EVALUATION OF INVENTORY MANAGEMENT PRACTICES FOR SUPPLY CHAIN PERFORMANCE OF ANTIBIOTICS IN RWANDA

"A Dissertation *submitted in partial fulfilment* of the Requirements for the award of the Degree of MASTER OF HEALTH SUPPLY CHAIN MANAGEMENT (MSc. HSCM) in the School of Public Health, College of Medicines and Health Sciences, University of Rwanda*"*

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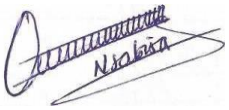
DECLARATION

I declare that this thesis is entirely original and hasn't been submitted to another university for a degree. Except when it is clearly mentioned, it contains my work. It has been examined by the system for detecting plagiarism and is deemed to be genuine and this is the approved final version.

Signature:  Date: **July 15th, 2023**

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DEDICATION

This research dissertation is primarily devoted to my wife Triphine NIYOMUKESHA, and my children GANZA NEZA Eloi, HIRWA NEZA Elven, IKUZWE NEZA Anaël, and ISINGIZWE NEZA Ariel, who give me pride and stability in my life.

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LIST OF ABBREVIATIONS AND ACRONYMS

LMICs: Low- and Middle-Income Countries

CSCMP: Council of Supply Chain Management Professionals

GDP: Gross Domestic Product

RMS Ltd: Rwanda Medical Supply Limited

SCP: Supply Chain Performance

TABLE OF CONTENT

LIST OF APPENDICES

LIST OF TABLES

LIST OF FIGURES

ABSTRACT

Access to essential medicines is a universal human right and is vital for the success of any functioning health system. However, unreliable supply systems hinder the uninterrupted supply of life-saving medicines in developing countries, affecting the availability of life-saving antibiotics. This is a serious problem, given that medicines account for a large percentage of the healthcare budget, and the availability of antibiotics is vital to providing high-quality care for the control of infectious diseases. The aim of this study is to evaluate the contribution of inventory management practices to Supply Chain Performance of antibiotics in Rwanda.

The study used descriptive, cross-sectional, and quantitative research design. The study population embraced 22 both public hospitals having Pharmacists and 30 Rwanda Medical Supply Ltd branches. The suitable method of data collection which has been used is the semi-structured questionnaire. Data analysis was done in the Statistical Software Package for data analysis (SPSS) and exported in MS Excel for tables and graphs.

The findings prevailed inventory management practices in 22 hospitals and 30 RMS Ltd branches include the use of inventory control techniques 81%, forecasting demand using consumption data 90%, stock-keeping records and reporting including data on stock on hand 98% and stock records which scored 97%. The reduced stock out rates 90% and reduced lead time scoring over 79% were found to be efficient among evaluated supply chain performance metrics. The challenges frequently affecting inventory management included inadequate training scoring 78%, poor record keeping with a score of 74%, and poor reporting which rated 71%.

Inventory management practices were performed in accordance to recommended best practices despite various challenges. The evaluated supply chain performance metrics were all found to be satisfactory owing to the high reduced stock out rates, reduced order lead time, reduced unusable to usable stock and increased reporting rates. Adoption of an electronic inventory system, staff capacity building, and supportive supervision on best use of inventory management tools are some strategies to improve inventory management.

Key words: Inventory Management Practices, Supply Chain Performance, antibiotics, stock-keeping records, stock out rates, order lead time, unusable to usable stock, reporting rates.

CHAPTER ONE: INTRODUCTION

1.1. Background of the study

Access to medicines is a universal human right, and their availability including antibiotics is a worldwide issue. From this, hundreds of millions of persons lack access to basic medicines, resulting in a cascade of unnecessary pain and diseases (1).

Increasing access to antibiotics is essential to minimize the weight of infectious diseases in low- and middle-income countries (LMICs). However, the challenges in maintaining access to antibiotics go beyond their physical availability or practical affordability; other obstacles include inadequate health systems due to limited government expenditure for health service, unreliable supply chains, and poor quality control, all of which avert antibiotics from reaching the people who need them (2).

Additionally, several of the currently available antibiotics are no longer effective due to the emergence and spread of antimicrobial resistance. Drug-resistant bacterial infections are a growing threat to the world's populations because of the lack of adequate medicines, which also leads to high rates of avoidable fatalities and is a major obstacle to the effective use of antibiotics in LMICs. (2,3).

Mortality rates in underdeveloped countries reflect a heavy burden of disease that can be significantly decreased with the availability and proper administration of well chosen, inexpensive antibiotics. From the mid-1950s to the mid-1970s basic essential medicines concept began to evolve in different countries as diverse. Since then, countries have gained a lot of expertise in managing the supply of essential medicines (4).

There is rising evidence that patient outcomes are improved by having access to high-quality healthcare, especially for those who have infectious diseases. Access and quality of antibiotics are vital are essential, and adequate inventory management will guarantee the steady supply of medicines required for the successful implementation of Antimicrobial Stewardship Programs (5).

Inventory management is crucial for the pharmaceutical supply chain as it involves controlling the standard medicines ordering procedure. It assists in ensuring a balanced flow of products to patients, preventing product stock outs and lowering inventory holding costs (6). Inventory

management portrays a key role in providing effective healthcare in three important areas: availability, safety, and affordability of essential medicines used in healthcare settings. These are the most significant factors that have the greatest impact on the standard of care and patients' satisfaction in public health facilities (6). Deprived inventory control may result to overstocking or understocking of essential medicines, subsequent in resource wastage and amplified morbidity and mortality outstanding for lack of life-saving pharmaceuticals (6).

In Rwanda, like many other LMICs, there has been few initiatives of manufacturing pharmaceutical products, the majority of health commodities are sourced internationally and through supply chains. As a result, essential medicines inventory management is critical to ensuring universal access to equitable and inexpensive high-quality health care for all Rwandans (7). Furthermore, proper inventory management of essential medicines is also required to ensure adequate stock levels. As a result, consistent stock-taking, inventory reconciliation, first-expired-first-out policies, and batch tracing are all effective strategies to carry out adequate inventory management practices (8).

1.2. Statement of the problem

The government of Rwanda is committed to promote universal access and affordability of equitable and high-quality healthcare for all Rwandans, thereby improving the population's overall well-being (7). Despite many efforts, there are still challenges with reliable access of antibiotics on a regular basis which prevent their delivery to patients in need at right time leading to: inefficiency in care delivery in relation to infectious diseases, antibiotic resistance, etc. While there is a direct link between antibiotic use and antimicrobial resistance development, very few new antibiotic classes are being developed. This implies that existing antibiotics must be used responsibly, which means that an effective management of antibiotics is required to ensure their non-interrupted availability and rational use (9). While a study conducted at Adama town (Ethiopia) has associated the shortage of essential medicines including antibiotics in some health centers with poor inventory management practices, to our knowledge no study has established the connection between inventory management practices and Performance of Supply Chain for antibiotics, especially in the context of Rwanda (6). In this regard, there is a need to conduct an evaluation of Inventory Management Practices for Supply Chain Performance of antibiotics to

truly understand where the problems are in antibiotic management and formulate recommendations with reference to findings.

1.3. Research objectives

1.3.1. General objective of the study

The main objective of this research is to evaluate the contribution of inventory management practices to Supply Chain Performance of antibiotics in Rwanda.

1.3.2. Specific objectives

The research study is divided up into the following specific objectives:

1. To identify the inventory management practices used for managing antibiotics in Rwanda;
2. To evaluate the performance of inventory management practices to supply chain of antibiotics;
3. To determine inventory management related challenges affecting Supply Chain Performance of antibiotics in Rwanda;
4. To suggest action points to overcome challenges related inventory management practices for antibiotics supply in Rwanda.

1.4. Research questions

To achieve the goal of this study, the following research questions served as the study's compass:

1. What are the inventory management practices used for managing antibiotics in Rwanda?
2. What is the performance of inventory management practice to supply chain of antibiotics?
3. What are inventory management practices related challenges affecting Supply Chain Performance of antibiotics in Rwanda?
4. What are the action points to overcome inventory management practices related challenges for antibiotics supply in Rwanda?

1.5. Purpose of the research study

The purpose of this research study is to find out the suitable model for inventory management practices for Supply Chain Performance of antibiotics in Public Hospitals and Rwanda Medical

Supply Ltd branches, to ensure that the Rwandan population has access to high-quality healthcare through performed supply of antibiotics. Once antibiotics are available, their proper use has played a part in the improvement of healthcare delivery as they contribute significantly to infectious diseases control.

1.6. Significance and anticipated output of the study

This research firstly helped the researcher to know the role of inventory management practices on Supply Chain Performance of antibiotics in Rwanda. These data are keys assist healthcare providers in identifying areas that require resource mobilization and capacity building in order to promote supply chain of antibiotics.

The research findings of the study may be used by the Government of Rwanda, notably the Ministry of Health, to guide decision-making on efficient supply of antibiotics and the coordination of inventory management procedures.

This research has most increased the body of knowledge on inventory management practices to improve the availability of antibiotics for future researchers.

The anticipated output of the research was to unearth the deficiencies of the existing inventory management procedures for Supply Chain Performance of antibiotics in Public Hospitals and Rwanda Medical Supply Ltd branches, and consequently provide policy recommendations and best practices as a result. The aforesaid output has been attained.

1.7. Limitation of the study

The limitations to this research comprised time constraints. These factors should affect the conduct of a comprehensive research and therefore this study has only target Public Hospitals and Rwanda Medical Supply Ltd branches by looking at inventory management procedures for the performance of Supply Chain of the selected antibiotics in Public Hospitals and Rwanda Medical Supply Ltd branches.

CHAPTER TWO: LITERATURE REVIEW

2.1. Introduction

Under this chapter inventory management practices, inventory management challenges, performance of supply chain for antibiotics, and best practices for managing inventories were discussed. Towards the end, a conceptual framework is presented to outline the factors examined and illustrate the correlation between the independent and dependent variables.

2.2. Inventory Management Practices

In today's economic environment, many company must raise their market share both locally and worldwide in the current economic climate in order to thrive and achieve their growth goals. The challenge is to have enough inventory on hand to fulfill customer demands while concurrently controlling it to avoid overstocking and stock-outs. Inventory is defined as raw materials, work-in-process items, component parts, and fully produced items that are part of a company asset and are currently or will soon be available. Inventories can be categorized depending on their intended use. These include the following: cycle inventory, decoupling inventory, expected inventory, buffer inventory, and transport inventory (10).

Inventory management is defined “as a form of administrative control that is especially important in industrial, wholesale, and retail businesses”. "To have the right commodities, quality and quantity, at the right place and time," is the essence of inventory. To protect the manufacturing system from any disruptions, this technique is necessary as part of the supply chain system. Inventory control is a method of ensuring that the proper products are accessible at the appropriate time and location (11).

Inventory management can also be defined as the strategies and techniques that establish and regulate which products to order, at what time to order them, what should be stored, and in what amounts. As a result, inventory management's main goal is to provide good customer service while keeping inventory expenses within realistic bounds, increasing company profitability, and reducing inventory investment (12). Therefore, Inventory management that is done correctly reduces inventory, reduces costs, and improves profitability. An appropriate inventory level can be established using the incremental profitability to the opportunity cost of carrying higher inventory amounts (11).

Inventory management contribute in the medical supply chain, as it entails the control of the routine medical product ordering process and then assists to uphold a consistent supply to individuals in need, hereafter avoiding product stock outs while lowering inventory holding costs (13).

Good inventory management requires accurate and current stock records since they are used to estimate future requirements. Holding stocks is compulsory to ensure availability of essential commodities almost all of the time. The selection of products to stock should be based on the item's value to public health and the amount of use (13).

According to Kefale and Shebo (2019), inventory management is essential to providing effective healthcare in three key areas: availability, safety, and accessibility of health commodities used in healthcare settings. These are the most important factors that have an impact on patient satisfaction with public health services and the quality of care. Poor inventory control can cause important essential medicines to be overstocked or understocked, resulting in resource wastage and increasing illness and death due to a lack of life-saving health commodities (6).

The primary themes covered, however, when looking at inventory management practices in healthcare settings include inventory control techniques, how quantities to order are calculated, the accessibility, correctness, and correctness' of stock-keeping records, as well as safety stock policy (14).

The trigger for reordering decides which model is being utilized in health commodities supply systems. The most often used system for managing health commodities is the maximum-minimum inventory control system. This technique is designed to keep stocks within a certain range, with the maximum stock being the upper limit and the minimum stock being the lower limit (14). From this system, it is stated that "the max-min inventory control system has 3 types: forced order system, continuous review system and the standard system" (15).

The forced order system is "the system which involves ordering items at the end of a review period, based on the deficit required to bring stock levels up to the maximum level". This method is easy for inventory managers, predictable, and easy to arrange transportation. However, it requires ordering almost all items, even those slightly below the maximum. Vendor Managed Inventory is another form of forced order, where suppliers ship medicines to a facility, assess stock, and top it up to the maximum level (15).

A continuous review system orders items based on their stock level, with the main advantage being the decrease of small orders. However, this system also has a disadvantage of making transportation harder as orders are placed at any time until the minimum stock level is reached. The two-bin system is "a version of the continuous review where two equal-sized bins are filled with a specific product. When the first bin is full, the minimum is attained, and when both bins are full, the maximum is reached (15)".

The standard system combines the benefits of forced and continuous review systems by initiating ordering when commodities reach minimum stock quantity. However, it necessitates a higher minimum stock level, raising the expense of maintaining inventory as well as the risk of commodity expiration (15).

The main data source for inventory management is stock-keeping records, which can be either manual or electronic. Data documented in stock records, whether manual or computerized, must be accurate and up-to-date. A stock record may contain incorrect data for a variety of reasons, the majority of which are avoidable. Theft, infrequent physical counts, poor training of inventory management personnel, removal of outdated or damaged goods without striking them from stock records, and holding inventories of one item in multiple places due to poor warehousing procedures are just a few examples (13).

According to MSH (2012), "the most crucial document is the stock card and should include the elements such as a product description, the unit of issue, the expiration date, columns and rows to indicate the date, issues, receipts, and balance". These are essential components of an ideal stock card. Vertical file cards and kardexes are two other commonly used stock records (13).
according to the USAID|DELIVER PROJECT "stock-keeping records should include stock on hand, losses and adjustments for each product" (15). Because a product rarely moves from the store to a client, consumption data is not captured on the stock-keeping records while it is the third important data for decision making.
Reports are crucial in logistics management as they provide essential data to decision-makers, reason why stock records without required data are irrelevant. MSH (2012) recommends reporting on consumption trends, service levels, inventory holding fees, and stock at the beginning and end

of the review period and medicines at risk of expiration in order to improve inventory management (13).

The safety stock is explained as “the inventory a company holds above normal needs as a buffer against delays in receipt of supply or changes in customer demand”. Safety stock is calculated using methods that take into account demand patterns, stock out costs, and inventory holding costs. The inventory holding cost of additional stock, on the other hand, is balanced against the health and political implications in the public health supply chain (14).

The standard safety stock formula, according to MSH (13), “is the product of average lead time and average monthly consumption adjusted for stock outs”. The safety factor is based on the stock manager's experience rather than any scientific derivation. Its objective is to compensate for shifting consumption patterns and supply delays. Safety stock is a crucial issue to consider when designing an inventory management system, regardless of the criteria applied(16).

2.3. Inventory management challenges

Shortages of health products, their loss or theft, overstocking, lack of enough storage space, product prevention, management and expiration, and subsequent billing and inventory reporting are just some of the challenges of inventory management. When vital medicines are not accessible at the health center pharmacy, patients cannot afford the additional expenses once such medicines including antibiotics, have to be sought from other private retail pharmacies. This exercise is cited as a key factor contributing to drug shortages (17).

Shadrack M. Meeme highlights that “lack of knowledge about storage conditions, lack of suitable storage facilities, poor communication between inventory management staff and healthcare personnel, lack of an adequate inventory system, lack of monitoring tools, lack of tools to collect essential data, and lack of human capacity” are also among the inventory management challenges (18). Shadrack M. Meeme adds that Inventory management also faces challenges such as subjective and ad hoc decisions on ordering frequency and quantity, inaccurate, outdated and inadequate stock records, lack of standard operating procedures (SOPs) to guide staff, and lack of frequent performance monitoring. The problem becomes worse when healthcare managers lack basic inventory management skills (18).

2.4. Supply chain performance

The operations of the extended supply chain in satisfying end-customer demands are referred to as supply chain performance. this include ensuring that the supply chain has all the inventory and capacity it needs to operate in a timely manner, that the products are available, that deliveries are performed on schedule, and more (19).

According to Anyona Johnson et al, supply chain performance could be enhanced with an understanding of how it is performing, and the only way to achieve this is to measure it in order to identify its strengths and weaknesses and, consequently, pinpoint the areas that need improvement (20).

Frazelle suggests using performance indicators that take into account quality, productivity, response time, and financial position (17). Quality indicators quantify your level of satisfaction with a specific work. It serves as a gauge of precision. Response time indicators demonstrate the supply chain's timeliness. While productivity indicators show resource use and if it is efficient, financial indicators show an organization's financial status and assist in identifying the drivers of cost (21).

The stock-out rate measures the availability and lack of product over a given period of time, evaluating a program's ability to meet client demand. Physical accounts taken during site visits, monitoring records, and LMIS records are some of the data sources that can be used to calculate the stock-out rate. It can be used for a single product or health commodities in specific facilities (22).

Wangu and Onyango (17) have stated that “in public hospitals in Nakuru, Kenya, deprived distribution (91%), scarce funding (58%), improper selection (58%) and irrational drug use (56%) were the main causes of stock outs”.

Aronovich et al (22) defines order lead time as a measure of how long it typically takes from the moment an order is placed until it is received by a certain health facility. This indicator evaluates the effectiveness of the central warehouse as well as the delivery point network. It is stated that “the order lead time can be calculated using information from order and requisition forms. To calculate order lead time, use the formula below: divided by the total number of orders placed, the total number of days between placing an order and getting it” (22).

According to a case study carried out at a Mexican company to examine ways to decrease order lead times, it was stated that “moving inventory from a central warehouse to strategically placed stores closer to customers and increasing space utilization for every shipment were found to be effective strategies of cutting order lead times” (17).

The ratio of stock that is damaged or expired to stock that is still useful is provided by the unusable to usable stock. The unusable to usable ratio can indicate poor inventory control, insufficient product rotation, excessive hoarding, and inappropriate storage conditions (22).

The reporting rate measures the percentage of facilities completing and submitting reports within specified timeframes. It evaluates accuracy, completeness, and timeliness. It was suggested by Aronovich et al that “timely information is crucial for managers to make effective decisions, such as restocking, redistribution, or resource mobilization. To calculate reporting rates, it is important to know the total number of facilities, reporting schedule, and recent report submission dates” (22).

2.5. Conceptual framework

The relationship between independent and dependent variables is explained by the conceptual framework that is provided below. The employed inventory management techniques influence the supply chain performance indicators. This study makes the assumption that the inventory management practices under investigation—inventory control techniques, order quantity estimation, and stock-keeping records and reporting—have had a significant impact on the supply chain performance, which has been measured as stock-out rates, order lead times, stock wastage and reporting rates. In other words, well conducted inventory management techniques have improved reporting rates while decreasing stock out rates, order lead times, and stock wastage rates.

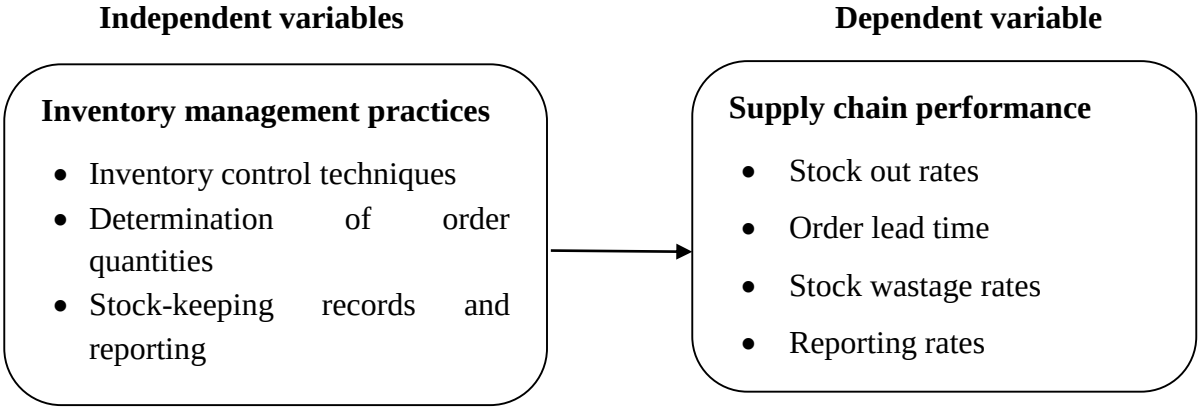

Figure 1.Conceptual Framework

2.6. Summary of literature review

The information form the literature captured under this chapter provides an understanding of theories concerning the contribution of inventory management techniques to the performance of supply chain of antibiotics in Rwanda. Many studies argued on inventory management practices and availability of antibiotics. This leaves a gap to know how inventory management practices can contribute to Supply Chain Performance of antibiotics in Public Hospitals and Rwanda Medical Supplies Ltd branches.

CHAPTER THREE: RESEARCH METHODOLOGY

3.1. Introduction

In this section, the study area is briefly described in terms of the research concept, research design, research methodology, demographic and sample selection, and data collecting and analysis techniques.

3.2. Study design and research approach

The used study design was a descriptive cross-sectional and quantitative using a retrospective method to gather data on inventory management practices and supply chain performance metrics from respondents and for gathering data on availability of tracer antibiotics in six months, between July and December of 2022.

The research approach was descriptive because there was no comparison group and it formulated a specific hypothesis. The study design was cross-sectional since it captured information based on data collected snapshot information of the inventory management practices happening hospitals and RMS Ltd branches across Rwanda for a specific point in time. The quantitative research method was applied since gathered information can be quantified, measured and expressed numerically.

A core list of 12 tracer antibiotics to be used in this study was picked from Rwanda National List of Essential Medicines for adults 7th Edition, 2015 and Rwanda National list of essential medicines for pediatrics, 1st edition, 2015 (23,24).

3.3. Location of the Study

The study was conducted in all hospitals having Pharmacists for all three levels (Referral, Provincial and District hospitals) and all 30 RMS Ltd branches existing in Rwanda.

3.4. Study Population

All hospitals with Pharmacists and all 30 RMS Ltd branches were included in this study. Two Staff working in the pharmacy of each of the above-mentioned hospitals (Pharmacist and Store Manager) and in the RMS branches (Pharmacist and Inventory Officer) dealing with daily stock management were considered as respondents. In total, 103 of the 104 participants were from the

22 hospitals with pharmacists and the all 30 RMS Ltd branches. The participant that needs to be added pant is the Store Manager who resigned from the Hospital.

3.4.1. Inclusion criteria

Staff working in the hospital pharmacy and RMS branch who have knowledge to deal with daily stock management practices was included in this study. These staff are mainly Pharmacists and Pharmacy Store Managers or Inventory Officer in the case of RMS Ltd branch. This means that the facility with pharmacist will only be considered.

3.4.2. Exclusion criteria

Any staff working in the hospital and in the RMS branch but providing a refusal to consent for participation in the study was automatically excluded. Note that Hospitals without Pharmacist have been automatically excluded from the study.

3.5. Data collection methods, analysis and instruments

Views of respondents were collected using a semi-structured data collection tool designed according Likert scale style to respond to the study objectives. Participants were asked to indicate the extent to which they agreed or disagreed with the information provided. Response options range from 1 (strongly disagree) to 5 (strongly agree) on a Likert scale data collection tool and scale rate responses were summed to obtain an overall score for each scale.

After data collection, the collected data were edited, coded, sorted, and tabulated to make them amenable to analysis. The Statistical Package for the Social Sciences (SPSS) was used for data analysis, then exported in MS Excel for tables and graphs.

3.6. Validity

Kothari describes validity as “degree to which an instrument measures what it is supposed to measure” (25). For this study, validity was examined in two different ways. Initially, the researcher evaluated the text of the data collecting tools to ensure that the items were consistent across the tools, succinct, intelligible, clear, and free of bias. The instruments used in similar published studies were compared to the one proposed in this study, and necessary adjustments and improvements were made based on the literature analysis.

3.7. Ethical Considerations

As summarized in the Belmont report (1979), respect for human subjects, beneficence, and justice are three essential ethical principles related to research involving human subjects (26). Since the study ensured that individuals had been fully informed about the study's purpose, risks, benefits, and alternatives, as well as an extended opportunity to ask questions, the research considered how to maximize benefits while minimizing risks that may arise as a result of the research.

Ethical considerations have been thought and granted by University of Rwanda, the Institutional Review Board (IRB) of the College of Medicines and Health Sciences and National Health Research Committee. Moreover, written appraisal from Rwanda Medical Supply Ltd headquarter to consent the study were also sought for all the 30 RMS branches. Another written appraisal was received from Kibungo referral Hospital to conduct the study in the institution.

The respondents were informed of the study's broad scope. Before giving their informed consent to participate in the research, they have been ensured of the safety, confidentiality, objectivity, and honesty of the provided data. Study participants were informed in advance that there was no payment made for taking part in the study.

Informed consent forms were employed, and they had to be signed by participants ready and eager to participate in the study. The confidentiality of the study participants has been maintained. The data have been analyzed in a way that makes it impossible to identify individuals.

CHAPTER FOUR: RESULTS

4.1. Introduction

This chapter summarizes the key findings of the research based on primary data collected using a digitalized questionnaire distributed to the respondents across the hospitals and the district pharmacy. The findings are displayed using graphs, charts, and tables.

4.2. Sociodemographic characteristics

During this research, 103 questionnaires were distributed, all of them were filled at a response rate of 100%. From all levels considered and visited we got a positive turnout and answers.

The participants were of different sex, age, working experience and education level. The composition of participants by gender were 25% of females and 75% of males. Most of the participants were aged between 36 to 45 years old, 75% followed by those with 25 to 35 years old. Working experience ranging between 1 and 5 years was the most dominant with 34% of representativity and those with bachelor's degree were around 35% followed by those with secondary schools as their highest level of education. Details are described in Table 1 below.

Table 1. Sociodemographic characteristics of respondents

Variable	Modalities	Frequency n	Percentage
Age groups	Above 45 years	8	8%
	Between 25-35 years	17	17%
	Between 36-45 years	78	75%
Sex	Female	25	25%
	Male	78	75%
Working experience	Below 1 year	16	16%
	Above 10 years	24	23%
	Between 5-10 years	28	27%
	Between 1-5 years	35	34%
Education	Master's degree	16	16%
	Diploma	23	22%
	Secondary	28	27%
	Bachelor's Degree	36	35%

4.3. Inventory management practices

This section provides an overview of the inventory management procedures including inventory control techniques, order quantity estimation, stock-keeping records, and reporting that were assessed to be effective for managing antibiotics in Rwanda.

4.3.1. Inventory control techniques

Inventory control techniques have been investigated to check for their use to keep and assess the stock out process and reporting for determining the next orders and reordering. The inventory management practices related to control techniques are displayed in the Table 2 below for its representativity.

Table 2. Distribution of inventory control techniques

Variable	Modalities	Frequency	Percentage
Forced order system: where the end of the review period serves as the trigger for ordering medicines.	Agree	66	64%
	Disagree	23	22%
	Neutral	14	14%
Continuous review system: where trigger for ordering medicines is when minimum stock level for each item is reached.	Agree	71	69%
	Disagree	14	14%
	Neutral	18	17%
Standard system: where trigger for ordering is the end of review period for medicines that hit minimum stock quantity.	Agree	83	81%
	Disagree	12	12%
	Neutral	8	7%

From the table above, it has been found that all three inventories control techniques highlighted above are used to monitor the stock-out levels in health facilities, the results showed that the standard system is the mostly used with scores of 81% followed by the continuous review system that scored 69% and finally the forced order system scored 64% of inventories control techniques.

4.3.2. Determination of order quantities

For the practices of determining order quantities, different used forecasting methods have been assessed such as the projective method, the causal method, judgement method and morbidity method as displayed in Table **3** below:

Table 3. Distribution of forecasting methods used in determining of order quantities

Variable: method used	Modalities	Frequency	Percentage
Projective method: where previous consumption data are used to forecast demand of antibiotics.	Agree	93	90%
	Disagree	2	2%
	Neutral	8	8%
Causal method "which predicts outcomes based on external factors such as epidemics and changes in the healthcare system's structure and size."	Agree	45	44%
	Disagree	40	39%
	Neutral	18	17%
Judgment method: where forecasts are based on individual judgment of experienced staff.	Agree	20	19%
	Disagree	49	48%
	Neutral	34	33%
Morbidity method: Forecasts are based on disease prevalence, incidences and expected number of attendances.	Agree	73	71%
	Disagree	20	19%
	Neutral	10	10%

The above table shows that among the methods used to determine the order quantities, the projective method was the most rated with 90% of approvals followed by morbidity method with 71% while the judgement method is the least used with 19%.

4.3.3. Stock-keeping records and reporting

Regarding the practices of inventory stock-keeping records and reporting, the results showed that different methods were used at various levels as displayed in Table 4 below:

Table 4. Distribution of stock-keeping records and reporting

Variable	Modalities	Frequency	Percentage
All antibiotics have stock records	Agree	100	97%
	Disagree	0	0.0
	Neutral	3	3**%**
"The stock records for antibiotic medicines are both accurate up to date"	Agree	95	92%
	Disagree	0	0%
	Neutral	8	8%
"Regular stock counts are done minimum once every reporting period for antibiotics"	Agree	96	93%
	Disagree	4	4%
	Neutral	3	3%
"Reports for antibiotic medicines are compiled at the end of each reporting period"	Agree	88	85%
	Disagree	9	9%
	Neutral	6	6%
"Data on consumption is included in every report"	Agree	90	87%
	Disagree	4	4%
	Neutral	9	9%
"Data on stock on hand is included in every report"	Agree	101	98%
	Disagree	0	0%
	Neutral	2	2%
"Data on losses and adjustments is included in every report"	Agree	92	89%
	Disagree	0	0%
	Neutral	11	11%
"Data on commodities near to expiry is included in every report"	Agree	80	78%
	Disagree	13	13%
	Neutral	10	10%

The results on inventory stock-keeping records and reporting has been done, and among different records applied on stocking, the data on stock on hand included is the most preferred with a rate of 98% followed by availability of stock records for all antibiotics with 97% and the last record is the data on commodities near expiry to be included as illustrated in table above.

4.4. Supply Chain Performance

4.4.1. Effect of inventory control systems to supply chain performance

Using the Likert scale style, we have classified the impact of using inventory control systems to supply chain performance of antibiotics in Rwanda where the score ranking showed the reduced stock out rates with a higher score of 89% followed by reduced unusable stock to usable with 81% as described in the Figure 2 below:

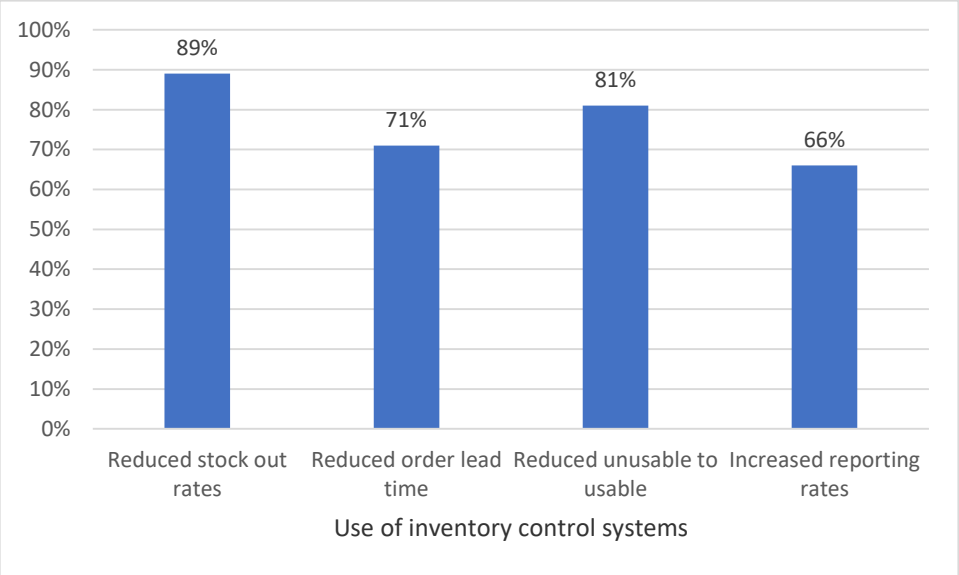

Figure 2. SCP metrics based on the use of inventory control systems

4.4.2. The relationship between the inventory control techniques and supply chain performance.

The inferential statistics test assessed the degree of association between inventory control system and supply chain performance, establishing its significance and presenting a fitness regression model in Table 5 below:

Table 5. Test analysis for the most preferred inventory control system and supply chain performance metrics

Model summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.073	.059	.021	0.000

The model summary table demonstrates R (.073), presenting a strong and positive relationship between inventory control systems and supply chain performance while the R^2 is .059, showing that only 5.9% of variance is predicted by inventory management system.

Table 6. Test analysis coefficient for the most preferred inventory control system and supply chain performance

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.033	0.000		8.000	.000
	Reduced stock out rates	0.011	0.033	0.032	0.000	0.000
	Reduced order lead time	0.059	0.048	0.000	1.000	0.000
	Reduced unusable to usable	0.002	0.041	0.000	-2.000	0.014
	Increased reporting rates	0.077	0.045	.000	1.000	0.093

The Beta values for each is of the independent variables are stock out rates reduction .011; order lead time reduction .059; unusable to usable stock reduction .002 and increased reporting rates .077 respectively. This illustrates that there is a positive relationship between the standard system which is the most preferred in three leader inventory control techniques and supply chain performance. Three variables are however highly significant with stock out rates reduction, order lead time reduction and unusable to usable stock reduction being highly significant as $p \leq 0.05$. The significance for inventory control techniques at .093 however shows no significance for increased reporting rates.

4.4.3. Impact of formula in determining order quantities to supply chain performance

Using the Likert scale style, we have classified the impact of using formula in determining the order quantities to supply chain performance of antibiotics in Rwanda where the score ranking has

shown a higher score of 92% for the reduced stock out rates followed by the reduced lead time with 79% as depicted in the below:

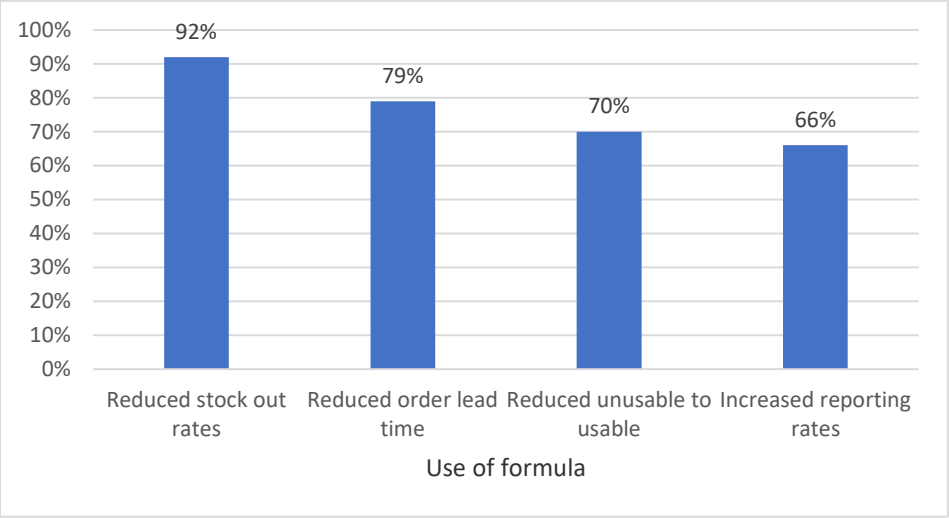

Figure 3. SCP metrics based on the use of formula in determining order quantities

4.4.4. The relationship between the formula in determining order quantities to supply chain performance.

The statistics test was conducted to evaluate the relationship between the formula in determining order quantities and the supply chain performance metrics as the model illustrates in Table 7 below:

Table 7. Test analysis for the most used forecasting method in determining order quantities and supply chain performance

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.006[a]	.088	.050	0.000

The model summary table above shows R (.006), showing a strong and positive relationship between forecasting methods in determining order quantities among inventory management practices and supply chain performance while the R^2 is .088, showing that only 8.9% of variance is predicted by inventory management system.

Table 8. Test analysis coefficient for the most used forecasting method in determining order quantities and supply chain performance

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.000	.088		13.021	.000
	Reduced stock out rates	0.006	.049	.016	0.000	0.000
	Reduced order lead time	0.089	.031	0.000	2.000	.006
	Reduced unusable to usable	0.002	.056	0.000	-1.000	.060
	Increased reporting rates	-0.010	.031	-.038	0.000	0.000

The Beta values for each is of the independent variables are stock out rates reduction .006; order lead time reduction .089; unusable to usable reduction .002 and increased reporting rates -.010 respectively. This illustrates that there is a positive relationship between projective method among forecasting methods used in determining order quantities and supply chain performance metrics in two of the attributes, with positive relationship. Two variables are however highly significant with reduced stock out rates and reduced order lead time while the increased reporting rates has a significant negative relationship with -.010 all with being highly significant as $p \leq 0.05$ and only the formula used in determining order quantities with .002 however shows no significance for reduced unusable to usable stock.

4.4.5. Impact of stock-keeping records to supply chain performance

Using the Likert scale style, we have classified the impact of using stock-keeping records to supply chain performance of antibiotics in Rwanda where the score ranking showed that reduced stock out rates was the highly impacted by using stock-keeping records with a score of 94% followed by the reduced order lead time with a score of 83%. It is depicted in the Figure 4 below:

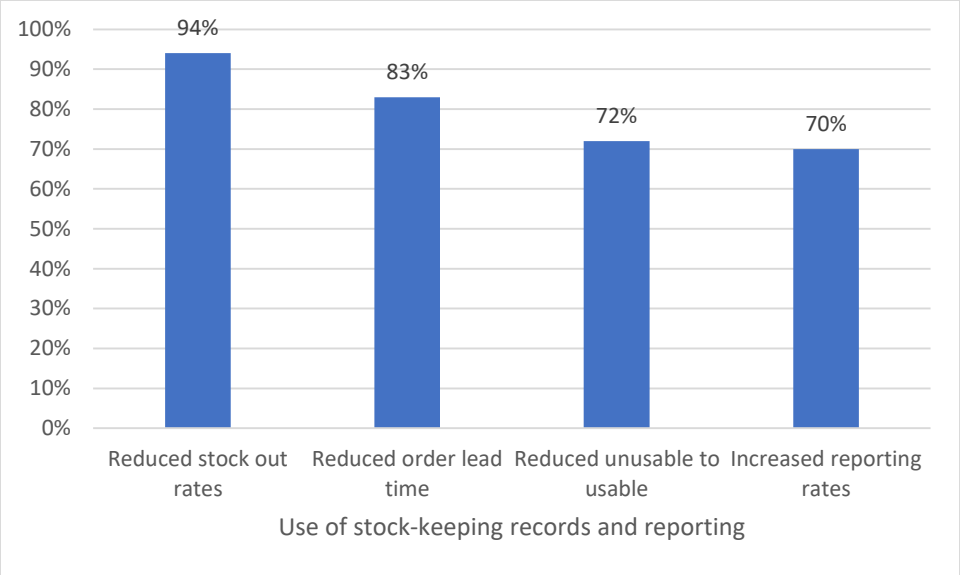

Figure 4. SCP metrics based on the use of stock-keeping records and reporting

4.4.6. The relationship between stock-keeping records and supply chain performance.

The statistics test was conducted to evaluate the relationship between the stock-keeping records and the supply chain performance as the below model illustrates in Table 9 below:

Table 9. Test analysis for the most stock-keeping records and supply chain performance

Model Summary				
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.000[a]	.086	.020	0.000

The model summary table displays R (.000), showing a strong and positive relationship between stock-keeping records among inventory management practices and supply chain performance while the R^2 is .086, showing that only 8.6% of variance is predicted by inventory management system.

Table 10. Test analysis coefficient for used supply chain performance inventory system and for the most preferred inventory control system

Coefficients						
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	1.000	.073		7.000	.000
	Reduced stock out rates	0.005	.033	0.000	-4.000	.000
	Reduced order lead time	0.000	.056	0.000	5.000	.000
	Reduced unusable to usable	0.017	.037	0.000	4.000	.000
	Increased reporting rates	0.004	.046	0.000	2.000	.017

The Beta values for each is of the independent variables are stock out rates reduction .005; order lead time reduction .000; unusable to usable stock reduction .017 and increased reporting rates .004 respectively. This expresses that there is a positive relationship between stock-keeping records among inventory management procedures and performance of supply chain in all the four attributes, with positive relationship. all with being highly significant as $p \leq 0.05$ which shows the positive significance in relationship.

In summary, the effect of inventory management procedures on the performance of supply chain for antibiotics showed that the utilization of stock-keeping records and formula in determining the quantities to order were successful in stock out rates and order lead time reduction at 94% and 92%, respectively. Inventory control systems, which were better at reducing stock waste than stock-keeping records and reporting (72%), came in second. Many efforts are needed to reduce stock out rates to the smallest value possible.

4.5. Inventory management challenges affecting Supply Chain Performance

In the framework of this study, it was identified different challenges affecting supply chain performance of antibiotics in Rwanda. According to findings, the most challenge found at facility level were inadequate training on inventory management with a score of 78% followed by the poor record keeping with a score of 74%, then the poor reporting with 71% and the least in the challenges observed was the lack of commitment by the top management that scored 37% as displayed by the Figure 5 below provides more details.

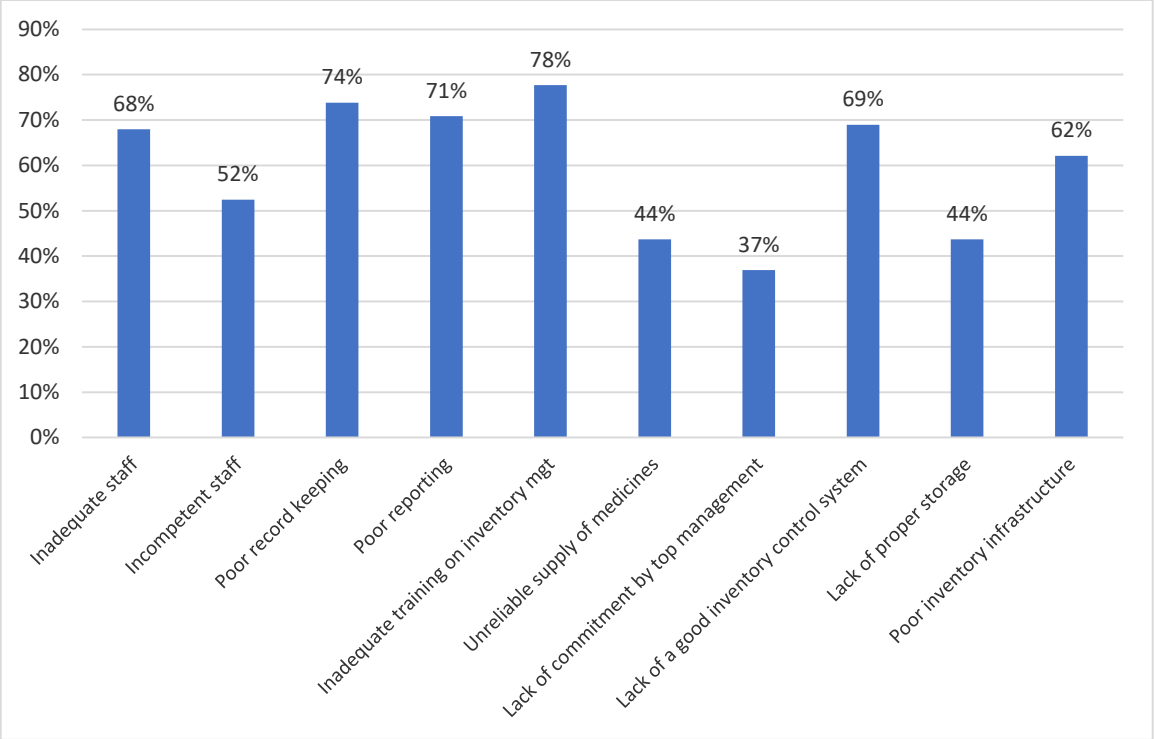

Figure 5. Challenges affecting supply chain performance of antibiotics

4.6. Action points to overcome challenges related to inventory management practices

Several action points to overcome the challenges encountered during inventory management practice were highlighted. The study results showed that the use of technology or system in inventory management with a score of 92% should be taken into accounts to better perform inventory management. The aforementioned action point is followed by an increase of staff and training with 88% as described in Figure 6 below.

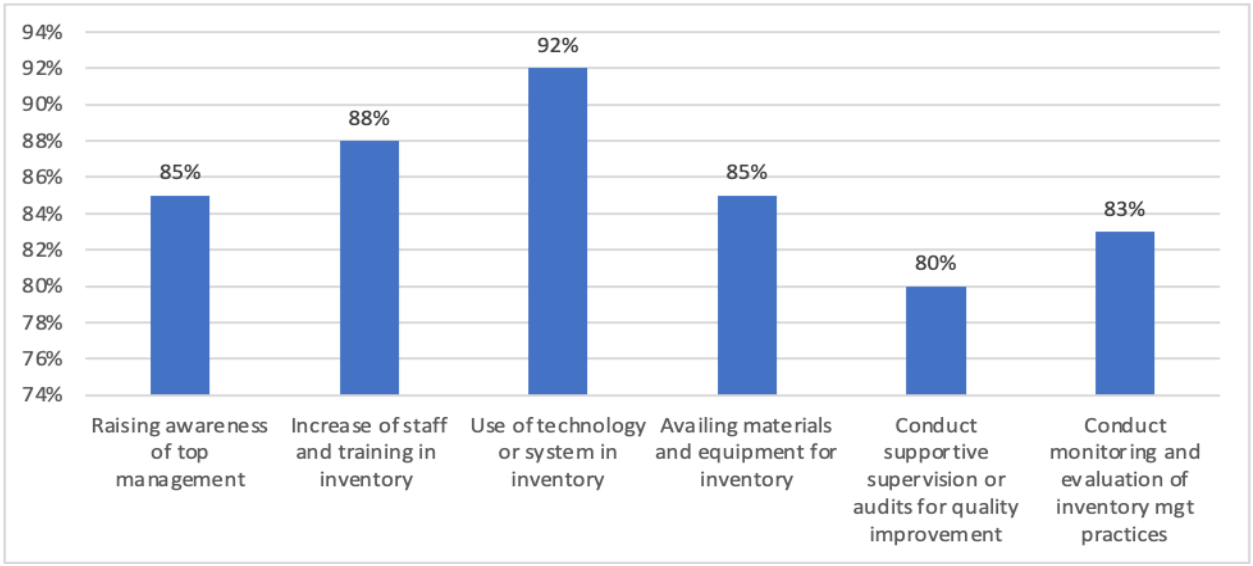

Figure 6. Distribution of actions identified to overcome identified challenges

4.7. Availability of antibiotics

The availability of tracer antibiotics was assessed in 22 public hospitals and 30 Rwanda Medical Supply Ltd branches for the period of last six months of 2022. The results have shown that all the assessed antibiotics were mostly available over the considered period at a percentage ranging from more than 70% and above as described in the Table 11 below:

Table 11. Availability of tracer antibiotics over six months' period considered

Tracer antibiotics medicines	Availability of antibiotics					
	July	August	September	October	November	December
Amoxicillin 250mg capsule	85.5%	78.9%	76.5%	78.9%	77.8%	87.5%
Ampicillin 500mg powder for injection	82.7%	83.1%	82.7%	82.4%	85.7%	81.5%
Ceftriaxone 1g injection	82.8%	78.7%	80.5%	77.8%	80.5%	84.6%
Clarithromycin tablet 250mg	80.4%	77.8%	77.8%	77.8%	78.0%	75.9%
Cloxacillin 250 mg capsule B/1000	81.4%	79.1%	81.4%	82.9%	80.2%	84.9%
Erytromycin 250mg tablet	81.4%	78.0%	78.0%	74.4%	76.2%	72.0%
Doxycyclin 100mg capsule	81.4%	83.1%	79.8%	77.8%	80.0%	72.5%
Gentamicin inj. 40mg/ml 2ml	80.6%	81.4%	79.5%	77.8%	77.8%	75.9%
Metronidazole inj 5mg/ml 100ml	81.2%	80.6%	81.1%	81.8%	78.4%	80.8%
Metronidazol 250mg tablet	81.8%	80.5%	82.9%	79.1%	78.6%	77.8%
Phenoxymethylpenicillin V 250 mg tablet	82.5%	85.1%	82.1%	79.7%	79.7%	78.9%

However, efforts are needed to reduce stock outs observed in different health facilities as unavailability of antibiotic medicines can be source of irrational use of antibiotics resulting in antimicrobial resistance.

From table above, this is to note that in general the high percentages in the availability of tracer antibiotics observed are explained by the high percentages of standard system among inventory control model, projective method among the forecasting methods used in determining the order quantities and data on stock on hand among stock-keeping record and reporting practices.

CHAPTER FIVE: DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

5.1 Introduction

The following section reviews and compares the results in relation with current literature. Conclusions and recommendations have been formulated in terms of policy, practice and further research based.

5.2 Discussion

Within the inventory control techniques used to manage antibiotics, the most identified inventory control technique by respondents was the standard system (81%), this technique has significantly contributed to stock out reduction as triggered for ordering is the end of review period for medicines that hit minimum stock quantity. this is in line with the published literature (27). However, in the standard system, the trigger for ordering may hit minimum stock quantity as benefits from both the forced and continuous review systems' advantages but also may raises inventory holding costs and increases the risk of commodities expiring. A study conducted in India found that the standard system is key component in determining the availability and accessibility of medicines for the population (27).

It has been found that the projective and morbidity approaches, which received scores of 90% and 71%, respectively, were the most predominant forecasting techniques used to calculate order quantities. This is in line with Management sciences for health (MSH) recommendations for quantifying health commodities (28). In fact, the projective method is based on previous consumption; the causal method, on external factors such as epidemics and market structure; the judgment method, on estimates made by experienced personnel; and the morbidity method, which uses data on disease incidence and standard treatment guidelines, are the most widely used methods in many developing countries, such as Uganda. However, it was discovered that the projective approach was the one that was most frequently employed, and that this method is appropriate for sophisticated programs with correct data and a full supply of commodities (29).

The inventory management tools are used in managing antibiotics. The results showed that the most used stock-keeping record and reporting is the data on stock on hand with a percentage range of 98% and stock records with a percentage of 97%. This showed that having stock cards and

others tools is important in Logistic Management Information System (LMIS) for a better performance of inventory management. The inventory control tools must be routinely updated and used as the primary source of information for all hospitals and RMS limited branches' procurement and distribution decisions (7).

This is in line with research conducted in developing countries that unveiled the importance of keeping stock records data for determining stock levels and status (22). Regular reporting used quantity, physical stocks on hand, expired stocks and stocks requiring changes is necessary for logistics data reported as recommended by WHO (30). A formula was used to account for efficient stocking in the orders for the necessary antibiotics. However, research revealed that compared to reduced stock out rate or reduced lead time approaches, the combined methods used to assess stock performance may provide very minor or no benefits (2).

The common problem for the underperformed data on stock records and reports were revealed that were related to few training, insufficient staff, oversight, and personnel turnover. A study conducted in the United States discovered that inaccuracy of data at one level of the supply chain has negatively impacted inventory performance at other levels (31).

The predominant methods used in averting stock outs were regularly updating stock-keeping records and using consumption data to forecast demand. A Tanzania and Kenya study recommended reliable forecasting and appropriate supply chain performance to prevent antibiotic stock-outs and changes in treatment regimens, based on findings from a study on antibiotic stock-outs (32,33).

The main challenges affecting inventory management of antibiotics medicines were mainly due to inadequate training, poor record keeping, poor reporting, lack of commitment by the top management. Thus, these challenges were similar to those found in other studies (33,34). To deal with these challenges, there is a need to facilitating more training, maintaining continuous mentorship and supervision as suggested by other studies.

The results given over last six months of 2022 showed that the antibiotics under consideration were available at a rate of over 70%. This availability was associated with the effective use of inventory management practices that contributed to reduced stock out rates and order lead time which were mainly based on the successful use of the register for stock-keeping and formula in

determining order quantities at a percentage of 94% and 92% respectively. In addition, the projective method with a score of 90% and the standard system which scored 81% were also identified as being associated with a high level availability of antibiotics. This is consistent with the study conducted in India, according to which availability of antibiotics is relatively related to high performance of inventory management practices in healthcare facilities (27).

A study on conducted antibiotic resistance in Uganda has also shown that the only way to fight antibiotic resistance is to carefully perform inventory management practices to ensure the availability of antibiotics to rationally use among patients in need (29).

According to respondents' responses regarding the effect of inventory management practices on the performance of the supply chain for antibiotics, stock out rates and order lead times were successfully reduced at 94% and 92% by using stock-keeping records and a formula respectively to determine quantities to order. Inventory control systems (81%) and stock-keeping records and reporting (72%) both performed better in terms of reducing stock waste.

The effect of inventory management practices on the performance of supply chain for antibiotics as answered by respondents has revealed that the effective inventory management practices in stock out rates and order lead time reductions were successful on the application of “stock-keeping records and use of formula in determination of order quantities at 94% and 92% respectively”. Stock wastages decrease was better attained by inventory control systems (81%) followed by stock-keeping records and reporting with (72%).

5.3 Conclusion

This research investigated the contribution of inventory management practices to supply chain performance of antibiotics in Rwanda. The findings showed that inventory management practices were in line with proposed best approaches notwithstanding various challenges and have positively contributed to supply chain performance of antibiotics, although further actions are needed to maximize availability of antibiotics in Rwanda. The most studied supply chain performance metrics including “stock-out rates, order lead time, stock wastage and stock reporting rates” were found to be satisfactory and were closely correlated with high availability antibiotics throughout the period considered. Some actions points like use of technology, increase of staff and training have been suggested to overcome encountered challenges during inventory management practices.

However, efforts are needed to reduce stock outs observed in different health facilities as unavailability of antibiotic medicines can be source of irrational use of antibiotics resulting in antimicrobial resistance.

5.4 Recommendations

This study shed more light on used inventory management approaches for supply chain performance of antibiotics in Rwanda. Based on findings uncovered from the study, the researcher gives the following recommendations:

Firstly, an electronic logistics management information system and inventory tracking tool should be adopted, strengthened and regularly used in all hospitals and RMS branches to promote data visibility and having accurate data for decision-making.

Secondly, the capacity building of staff through regular training on inventory management should be encouraged to improve skills and continuously maintain experienced staff.

Thirdly, conduct supportive supervision or audits for quality improvement by regular monitoring and evaluation on the best use of available inventory management tools for improving supply chain performance of medicines including antibiotics is a must.

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Appendix 1: INFORMED CONSENT

Participation information and consent form for Key Informants

Title of study: "EVALUATION OF INVENTORY MANAGEMENT PRACTICES FOR SUPPLY CHAIN PERFORMANCE OF ANTIBIOTICS IN RWANDA".

Name and contact information of principal investigator

Isaie Nsabimana
University of Rwanda
EAC Regional Centre of Excellence for Vaccines, Immunization and Health Supply Chain Management

Introduction

I am conducting a study to evaluate the contribution of Inventory Management Practices to Supply Chain Performance of antibiotics in Rwanda; particularly in Public & faith-based Hospitals and Rwanda Medical Supply Ltd branches. I would like to tell you about this study being conducted. The purpose of this consent form is to give you the information that you will need to help you decide whether or not to participate in the study. Please feel free to ask any questions about the purpose of the research, what happens if you participate in the study, the possible risks and benefits, your rights as a volunteer, and anything else you would like to know about the research. When we have answered all your questions to your satisfaction, you may decide to be in the study or not. This process is called **'informed consent'.**

Once you understand and agree to be in the study, I will request you to write your name and sign on this form. Your decision to participate is entirely voluntary and you may withdraw from the study at any time without necessarily giving a reason for your withdrawal. Refusal to participate in the study will not affect the services you are entitled to in your institution.

Purpose

The study will evaluate the contribution of Inventory Management Practices to Supply Chain Performance of antibiotics in Public Hospitals and Rwanda Medical Supply Ltd branches for coming up with the findings and recommendations that will help the decision makers and

stakeholders to ensure that the Rwandan population has access to high-quality healthcare through improved antibiotics availability on timely basis, their proper use will contribute to the improvement of healthcare delivery as they significantly contribute in infectious diseases control.

Procedure

This study will require the completion of the data collection tool and review of documentary files. An interview with the key informant to validate the information obtained from the documented evidence if necessary can be conducted. I am inviting you to take part in this activity, because I feel that your experience can contribute much to my understanding about Inventory Management Practices and Supply Chain Performance of antibiotics in Public Hospitals and RMS Ltd branches in Rwanda. If you agree, you will be asked a series of questions on the research topic. You will not be asked any personal or sensitive questions, nor will you be asked to provide any information with which you are uncomfortable. I estimate that this session will last no more than thirty minutes.

Benefits

There will be no direct benefit to you from participating in this activity.

Risks

Your participation in this study is completely voluntary. It is entirely up to you whether or not to engage. There will be no negative consequences if you choose not to participate. If you decide to participate, you can change your mind and withdraw at any moment with no repercussions. As a result, the risks of participating in this activity are considered minor.

Privacy and confidentiality

We will not share information about you and your institution/company to anyone outside of the team undertaking this activity. The information that we collect will be kept private. All collected data will be stored in a database accessible only by the principal investigator. Any information about you and your institution will be identified by a number on it instead of your name/your institution. You do not have to take part in this activity if you do not wish to do so, and choosing to participate will not affect your job.

Study approval

The Institutional Review Board (IRB) of the College of Medicine and Health Sciences (CMHS) has reviewed and approved this proposal. The IRB's task is to ensure that research participants are protected from any harm. If you wish to know more about the ethics committee, please contact the Chairperson of the CMHS IRB (0788 490 522) and Deputy Chairperson (0783 340 040).

For any questions about any part of the study, you may contact Isaie Nsabimana, the Principal investigator. Tel: 0788883011 email: nsabisa@gmail.com

CONSENT FORM (STATEMENT OF CONSENT)

Participant's statement

I have read this consent form. I have had the chance to discuss this research study with a study researcher. I have had my questions answered to my satisfaction in a language that I understand. The risks and benefits have been explained to me. I understand that my participation in this study is voluntary and that I may choose to withdraw at any time. I freely agree to participate in this research study. I understand that all efforts will be made to keep information regarding my personal identity confidential

Print name of participant

_____

Signature of participant

_____

Date

_____

Day/month/year

Researcher's statement

I, the undersigned, have fully explained the relevant details of this research study to the participant named above and believe that the participant has been given an opportunity to ask questions about the activity, and all the questions asked by the participant have been answered correctly and to the

best of my ability. I confirm that the individual has not been coerced into giving consent, and the consent has been given freely and voluntarily.

Researcher's Name: **_____**

Signature: _____

Date: **_____**

Appendix 2: DATA COLLECTION TOOL FOR THE STUDY

"EVALUATION OF INVENTORY MANAGEMENT PRACTICES FOR SUPPLY CHAIN PERFORMANCE OF ANTIBIOTICS IN RWANDA"

Name and contact information of principal investigator

Isaie Nsabimana
Student completing Masters in Health Supply Chain Management,
University of Rwanda, College of Medicine and Health Sciences
EAC Regional Centre of Excellence for Vaccines, Immunization and Health Supply Chain Management,
Tel: +250788883011
E-mail: nsabisa@gmail.com

INSTRUCTIONS

1. This is questionnaire to collect data on Inventory Management Practices and Supply Chain Performance of antibiotics in Public Hospitals and Rwanda Medical Supply Ltd branches. it is composed by two parts: Part I and Part II
2. Participant is requested to answer all questions
3. Answers have to be provided in appropriate, mentioned space
4. You are not allowed to mention your name on this questionnaire

Part I. Demographic data profile

Please answer the following questions and mark with a TICK (√) in the applicable box**.**

1. Gender

	Male	Female
Gender of respondents		

2. Please indicate the age bracket you belong to

	Below 25 years	Between 25-35 years	Between 36-45 years	Above 45 years
Age of Respondents				

3. For how long have you been working in your organization?

	Below 1 year	Between 1-5 years	Between 5-10 years	Above 10 years
Working Experience				

4. What is your level of education

	Secondary	Diploma	Bachelor	Masters	PhD
Education level					

Part II: Questions related to the research objectives

A. Questions about objective one: Inventory management practices used for managing antibiotics

Below are statements about inventory management practices. State whether they are in use in your facility by marking with a tick (√) in the applicable box.

Statements on inventory management practices	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
	1	**2**	**3**	**4**	**5**
Inventory control models					
Trigger for ordering medicines is the end of review period ***Forced order system***					
Trigger for ordering medicines is when minimum stock level for each item is reached ***Continuous review system***					
Trigger for ordering is the end of review period for medicines that hit minimum stock quantity ⇨ ***Standard system***					
Determination of order quantities					
Previous consumption data are used to forecast demand of antibiotics ⇨ ***Projective method***					

Forecasts are based on external factors like epidemics, change in health system structure and size ⇨ ***Causal method***					
Forecasts are based on individual judgment of experienced staff ⇨ ***Judgment method***					
Forecasts are based on disease prevalence, incidences and expected number of attendances ⇨***Morbidity method***					
Stock-keeping records and reporting					
All antibiotics have stock records					
Stock records for antibiotics are accurate and up to date					
Regular stock counts are done minimum once every reporting period for antibiotics					
Reports for antibiotics are compiled at the end of each reporting period					
Data on consumption is included in every report					
Data on stock on hand is included in every report					
Data on losses and adjustments is included in every report					
Data on commodities near to expire is included in every report					

B. Questions to the objective Two: Evaluation of the performance of inventory management practices to supply chain of antibiotics;

Below are statements about Supply Chain Performance. State whether they are in use in your facility by marking with a tick (√) in the applicable box.

Statements on Supply Chain Performance	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
	1	**2**	**3**	**4**	**5**
Use of an inventory control system has: Reduced stock out rates					
Reduced order lead time					
Reduced unusable to usable stock ratio					
Increased reporting rates					
Use of a formula in determining reorder quantities has: Reduced stock out rates					
Reduced order lead time					
Reduced unusable to usable stock ratio					
Increased reporting rates					
Use of stock-keeping records has: Reduced stock out rates					
Reduced order lead time					
Reduced unusable to usable stock ratio					
Increased reporting rates					
Use of reports has: Reduced stock out rates					
Reduced order lead time					
Reduced unusable to usable stock ratio					
Increased reporting rates					

C. Question about objective Three: inventory management practices related challenges affecting Supply Performance of antibiotics

Below are statements about inventory management challenges affecting Supply Performance of antibiotics. State whether they are in use in your facility by marking with a tick (√) in the applicable box.

inventory management challenges affecting Supply Performance of antibiotics.	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
	1	**2**	**3**	**4**	**5**
Inadequate staff					
Incompetent staff					
Poor record keeping					
Poor reporting					
Inadequate training on inventory management					
Unreliable supply of medicines					
Lack of commitment by top management					
Lack of a good inventory control system					
Lack of proper storage					
Poor inventory infrastructure					

D. Question about objective Four: Action points to overcome challenges related inventory management practices for antibiotics supply.

Below are statements about Action points to overcome challenges related inventory management practices for antibiotics supply. State whether they are in use in your facility by marking with a tick (√) in the applicable box.

Action points to overcome challenges related inventory management practices for antibiotics supply	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
	1	**2**	**3**	**4**	**5**
Raising awareness of top management					

Increase of staff and training personnel involved in inventory management					
Use of technology or system in inventory management					
Availing materials and equipment for inventory management activities					
Conduct supportive supervision or audits for quality improvement					
Conduct monitoring and evaluation of inventory management practices					

Stock-out rates of tracer antibiotics in six last months of 2022

N°	Product Description	Jul	Aug	Sep	Oct	Nov	Dec
		SoH	SoH	SoH	SoH	SoH	SoH
1	Amoxicillin capsule 250 mg						
2	Ampicillin 500mg powder for injection						
3	Ceftriaxone 1g powder for injection						
4	Clarythromycin tablet 250mg						
5	Cloxacillin 250 mg capsule B/1000						
6	Erythromycin tablet 250 mg						
7	Doxycycline tablet 100 mg						
8	Gentamycin injection 40 mg /ml 2ml						
9	Metronidazole injection 500 mg/100ml						
10	Metronidazole tablet 250mg						
11	Phenoxymethylpenicillin tablet 250 mg						

Appendix 3: RESEARCH PLAN

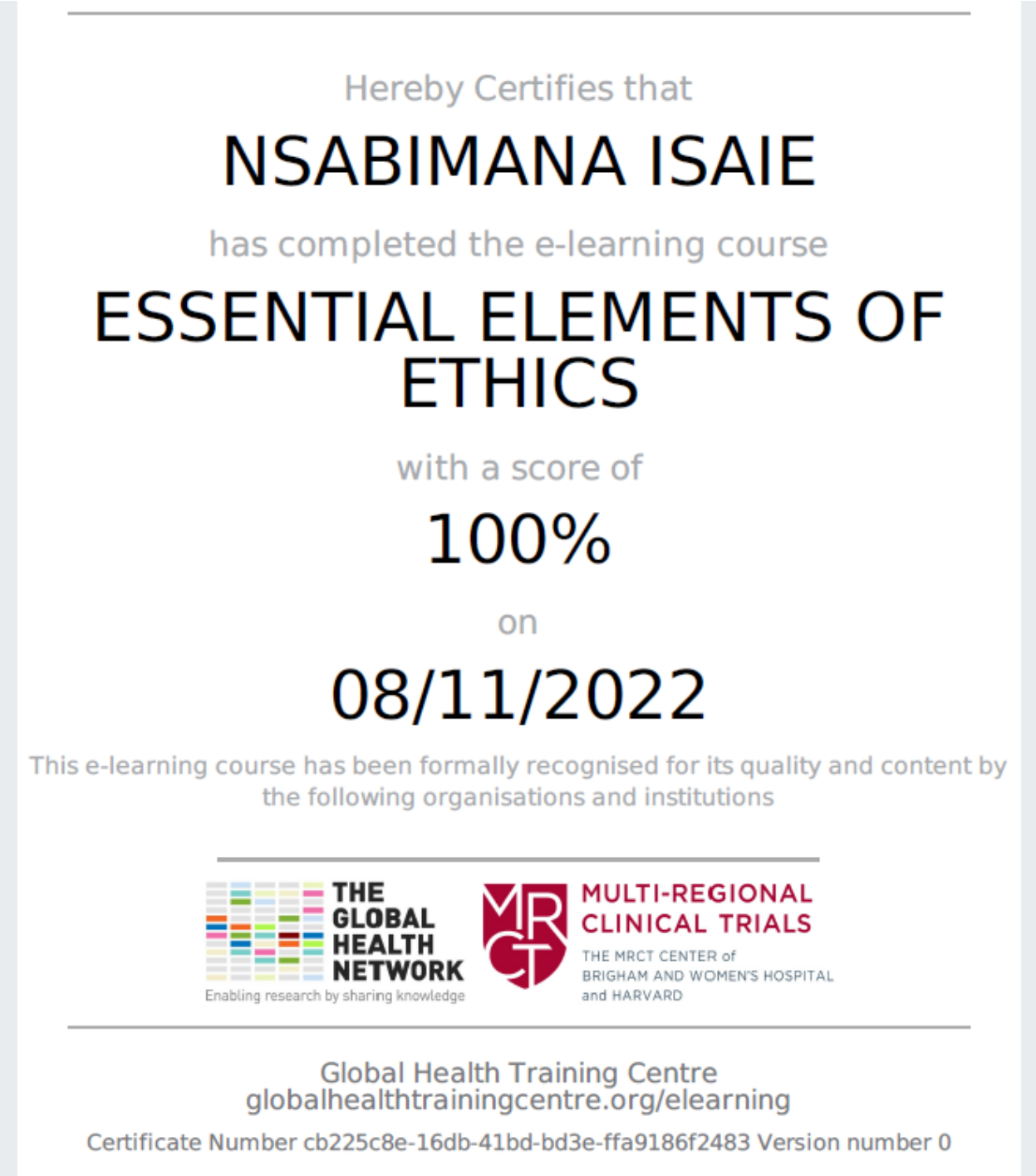
PERIOD	ACTIVITIES PLANNED FOR THIS PERIOD
May-June 2022	o Research proposal writing o Refining the data collection tool o Presentation of research proposal to the panelists
July 2022	o Addressing comments received from panelists o Fine-tuning the data collection tool
August- October 2022	o Submission of the proposal to research committee o Review of the proposal by the research committee
November 2022	o Addressing comments received from research committee o Ethical clearance application to Ethical committee
December 2022	o Finetuning the data collection tool
January- February 2023	o Reception of Ethical clearance o Request the permission of data collection in health facilities
March 2023	o Data collection o Data entry, processing and coding
April 2023 Week 1 & 2	o Data analysis o First draft dissertation writing o First draft dissertation submission
April 2023 Week 3 &4	o Addressing manuscript reviewer comments o Second draft dissertation writing and submission o Submission of the dissertation to research committee
May 2023	o Defense of dissertation o Final submission

Appendix 4: BUDGET IN RWANDAN FRANCS (FRW)

(Source of fund: Self-funding)

Particulars	**Units**	**Cost per item (Frw)**	**Total amount (Frw)**
Pilot study	4	150,000	600,000
Transport	20	32,000	640,000
Data Analysis	2	100,000	200,000
Printing	8	40,000	320,000
Ream of papers	4	10,000	40,000
Internet facilities	8	10,000	80,000
Communication fees	1	20,000	20,000
Photocopying	168	100	16,800
Binding/ Lamination	4	10,000	40,000
Total amount in Frw			**1,956,800**

Appendix 5: A CERTIFICATE OF ATTENDANCE OF RESEARCH ETHICS TRAINING



Hereby Certifies that

NSABIMANA ISAIE

has completed the e-learning course

ESSENTIAL ELEMENTS OF ETHICS

with a score of

100%

on

08/11/2022

This e-learning course has been formally recognised for its quality and content by the following organisations and institutions

THE GLOBAL HEALTH NETWORK
Enabling research by sharing knowledge

MULTI-REGIONAL CLINICAL TRIALS
THE MRCT CENTER of BRIGHAM AND WOMEN'S HOSPITAL and HARVARD

Global Health Training Centre
globalhealthtrainingcentre.org/elearning

Certificate Number cb225c8e-16db-41bd-bd3e-ffa9186f2483 Version number 0

Appendix 6: APPROVAL FROM CMHS INSTITUTIONAL REVIEW BOARD (IRB)

UNIVERSITY of RWANDA

COLLEGE OF MEDICINE AND HEALTH SCIENCES

DIRECTORATE OF RESEARCH & INNOVATION

CMHS INSTITUTIONAL REVIEW BOARD (IRB)

Kigali,9th/01/2023
Ref: CMHS/IRB/**026**/2023

Isaie NSABIMANA
EAC Regional Centre Of Excellence For Vaccines, Immunization & Health Supply Chain Management
College of Medicine and Health Sciences, UR

Dear Isaie Nsabimana

RE: ETHICAL CLEARANCE

Reference is made to your application for ethical clearance for the study entitled ***"Evaluation of Inventory Management Practices for Supply Chain Performance of Antibiotics in Rwanda".***

Having reviewed your application and been satisfied with your protocol, your study is hereby granted ethical clearance. The ethical clearance is valid for one year starting from the date it is issued and shall be renewed on request. You will be required to submit the progress report and any major changes made in the proposal during the implementation stage. In addition, at the end, the IRB shall need to be given the final report of your study.

We wish you success in this important study.

Prof Stefan JANSEN
Ag Chairperson Institutional Review Board,
College of Medicine and Health Sciences, UR

Cc:

- Principal, College of Medicine and Health Sciences, UR
- University Director of Research and Postgraduate studies, UR

Appendix 7: A LETTER AUTHORIZING DATA COLLECTION IN RMS BRANCHES

RWANDA MEDICAL SUPPLY
Faster | Reliable | Affordable

Kigali, on.....9/2/2023

Ref: No 381../RMS/CEO /2023

Chief Executive's Office

Mr. Isaie NSABIMANA
nsabisa@gmail.com

Dear Williams,

Subject: Response to your Request for data collection.

Reference is made to your letter received on 7th February 2023 applying for authorization to conduct research in Rwanda Medical Supply Ltd.

After carefully analyzing your study focus and the methodology intended to be used. Also looking at the intent of the study.

I am pleased to inform you that your request has been granted.

At the beginning of your study, you will be required to present this letter to the legal office to sign a Non-Disclosure Agreement (NDA) as per the company policy.

Sincerely,

Pie HARERIMANA
Chief Executive Officer

RWANDA MEDICAL SUPPLY
Faster | Reliable | Affo...dable

cc.
- **Company Secretary**

Email: info@rmsltd.rw

Website: www.rmstld.rw

Appendix 8: NON-DISCLOSSURE/ CONFIDENTIALITY AGREEMENT

Acrobat Document

Appendix 9: CLEARANCE LETTER FROM KIBUNGO REFERRAL HOSPITAL

Acrobat Document