequency. These measures aimed to bolster the supply chain's efficiency and resilience, addressing both routine and emergency needs effectively.

VI. DISCUSSION AND IMPLICATION

The study on ZAMMSA's medical supply chain highlighted both strengths and areas for improvement. Positive perceptions were evident in several aspects: information systems (Mean: 4.20), communication channels (Mean: 4.45), supply chain resilience (Mean: 4.15), and overall performance (Mean: 4.35). These high ratings aligned with Xing et al. (2021), who emphasized the role of technology and resilience in medical supply chains. Effective communication (Mean: 4.45) mirrored Kumar et al.'s (2020) findings on the importance of robust information sharing, while the overall performance score (Mean: 4.35) supported McCullough et al.'s (2019) conclusions on performance correlating with end-user satisfaction.

However, moderate scores in transportation methods (Mean: 3.90) reflected issues similar to those noted by Yadav et al. (2019) regarding unreliable transport infrastructure in developing countries. The moderate scores for procurement delays (Mean: 3.75), transportation bottlenecks (Mean: 3.80), inventory management challenges (Mean: 3.85), and regulatory

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compliance issues (Mean: 3.95) confirmed findings from Njoroge et al. (2017) and Yadav et al. (2019) about common supply chain obstacles in sub-Saharan Africa. Information asymmetry (Mean: 3.65) aligned with Ozcan et al.'s (2017) research on transparency barriers, while communication gaps (Mean: 3.60) reflected Kumar et al.'s (2020) concerns about varying perceptions of supply chain challenges.

The second objective identified specific challenges at each supply chain stage. Lower scores for external disruptions (Mean: 3.55) contrasted with Rodriguez-Antolin et al.'s (2016) findings on the impact of exogenous shocks in sub-Saharan Africa, suggesting ZAMMSA stakeholders might have perceived these risks as less critical, potentially due to adaptive measures or shifting priorities. The findings revealed a blend of shared concerns and varied opinions, consistent with observations by Xing et al. (2021) on context-specific heterogeneity.

For the third objective, strategies to improve supply chain performance included technology adoption (Mean: 4.20), collaboration (Mean: 4.40), training (Mean: 4.10), and real-time tracking (Mean: 4.35). These strategies reflected McCullough et al.'s (2019) emphasis on technology and Xing et al.'s (2021) focus on resilience technologies. The high consensus on collaboration and communication (Mean: 4.40) supported McCullough et al.'s (2019) and Xing et al.'s (2021) assertions on the need for effective coordination.

Despite this, there was lower agreement on transportation network improvements (Mean: 4.05), with variability reflecting the complex challenges and budget constraints noted by Njoroge et al. (2017) and Yadav et al. (2019). The overall embrace of diverse strategies, including technology, collaboration, training, tracking, quality control, audits, and streamlined regulations, aligned with Ozcan et al. (2017), emphasizing holistic approaches to tackle various supply chain facets. This multidimensional strategy suggested a tailored approach to strengthening ZAMMSA's supply chain resilience.

VII. CONCLUSIONS AND RECOMMENDATIONS

The study also identified challenges across various supply chain stages. Key issues include procurement delays, transportation bottlenecks causing shortages, communication gaps, inventory management inefficiencies, product quality concerns, regulatory challenges, external disruptions, information asymmetry, and product expiration management. These insights highlight critical pain points in procurement, logistics, distribution, inventory control, and product reliability, suggesting that targeted interventions are necessary to enhance overall efficiency.

To address these challenges, the study proposed several strategies. These include technological solutions for inventory tracking, improved communication channels, collaborative regulatory compliance efforts (Mean: 3.9), contingency planning for disruptions, feedback mechanisms on product issues, transportation route optimization, and provider training. The recommendations aim to tackle identified issues through enhanced technology adoption, better coordination, improved infrastructure, and refined operations. Mean scores reflect a collectively perceived utility in these strategies.

In conclusion, while ZAMMSA's medical supply chain exhibits positive attributes, targeted interventions are needed to address the challenges. Integrating technological solutions, fostering collaborative efforts, and optimizing transportation routes offer promising opportunities for improvement. The findings align with established supply chain management principles and underscore the need for a tailored approach to overcome the diverse challenges identified.

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