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Effectiveness of Logistics Management Information System (LMIS) in Improving the Availability of Essential Medicines and Medical Supplies in Public Hospitals in Zambia: A Cross-Sectional Study

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Abstract

Background: The availability of essential medicines and medical supplies is crucial for effectively delivering healthcare services. In Zambia, the Logistics Management Information System (LMIS) is a key tool for managing the supply chain of these commodities. This study aimed to evaluate the effectiveness of LMIS in ensuring the availability of essential medicines and medical supplies in public hospitals in the Copperbelt Province of Zambia. **Materials and Methods:** From February to April 2022, a cross-sectional study was conducted in 12 public hospitals across the Copperbelt Province. Data were collected using structured questionnaires, checklists, and stock control cards. The study assessed LMIS availability, training, and knowledge among pharmacy personnel, as well as data accuracy, product availability, and order fill rates. Descriptive statistics were used to analyse the data. **Results:** All surveyed hospitals had LMIS implemented and were using eLMIS as the primary LMIS. Only 47% and 48% of pharmacy personnel received training in eLMIS and Essential Medicines Logistics Improvement Program (EMLIP), respectively. Most personnel demonstrated good knowledge of LMIS, with 77.7% able to log in to eLMIS Facility Edition, 76.6% able to locate stock control cards in the system, and 78.7% able to perform transactions. However, data accuracy from physical and electronic

records varied from 0% to 60%, and product availability ranged from 50% to 80%. Order fill rates from Zambia Medicines and Medical Supplies Agency (ZAMMSA) were consistently below 30%. Discrepancies were observed between physical stock counts and eLMIS records. **Conclusion:** This study found that most hospitals in the Copperbelt Province of Zambia have implemented LMIS use. While LMIS implementation is high in the Copperbelt Province of Zambia, challenges such as low training levels, data inaccuracies, low product availability, and order fill rates persist. Addressing these issues requires a comprehensive approach, including capacity building, data quality improvement, supply chain coordination, and investment in infrastructure and human resources. Strengthening LMIS effectiveness is crucial for improving healthcare delivery and patient outcomes in Zambia.

Keywords

Logistics Management Information System, Essential Medicines, Medical Supplies, Supply Chain Management, Zambia

1. Introduction

Access to essential medicines and medical supplies is a fundamental human right and a critical component of a well-functioning health system. Governments in most countries have increased spending significantly to ensure the availability of medicines and medical supplies [1]. However, despite increased investment, the availability of essential medicines in health facilities in many low- and middle-income countries, particularly in sub-Saharan Africa, remains extremely low [2] [3]. This is often attributed to the lack of a well-functioning supply chain [4].

Logistics Management Information Systems (LMIS) plays a crucial role in managing the supply chain of essential medicines and medical supplies. An LMIS is a system of records and reports, whether paper-based or electronic, used to aggregate, analyse, validate, and display data from all levels of the supply chain, enabling informed decision-making and effective supply chain management [5]. Logistics professionals emphasize the importance of LMIS in ensuring accurate supply chain information, as without precise insights into needs and inventory, operational efficiency at every level becomes challenging [5] [6]. Some of the implemented LMIS systems include a combination of web-based and mobile-based technologies to track inventory levels, monitor stockouts, and optimize logistics operations [4].

Studies conducted in Ethiopia have shown that the unavailability of tracer drugs in public health facilities was largely due to poor use of records and inadequate supply [6] [7]. Other studies have attributed this to insufficient health staff, leading to reduced usability of the health systems [7]. However, there is a lack of studies assessing the role of LMIS in the availability of essential medicines and medical supplies in Zambian public health facilities.

Zambia, like many other sub-Saharan African countries, faces significant challenges in ensuring access to essential medicines and medical supplies [4] [8]. The Zambian government has made efforts to improve the availability of essential medicines through various initiatives, such as the Essential Medicines Logistics Improvement Programme (EMLIP) and the decentralising of the procurement function through the Zambia Medicines and Medical Supplies Agency (ZAMMSA) [9] [10]. These initiatives aim to strengthen the supply chain management of essential medicines and medical supplies in the country.

Despite these efforts, studies have highlighted persistent challenges in the Zambian public health supply chain. A previous study in public health facilities in Zambia reported that stock-outs of essential medicines were common, with an average stock-out rate of 30% across all levels of care [4]. The study also identified weaknesses in the LMIS, such as incomplete and inaccurate data, as contributing factors to the stock-outs [4]. The present study evaluated the effectiveness of the LMIS in ensuring the availability of medicines and medical supplies in public hospitals in the Copperbelt Province of Zambia.

2. Materials and Methods

2.1. Study Site

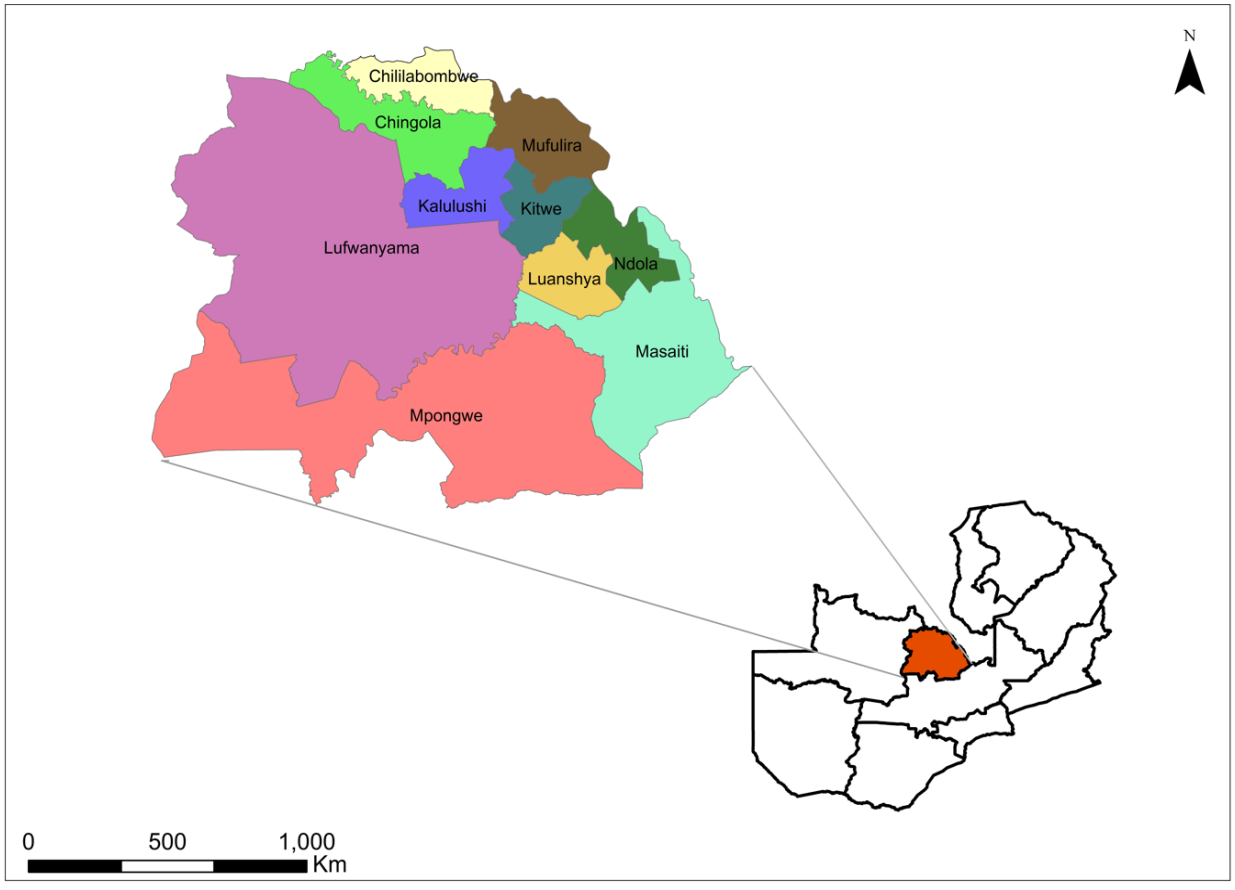

Figure 1. Map of the Copperbelt province of Zambia [11].

The study was conducted in the Copperbelt Province of Zambia (Figure 1). A total of 12 hospitals were selected which included Ndola Teaching Hospital and Arthur Davison's Children's Hospital in Ndola, Roan Antelope Hospital and Thompson Hospital in Luanshya, Masaiti District Hospital in Masaiti, Kakoso Level 1 Hospital in Chililabombwe, Kitwe Teaching Hospital in Kitwe, Kalulushi General Hospital in Kalulushi, Ronald Ross Hospital and Kamuchanga District Hospital in Mufulira, Nchanga North General Hospital in Chingola and Lufwanyama District Hospital in Lufwanyama. The chosen Tertiary and Secondary-level hospitals are the main referral hospitals in the districts with Ndola Teaching Hospital, Kitwe Teaching Hospital and Arthur Davison Children Hospital serving as specialist hospitals for the rest of the province.

2.2. Study Design

We employed a facility-based, cross-sectional descriptive design to assess the effectiveness of the Logistics Management Information System (LMIS) in managing essential medicines and medical supplies across public hospitals in Copperbelt Province, Zambia.

2.3. Study Population, Sample Size Determination, and Sampling Procedures

The included hospitals were selected because they were the main referral hospitals in the districts across the Copperbelt Province. A purposive sampling method was used to sample the hospitals that met the inclusion criteria of being a referral hospital. The study population consisted of pharmacy personnel working in 12 public hospitals across Copperbelt Province, which included level one hospitals (Kakoso Level 1 Hospital, Kamuchanga District Hospital, Lufwanyama District Hospital, Thomson District Hospital and Masaiti District Hospital), level two (Nchanga North General Hospital, Kalulushi General Hospital, Ronald Ross General Hospital and Roan Antelope General Hospital), and level three hospitals (Kitwe Teaching Hospitals, Ndola Teaching Hospital and Arthur Davison Children's Hospital). According to data from the Pharmacy unit at the Ministry of Health (MOH)—Provincial Health Office (PHO) in the Copperbelt Province, the total number of pharmacy personnel in these hospitals was 120 comprising Pharmacists, Pharmacy Technologists, and Pharmacy Dispensers.

The sample size was calculated according to methods described for the sample size for cross-sectional studies described previously [12]. Due to the absence of similar studies, we adopted a conservative prevalence proportion of 50%, an error margin of 5% and extrapolated to a finite population of 120 pharmacy personnel. A minimum sample size of 92 participants was required. A total of 102 pharmacy personnel were approached to participate in the study with 94 finally enrolled in the study giving a response rate of 92%. All pharmacy personnel present during the period of data collection were enrolled in a continuous manner from the health facility study sites.

2.4. Data Collection Procedures and Measurements

Data were collected using structured questionnaires, checklists, and both electronic and physical stock control cards. The structured questionnaire assessed the pharmacy staff's awareness of the LMIS for essential medicines and medical supplies. The questionnaire covered aspects such as staff's knowledge of LMIS purpose, functionality, and their roles and responsibilities within the system. Checklists were used during interviews with hospital Heads of Pharmacy departments and supply chain personnel to gather information on LMIS implementation, challenges, and perceived effectiveness.

To assess the accuracy of stock control data and validate electronic LMIS records, we selected 10 medicines and medical supplies from the tracer availability list as approved by the Ministry of Health. These items were chosen based on their essential nature, high usage, and potential impact on patient care. Physical stock counts were conducted in pharmacy storage areas, and the results were compared with the data on both electronic and physical stock control cards.

To ensure data quality, survey instruments were validated through expert review by 2 faculty members from the Department of Pharmacy at The University of Zambia, and pilot testing was done among 20 pharmacy personnel from the University Teaching Hospital and Chilenje Level 1 Hospital in Lusaka. The findings from the pilot study were not included in the final dataset and were used to optimise the data collection instruments. All the data collectors underwent comprehensive training on the study protocols, data collection tools, and ethical considerations before the commencement of the study.

2.5. Data Processing and Analysis

Data processing and analysis were conducted using Microsoft Excel 2010 (Microsoft, Redmond, WA, USA). The collected data were entered into Excel spreadsheets and data cleaning processes, including range and consistency checks, were employed to minimize errors and enhance data reliability. Descriptive statistics were used to summarize the data, including frequencies and proportions for categorical variables such as staff awareness of LMIS, availability of essential medicines and medical supplies, and accuracy of stock control data.

2.6. Ethical Approval

Approval for the study was granted by the University of Lusaka Committee. Additionally, permission to conduct the study in the health facilities was sought from the Provincial Health Office and the heads of respective hospitals. Informed consent was obtained from all study participants and all collected data were restricted to the investigators.

3. Results

3.1. Demographic Information

The study included 94 participants of which 54.3% were male. Close to two-thirds

(60.6%) of the respondents were pharmacists while 2.1% were Pharmacy Dispensers. A third of the participants (33.0%) had work experience between five and ten years (Table 1).

Table 1. Demographic information of participants.

Category	Frequency (N = 94)	Percentage (%)
Gender		
Male	51	54.3%
Female	42	44.7%
Prefer not to say	1	1.1%
Qualification		
Pharmacist	57	60.6%
Pharmacy Technologist	35	37.2%
Pharmacy Dispenser	2	2.1%
Years in Practice		
Less than 1 year	2	2.1%
Between 1 and 3 years	13	13.8%
Between 3 and 5 years	27	28.7%
Between 5 and 10 years	31	33.0%
Above 10 years	21	22.3%

3.2. LMIS Availability and Training

All respondents confirmed the availability and use of the Logistics Management Information System (LMIS) in their healthcare facilities, indicating a 100% implementation rate. However, less than half of the respondents reported having received training in either eLMIS (47%) or the Essential Medicines Logistics Improvement Program (EMLIP) (48%) (Table 2).

Table 2. LMIS availability and training.

LMIS Type	Percentage of Respondents Indicating "Yes"
Availability of LMIS in healthcare facilities	100%
Use of electronic LMIS (eLMIS) in healthcare facilities	100%
Training in eLMIS among healthcare personnel	47%
Training in the Essential Medicines Logistics Improvement Program (EMLIP) among healthcare personnel	48%

3.3. Knowledge of Pharmacy Personnel on LMIS

Among the respondents familiar with different types of eLMIS (63.8%), the majority (71.7%) were familiar with both facility and central editions, while 26.7% were familiar with the facility edition only, and 16.7% with the central edition only (Table 3). A significant proportion of respondents reported being able to perform essential tasks in eLMIS, such as logging in (77.7%), locating the Stock Control Card (76.6%), performing transactions (78.7%), and generating and sending reports (74.5%) (Table 3).

Table 3. Knowledge of pharmacy personnel on LMIS.

Question	n (%)
Are you familiar with the different types of e-LMIS?	
Yes	60 (63.8%)
No	34 (36.2%)
Types of eLMIS respondents are familiar with	
Both facility and Central Editions	43 (56.6%)
Facility Edition	20 (26.3%)
Facility Edition, Central Edition	3 (3.9%)
Central Edition	10 (13.2%)
Are you able to log in to the e-LMIS?	
Yes	73 (77.7%)
No	21 (22.3%)
Are you able to locate the Stock Control Card in the e-LMIS?	
Yes	72 (76.6%)
No	21 (22.3%)
Maybe	1 (1.1%)

3.4. Data Accuracy, Product Availability, and ZAMMSA Order Fill Rates

Table 4 summarizes the key metrics analysed for the 12 sampled hospitals, focusing on data accuracy, product availability, and ZAMMSA order fill rates. Data accuracy, which compares physical counts, physical stock control card balances, and electronic stock control card balances, ranges from 0% to 60%, with several hospitals having incomplete data (N/A). Product availability for the 10 sampled essential medicines and medical supplies varies between 50% and 80%, indicating substantial stockout issues. ZAMMSA order fill rates are consistently low, with most hospitals reporting rates below 30%.

Table 4. Summary of key metrics for sampled hospitals and products.

Hospital	Data Accuracy	Product Availability	ZAMMSA Order Fill Rate
1	0%	50%	20%
2	20%	80%	25%
3	20%	80%	24%
4	30%	60%	<20%
5	30%	60%	10% - 20%
6	N/A	50%	<20%
7	20%	50%	10% - 22%
8	60%	60%	<30%
9	50%	50%	20%
10	N/A	60%	21%
11	40%	60%	<23%
12	40%	60%	17%

Note: N/A indicates that data was not available for the respective hospital.

3.5. Availability of Medicines and Medical Supplies

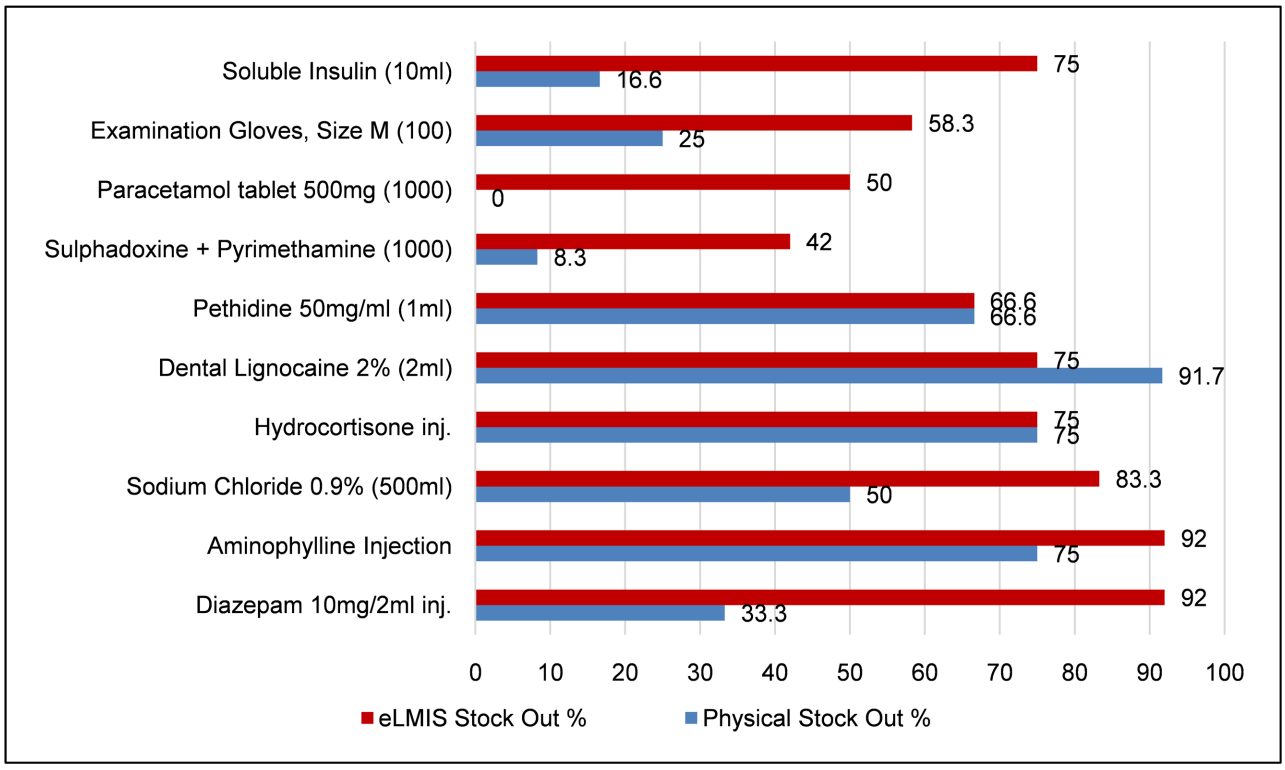

Figure 2. Comparative analysis of Stockouts in health facilities for selected medicines and medical supplies.

Figure 2 depicts the stockout percentages for ten selected medicines and medical supplies across health facilities in the Copperbelt Province on the date of data collection, using both physical count and electronic Logistics Management Information System (eLMIS) stock control cards. The graph reveals significant discrepancies between the two methods: 16.6% of facilities reported a stockout of Soluble Insulin (10 ml) based on physical counts, whereas the eLMIS recorded a 75% stockout rate.

25.0% of facilities experienced a stockout of examination gloves (size M) according to physical counts, compared to 58.3% reported by eLMIS. No stockouts were recorded for Paracetamol tablet 500 mg (1000) based on physical counts, while the eLMIS reported a 50% stockout rate (Figure 2).

4. Discussion

The study findings highlight the critical role of the LMIS in ensuring the availability of essential medicines and medical supplies in public hospitals in the Copperbelt Province of Zambia. The 100% implementation rate of LMIS in the healthcare facilities surveyed demonstrates the Zambian government's commitment to improving the supply chain management of essential medicines. However, the low levels of training among pharmacy personnel in eLMIS (47%) and EMLIP (48%) suggest a need for increased capacity building to optimise the utilization of these systems.

The knowledge of pharmacy personnel on LMIS was generally good, with a majority being able to perform essential tasks such as logging in, locating stock control cards, performing transactions, and generating reports. This finding is consistent with a previous study which highlighted the importance of staff knowledge and skills in the effective use of LMIS [13]. However, the discrepancies observed between physical stock counts and electronic LMIS records emphasize the need for regular data validation, quality assessments and audits to maintain accurate inventory information. This finding aligns with the study which identified data accuracy as a critical challenge in the supply chain management of essential medicines in Zambia [4].

The low product availability and Zambia Medicines and Medical Supplies Agency (ZAMMSA) order fill rates observed in the sampled hospitals indicate significant challenges in ensuring a consistent supply of essential medicines and medical supplies. These findings are consistent with previous studies in Zambia and other low- and middle-income countries, which have reported high stockout rates and inadequate supply of essential medicines [4] [8] [14]. Addressing these challenges requires a multi-faceted approach, including strengthening collaboration between healthcare facilities and ZAMMSA, improving forecasting and supply planning processes, and investing in infrastructure and human resources for supply chain management.

The variations in stockout data between physical and eLMIS records underscore the importance of data quality and validation in the effective management

of essential medicines. This finding is consistent with those reported in Ethiopia, which emphasizes the need for regular data quality assessments and feedback mechanisms to improve the accuracy and reliability of LMIS data [15]. Strengthening data quality assurance processes and providing ongoing training to pharmacy personnel can help address this challenge.

The findings of this study are consistent with previous research on the implementation and effectiveness of LMIS in low- and middle-income countries. A study in Uganda found that while LMIS implementation was high, data quality and stock availability remained a significant challenge [16]. Similarly, a study in Tanzania highlighted the importance of staff training and data quality in the effective use of eLMIS for managing essential medicines [17]. We believe that enhanced staff training can improve their knowledge and attitudes towards LMIS and its importance in promoting data quality and availability of essential medicines in hospitals.

The challenges identified in this study, such as low product availability and order fill rates, are consistent with findings from other studies in sub-Saharan Africa. Studies conducted in Zambia, Kenya, and Uganda found that stockout rates for essential medicines ranged from 25% - 40%, with inadequate supply chain management being a key contributing factor [14]. Similarly, a study in Mozambique reported stockout rates of 30% - 40% for essential medicines, highlighting the need for improved supply chain management and coordination [18]. Our findings and those from similar studies indicate the need to strengthen LMIS in the healthcare system.

4.1. Limitations of the Study

This study has several limitations that should be considered when interpreting the findings. First, the study was conducted in a single province in Zambia, which may limit the generalizability of the results to other regions or countries with different health system contexts. Second, the study relied on a cross-sectional design, which does not allow for the assessment of causal relationships between LMIS effectiveness and medicine availability. Third, the study sample was limited to pharmacy personnel in public hospitals, and the perspectives of other key stakeholders, such as other healthcare providers and patients, were not captured.

4.2. Recommendations

Based on the findings of this study, we would like to make some recommendations to improve the effectiveness of LMIS in enhancing the availability of essential medicines and medical supplies in public hospitals in the Copperbelt Province of Zambia. These include:

1) Increasing investment in capacity building and training for pharmacy personnel to improve LMIS utilization and data quality.

2) Strengthening data validation and audit processes to ensure the accuracy and reliability of LMIS data.

3) Enhancing collaboration between healthcare facilities and ZAMMSA to improve supply chain coordination and increase order fill rates.

4) Investing in infrastructure and human resources for supply chain management to optimize the performance of LMIS and improve the availability of essential medicines.

5) Conducting further research to identify best practices and innovative strategies for strengthening LMIS and supply chain management in resource-limited settings such as ours.

5. Conclusion

The current study found that implementation of LMIS utilization was high in Zambia. However, there were challenges in the implementation of eLMIS use, including low training levels and data inaccuracies that led to low product availability and order fill rates. Continuous strengthening of LMIS effectiveness is crucial for improving healthcare delivery and patient outcomes in Zambia. Future studies should be conducted using qualitative methods to understand the challenges that affect the effective implementation of LMIS in Zambia. Additionally, future studies should explore qualitative factors such as healthcare workers' experiences with LMIS, barriers to its effective use, and potential strategies for improving data accuracy and supply chain coordination.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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