THE EFFECT OF USE OF INVENTORY MANAGEMENT SYSTEMS ON AVAILABILITY OF ESSENTIAL MEDICINES AND SERVICE DELIVERY- A CASE STUDY OF ISHIARA LEVEL 4 HOSPITAL

NICOLE SHARON WANENO
MBA HCM
ADMISSION NUMBER 138552

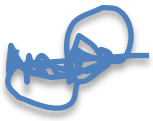
DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE AWARD OF THE MASTERS DEGREE IN BUSINESS ADMINISTRATION IN HEALTHCARE MANAGEMENT, STRATHMORE BUSINESS SCHOOL, NAIROBI, KENYA.

APRIL 2024

DECLARATION

I declare that this work has not been previously submitted for the award of the degree from this or any other university. The thesis contains no material previously published or written by any other person except where reference is made.

Name of Candidate: Nicole Waneno

Signature: 

Date: 20/04/2024

Approval

This thesis was reviewed and approved for examination by

Name: Dr John Olukuru

Signature: 

Date:20/04/2024

ABSTRACT

The study examined the effect of use of a digitized inventory management on availability of essential medicines and hence service delivery in a public hospital, Ishiara Level 4 Hospital in Embu County. The objectives of the study were to assess the current inventory management system, to evaluate the effect of staff skills and competence on inventory management and to forecast inventory management to aid in service delivery. This was done by use of primary data from questionnaires distributed to a sample size of 79 out of the 130 health workers directly involved in service provision at the facility. Secondary data was derived from the DHIS tool on trends of patient visits over a period of ten years to the dental clinic in the facility. The variables in the secondary data were the number of patients attended to and the number of procedures done. Analysis of the primary data was done using descriptive analysis and regression equation and analysis. Secondary data was analyzed using descriptive analysis using the excel tool, trend analysis, correlational analysis and predictive analysis by use of the ARIMAX and SARIMAX models. The main findings of the study were that inventory management system in the facility has not been able to ensure availability of essential medicines. Staff competence and skill affect inventory management use and hence service delivery. Therefore, there needs to be more facilitation of staff in terms of training and more emphasis needs to be put on training and facilitation of staff. From the secondary data, it was determined that predictive analysis can be useful in ensuring availability of essential medicines through improvement of inventory management. This would reduce cases of stock outs and patient referrals from the facility with an improvement in service delivery.

Key terms; Inventory Management, Service delivery, Demand forecasting.

List of Acronyms

EOQ - Economic Order Quantity

IMS - Inventory Management Systems

LMIS- logistics Management Inventory System

LMICs - Low- and Middle-Income Countries

SOPs - Standard Operating Procedures

ARIMAX -Autoregressive integrated moving average

SARIMA- Seasonal Autoregressive Integrated Moving Average

Definition of terms

Essential medicines-Medicines that need to be available in any health care facility to ensure that the demands of a given population are met without fail

Stock out – Stockouts are generally defined as a medical commodity that is purposed to be availed at a health facility but is unavailable totally at a given period of time.

Supply Chain- network of all individuals, organizations, resources, activities involved in the production and sale of an item.

Inventory Management System- A system that combines technology, flow of processes and human interface to track health commodities

Contents

LIST OF FIGURES

LIST OF TABLES

Chapter 1: INTRODUCTION

1.1 Background

The health system framework is composed of six core components namely; access to essential medicines, health workforce, reliable information system, suitable health financing, good leadership and governance, and quality service delivery (World Health Organisation,2010). It further describes a functioning health system as one in which the six building blocks interact in a manner to meet the requirements of a given population. This is achieved by promoting the health status of the population while shielding them from catastrophic health expenditure and enabling access to healthcare. Access to essential medicines defines healthcare as a right of every citizen. (Constitution of Kenya,2010)

Access to essential medicines can preserve lives, reduce mortality and improve health outcomes. (Writz VJ, et al,2017). These medicines should be readily available and accessible by all. The WHO reported that about 30% of the populace lack the required access to essential medicines and in Africa and Asia it goes to an unacceptable margin of 50%.Lapses in inventory management especially in public health facilities has led to wasted financial resources and unavailable essential medicines, expiration of medicines and decline in quality health care (USAID, 2012) Poor inventory management can be detected through erroneous stock record and uncoordinated tracking of medical inventory. Inventory management can result in insignificant improvements in service delivery while also ensuring optimal use of resources (Kadasha and Massawe, 2012). To improve efficiency of the medical supply system several guidelines have proven to be useful. Selection of products/medicines should be linked to demand. Secondly, inventory and procurement decisions should be based on established quantification methodology. Lastly, the use of ICT to aid in tracking of stock movements through feedback mechanisms. (Chandani et al., 2009)

1.1.1 Inventory Management.

Inventory management in healthcare can be defined as the process of preparing, purchasing and tracking medical commodities with the aim of having them when required. The aim of inventory management is to minimize costs while maintaining a continuous supply of inventory that meets the service level requirements of the consumer (Sandeep, K. 2007). Inventory management is important to ensure stock levels are controlled. Proper systems of demand forecasting help to avoid

stock outs and also ensures supply meets demand. The end result is minimized operational costs, increased efficiency and improved customer satisfaction. (Agus. A & Noor, Z. 2010) The Health Policy provides for health commodity tracking based on the Public Procurement and Disposal Act 2005 with an aim to provide quality, accessible, affordable health care. As depicted in figure 1 below, hospital inventory management when integrated with the appropriate technology can aid in access to essential medicines by automated ordering of stock, efficient management of stock through location tracking, prediction of future demand and minimization of expiry of existing inventory.

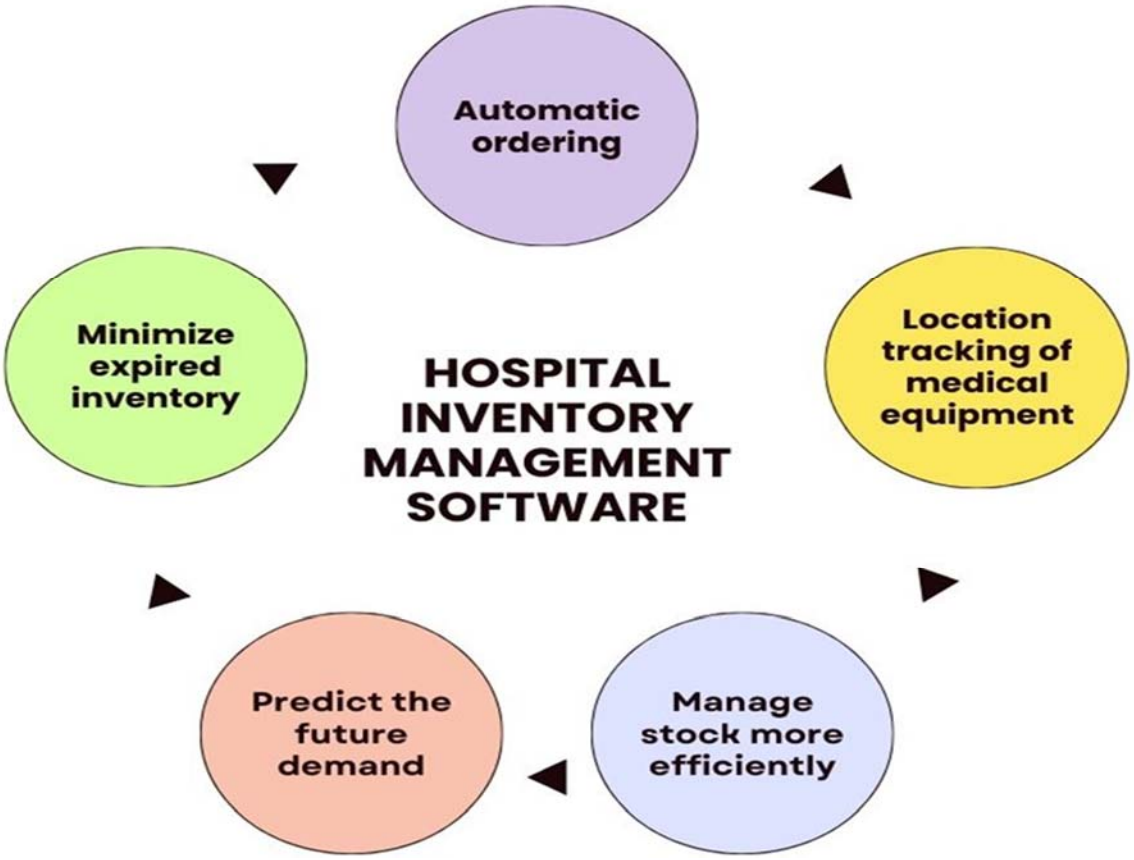


Figure 1.1: Importance of inventory management in healthcare.

Source IDENTI Medical

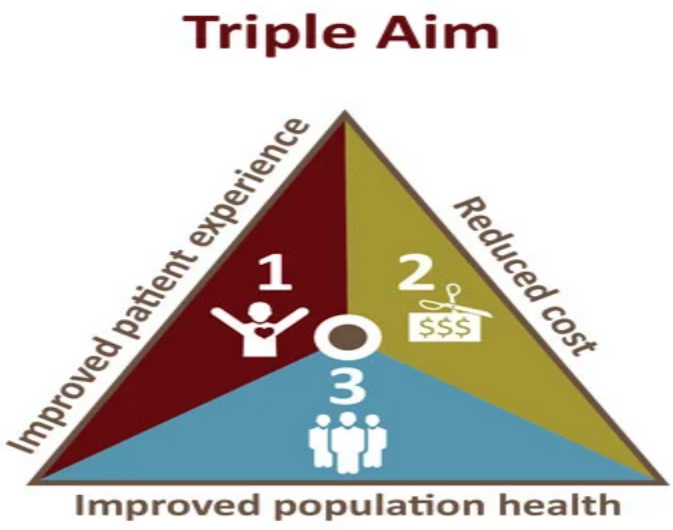
Introducing new technology means the organizational culture must be ready to absorb the technology. Kodama (2013) posits that technological change includes any incorporation of new ways to bring about change in resources into the product or service. In a study done in Uganda,

(Namagembe,2010) it was demonstrated that there is a cause-and-effect relationship between the sharing of information and the supply chain. This means that if shareholders can work together then transformation in the supply chain will be seen. In addition, user satisfaction should be factored in decisions around commodity procurement.

1.1.2 Service delivery in healthcare

A core function of the healthcare system is service delivery. The major concern of service delivery is the selection of which services to provide, how to organize their provision, to ensure continuous improvement of this process as well as the task of managerial oversight in the entire process (Tam,2005) Therefore, the success of service delivery in healthcare is pegged on the understanding of the root causes of poor performance in service delivery and more importantly, how to mitigate them.

Health service delivery can be defined as people centered where resourcing, financing and management of the service is centered on meeting health needs and demands of a given population (Dean and Lang,2008). The focus being on competencies of the health workforce, the use of the resources and responsiveness to the needs of the population with the assurance of continuity and acceptability of the service by the end user, being the patients. The overall goal is to improve health outcomes of the population while providing improved patient experience with minimal wastage of resources. This is represented in figure 1.2 below



Source: Institute for Healthcare Improvement

Figure 1.2 Triple Aim of Healthcare service delivery.

Source: Institute for Healthcare Improvement

It is also noted that the health system dictates how the service delivery will be achieved. Health service delivery and its responsiveness to a population need will be influenced by the interaction between the social determinants of the health system such as economic status, social needs, housing, education levels and quality as detailed in figure 1.3 below

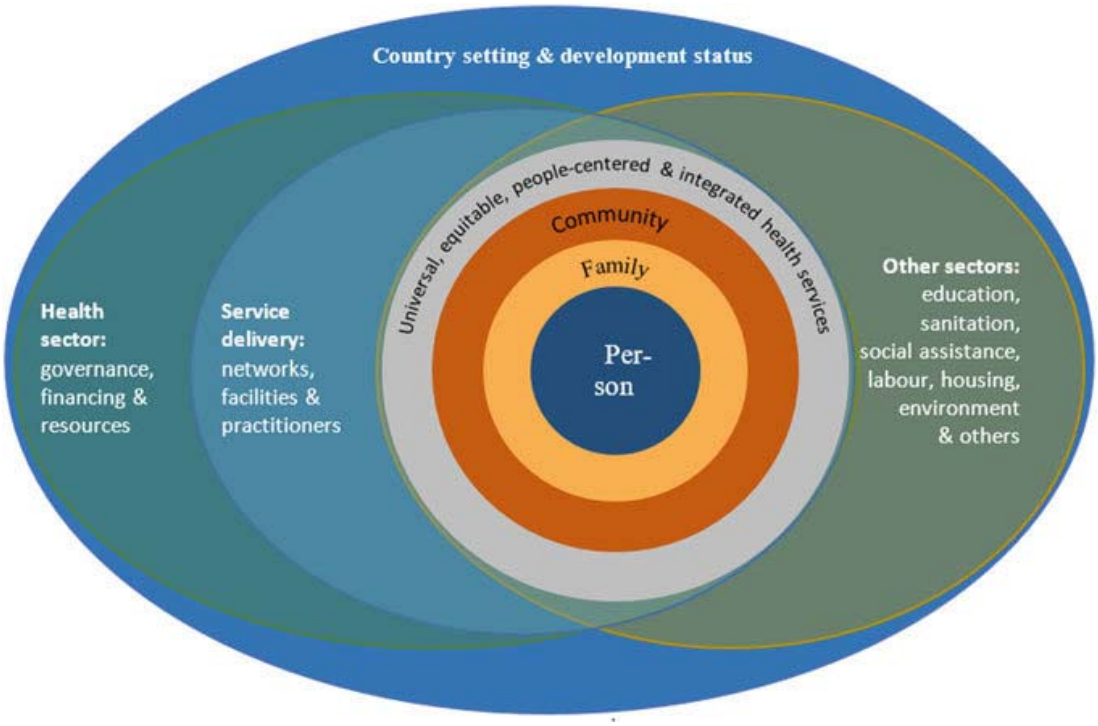


Figure 1.3 Interacting determinants of the health system

Source WHO Conceptual framework for people centered health systems

1.1.3 Strengthening health system delivery

To enable transformation on service delivery there has to be a root cause analysis of the factors that affect service delivery (Health service delivery programme, WHO 2014) These are the factors that promote or support the provision of optimal service delivery that is responsive to patient's needs, efficient and reliable. This then allows for a review of possible interventions that will both catalyze and sustain the necessary change. The factors of importance in this case are people, culture and leadership.

In order to bring transformational change in service delivery, healthcare workers who are also known as service providers are very instrumental. They need to be engaged in the design and organization of the health system and equally motivated to lead change. This is achieved by empowering them in terms of continuous improvement opportunities, training facilities and creation of a feedback loop to gather information needed for improvement. Studies have shown that there is a positive relationship between highly skilled personnel and improved service delivery outcomes (Argote and Ingram,2010)

Organizational culture aids in transformation and fostering of attitudes among staff that will bring about desired improvements in service delivery. This is noted in organizations where the professional culture is conducive to integrated service delivery and thereby allows for sustainable change. In addition, such a work culture can lead to inspire healthcare workers to work in unison towards a common goal and sense of purpose aimed at improved service delivery. The organizational culture is determined by the management and unfortunately most public health care facilities are not led by professional managers as determined in a study by Mosadeghrad (2014).

Impactful leadership for change requires that which will have a detailed and well-planned strategy for change that is communicated to all healthcare workers. Sagaren Govender et al (2023) in their study on the role of leadership in facilitating healthcare service delivery determined that there needs to be empowerment, indulgence and motivation of staff from leaders by providing the necessary training opportunities, the required optimal resources such as ICT and medical technology.

.

1.2 Problem statement.

Despite reforms within the law, in policy and within healthcare institutions around the public health inventory management sphere in Kenya, county governments are still facing many challenges in effective management of inventory (Koross et al., 2016) Based on findings in a report by United Nations (UN 2013) more than 65% of major health projects funded by the government of Kenya are negatively affected by failures in inventory management practices leading to ineffective service delivery. Decline in health service outputs in public hospitals is as a result of poor inventory control and reduction in customer demand (RoK, 2015). Public hospitals in Kenya face problems of poor inventory, inaccurate forecasting, poor responsiveness to customers needs and lack of proper ICT application resulting in poor service delivery (Mathura, 2013).

Lack of essential medicines has led to patients' inability to access health services. This has led to patient referrals to other facilities, and in some cases, patients seeking alternative remedies, with poor health outcomes. Coupled with the demoralized healthcare workers, this has led to a lack of faith in public service delivery systems. This concurs with results of a study by Mutale et al.,2013 which highlights barriers to meeting the threshold of good health outcomes in LMICs is nonfunctional health systems.

Public service delivery has experienced challenges that have led to discontent among patients, high staff turnover and low staff morale (Owino and Korir, 2020). According to a study done by Wanjau, Muiruri and Ayodo,2012 identified low employee capacitation, poor uptake of technology and poor communication as factors that affect the quality-of-service delivery in public health care facilities.

The ideal health system should provide the appropriate health commodities where and when they are needed. This demands that health commodities should be available where and when they are needed with emphasis on quality and quantity (Peters et al. 2008). This study will demonstrate how digitization of the inventory management system through methods such as demand forecasting can be invaluable in ensuring adequate supplies of medical supplies and hence improve service delivery and overall health outcomes in the population seeking health care at a given facility. It will also highlight the need for facilitation of training of staff in inventory management to improve the effectiveness of the system used to manage inventory to ensure availability of essential medicines.

1.3 General Objective

The general objective of this study is to establish the relationship between inventory management and service delivery and determine the factors affecting inventory management with regard to service delivery.

1.4 Specific Objectives.

1. To assess the efficiency of inventory management systems in service delivery
2. To evaluate staff skill and competency in use of IMS in relation to stockouts.
3. To forecast prediction of patient visits to ensure availability of essential medicines.

1.5 Research Questions.

- Can the inventory management system ensure efficient service delivery
- Can staff skills and competency affect inventory management?
- Can a data prediction model be used to prevent stock outs of medical supplies?

1.6 Scope of Study

The study will take place at Ishiara Level 4 Hospital, Embu County, with primary data collection from questionnaires distributed among a sample of the population of healthcare workers in the facility. Secondary data will be derived from the DHIS2 tool for patient data trends from the dental clinic which requires the essential drug, lignocaine for all operations. The dental clinic has thus experienced a steady decline in service delivery. This informed the choice of the dental clinic as a representative functional unit of the facility for implementation of digitization of the inventory management system.

1.7 Justification for the Study.

This research aims to improve gaps in health commodities inventory management to promote a constant supply of health commodities. Stock outs of essential medicines leads patients to seek services in other facilities. For some, this may not be possible due to financial barriers that may lead to alternative remedies that may affect health outcomes. Furthermore, there is a loss in confidence in the public health system that negatively affects health seeking behavior and access to health care on the whole.

Ideally the findings of this study can aid in improvement in procurement, supply and tracking of essential health commodities used at the facility to reduce the cases of stock outs that negatively impact service delivery and health outcomes.

Chapter 2. Literature Review

Introduction

This chapter presents documented literature on factors affecting procurement protocol and management of essential medicines and other health commodities and the corresponding impact on service delivery. It also presents a theoretical and conceptual framework that is the basis of this research. There is extensive research on supply chain and inventory management in healthcare. The aim of this research is to contribute to evidence-based impact of factors that affect service delivery in public healthcare institutions with emphasis on technology in inventory management and the human resource factors that also play a critical role.

2.1 Theoretical Review

2.1.1 Technology Acceptance Model

The technology acceptance model as theorized by Davis (1989) is useful in this study as it helps to highlight the effect of information and communication technology on service delivery at the health facility. This model lays emphasis on the perceptions of the potential user on the benefits of using technology and the practicality of the particular technology. In this case the technology in question is the LMIS. The perceived usefulness of the system refers to the level to which an individual views that the system would improve their job performance and thus service delivery at the facility while the perceived ease of use of the system refers to the level to which a person believes that using a particular type of technology would be effortless.

The Refined Technology Acceptance Model as described by Bjerge et al, 2016 and detailed in the figure 2.3 below, defined the main factors that determine system usage to be perception of usefulness, perception of ease of use and external factors and intent of use.

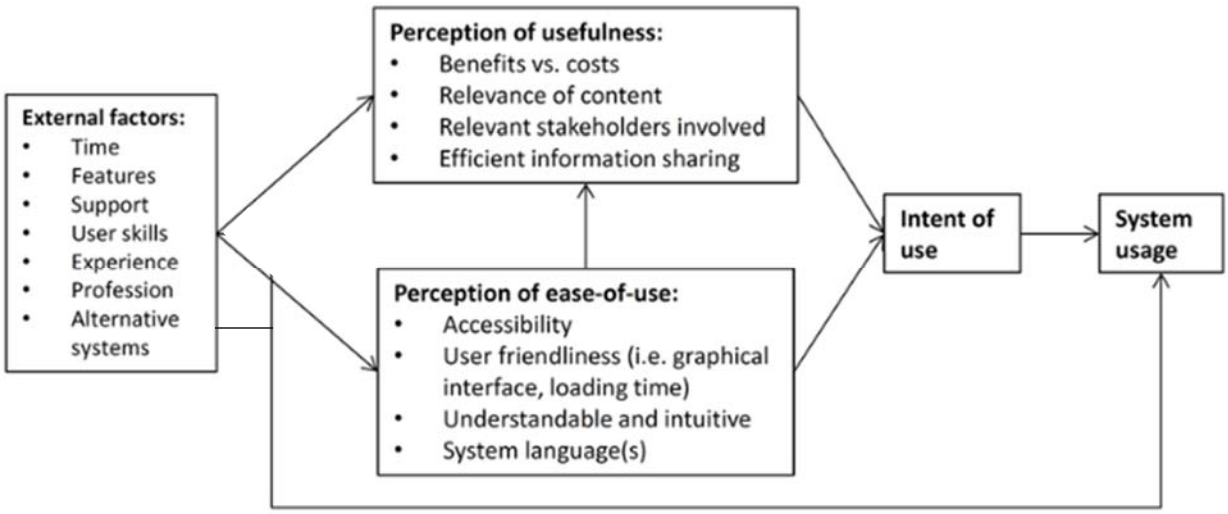


Figure 2.1 Refined Technology Acceptance Model. Bjerge et al (2016). Technology and Information Sharing in Disaster Relief.

2.1.2 Change Theory

The change theory as spelt out by Kurt Lewin introduced the three steps of change which inform this study. It requires prior learning to be rejected and reworked for replacement in order to bring success. With the concepts of unfreeze, change and refreeze, stakeholders are given room to implement change as seamlessly as possible.

The changes are likely to face resistance but with understanding of the need for change, healthcare managers will be able to communicate this to their team members in terms of implementation of ICT, regular training and thus streamlining the inventory management system to ensure uninterrupted supply of essential medicines and hence service delivery to the population.

2.1.2.1 Unfreeze

When structures have been in place for a while, habits and routines naturally have set in among the staff. unfreezing implies communicating to the healthcare workers why the change in their daily activities in service delivery is necessary, to reject the undesirable habits and hopefully be open minded to new ways of achieving set objectives

2.1.2.2 Change

Once the healthcare workers are receptive to accomplishing the set objectives, then change can begin. This is a dynamic shift which requires a defined transition period. The new tasks and

responsibilities given to healthcare workers will help to gain efficiency in inventory management. However, this has to be gradual and may initially bring a slowdown in inventory management procedures but will become steady with time

2.1.2.3 Refreeze

Change needs to be made permanent for it to be effective. All efforts must then be made from management to healthcare workers to ensure its success

2.1.2.4 Force field analysis

Lewin further described the force field analysis model which detailed restructuring and decision making between driving and restraining forces and eventually an equilibrium where these forces match. An investigation on where power concentrates, decision makers, those pro and against change and then ways to positively influence dissenting voices.

Driving forces identify opportunities to improve while restraining forces as the name suggests are those that promote the status quo. The end goal is to achieve equilibrium. This theory is relevant to the study as it will determine any potential conflict areas between management and healthcare workers in digitization of the inventory management system and how to go about conflict resolution where needed. It will also assist the researcher to best comprehend how implementation of the digitization of the inventory management system will bring about change and consider challenges that may be faced afterwards.

2.1.3 Demand forecasting in healthcare

Forecasting demand for health services can be utilized in decision making for supply chain management for health care institutions. It has been demonstrated that implementing forecasting methods in a healthcare setting can improve management of finances and resources with improved the effectiveness of the system (Lapierre et al., 1999; Cote and Tucker, 2001; O'Brien-Pallas et al., 2008). This has led to focus on demand forecasting in healthcare on issues such as predicting demand and scheduling of resources. Lapierre et al. (1999) studied the seasonal demand of various medical services to determine the number of beds needed in medical and surgical areas. Cote and

Tucker (2001) detailed four forecasting methods to predict demand for health services, namely: percent adjustment, 12 month moving average, trendline and seasonalized forecast.

Percent adjustment is based on adjustment of percentage over the past 12 months of historic demand. An increase or decrease is an estimation of what is expected to happen over the next year. The drawback of this method is the possibility of inaccurate results because it ignores considerable historical data and also does not recognize seasonal effects.12 month moving average uses the averages of patient visits for the past 12 months to forecast the number of visits for the next month. The shortcoming is that it does not account for trends or seasonal effects. Trendline is determined from recent demand and is more accurate than percent adjustment and 12 month moving average. It provides a line of best fit in terms of regression analysis between past months (x variable) and the actual utilization in those months (y variable). It determines general direction of demand whether increasing or decreasing over time but unfortunately does not account for seasonal effects. Seasonalized forecast gives projections that include seasonal variations in demand. Therefore, to project demand at a demand. Therefore facility, stakeholders must weigh the advantages and disadvantages of each method of demand forecasting and select the one that best suites the facility.

Regression analysis is a statistical tool able to handle a variety of data patterns. Regression analysis is a set of statistical methods used to explain the relationship between two or more variables. Regression is also used in predicting and forecast modelling.

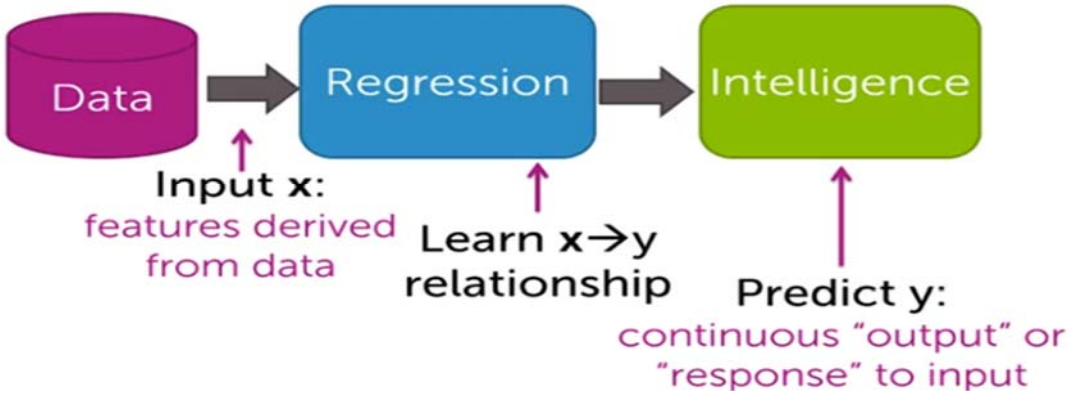


Figure2.2: Regression Analysis

2.1.4 Time Series Modelling

A time series is an amalgamation of data points at equally spaced points in time and placed in chronological order. Predictions based on time series are generated by models on the basis of changes over time in values obtained before-hand or on historical datasets (McCleary R, et al 1980). ARIMA and SARIMAX modelling have been adopted for use in forecasting as detailed in a study by Chunwei L et al, (2017). ARIMA stands for auto-regressive integrated moving average. It is a means of forecasting in such a way that a pattern of growth/decline in the data is accounted for (hence the "auto-regressive" part), the rate of change of the growth/decline in the data is accounted for (hence the "integrated" part) and noise between consecutive time points is accounted for (hence the "moving average" part. SARIMA (Seasonal Autoregressive Moving Average) on the other hand differs from ARIMA as the seasonality and exogenous factors (external data used in forecasting) are employed in forecasting using this method.

2.2 Empirical Review

LMIS use is based on the need for change and as stakeholders must be aware of the factors that decrease its impact or negate this change and thereby reduce the negative impact they may have on the process (Bergum, Nielsen & Sæbo, 2017). This section elaborates on factors affecting LMIS usage and hence its efficiency which can broadly be classified into technology and culture and institutional leadership. Technology includes tools, machinery, development and research. Behavior is influenced by individual and group norms that are impacted by organizational culture, interpersonal connections, knowledge, skills, attitudes, and personnel policies. Alterations in any one of these interconnected components might affect the other components (Annan, 2013).

2.2.1 LMIS and culture

To measure the success of any application the feedback from the users is the most reliable and utilized measurement. (Delone and McLean, 1992; Omary and Kalinga, 2017; Cai et al, 2017; Xiao and Dasgupta, 2002). Delone and McLean (2003) posited that satisfaction of the users is dependent on the system and the information given. This results in advanced positivity in the workplace and better outputs from individuals and the organization as a whole. P-C Sun et al (2008) described the factors affecting user satisfaction to be; technological mismatch and associated anxiety in its use, the feedback from the instructor, the allowance from the course to accommodate for differences in technological know-how, the quality of the course, the gains to be

made from the course, the adaptability to use of the course and the learning points taken from the course. Dwivedi et al (2012) posited that the standards of the system quality, the diversity in output of the system and the benefits of using the system had a great influence on the user friendliness of the system.

2.2.2 LMIS and technology

Computers have modified information extraction and organizational culture (Grabara, Kolcun & Kot, 2014). ICT has proven to be critical in improving operational efficiency and this includes availability of software and hardware in health facilities. Incorporating a logistics management system is key to managing inventory of medical commodities in a medical facility. Its implementation will manage resources and improve the overall health outcomes of health service delivery. In Pakistan, web-based cLMIS (Contraceptive LMIS) helped stakeholders have better visibility into the supply chain resulting in evidence-based decisions to ensure product availability. The cLMIS enables data entry and access via a web browser. The web-based vLMIS (vaccine LMIS) application has given stakeholders eye opening visibility of inventory management through a multilevel dashboard based on numerous key performance indicators (KPIs). This ensures vaccine availability at all levels of the public health system. (USAID Deliver Project, 2016)

In Zambia and Tanzania, the central-level, web-based eLMIS interface with the ERP and WMS software used in each country respectively used to process orders for delivery by the Medical Stores Department (MSD) Tanzania and the Medical Stores Limited (MSL) in Zambia. In Zambia, the system automates stock control cards and daily activity registers in public hospitals and health centers by compiling and sending data via a web-based interface to the central eLMIS. (USAID Deliver Project, 2016). In Nepal, health outcomes for family health programs were improved from 36 per cent in 1995 to 92 per cent in 2005 due to implementation of specially designed LMIS forms to collate data on seven key commodities for the Family Health Program with improved reporting rates from 36 per cent in 1995 to 92 per cent in 2005.

In Uganda, the automated pharmacy information management system based on the LMIS system has helped in reducing errors in data generated from facilities (Ssali and Lyavala, 2009). In Tanzania, incorporation of mobile phone technology, SMS messaging and electronic mapping technology were used in a pilot study to improve collection and reporting of logistics data on anti-

malarial medicines in three districts. There was an improved average response rate of 95 per cent to SMS directed requests for stock count data (Barrington et al, 2010).

In addition, electronic LMIS implementation in the health care system in Bangladesh has improved decision making and stock-outs of essential medicines have been reduced. Early warning system (EWS) designed to track information on HIV and AIDS commodities across five west African countries has helped a lot in preventing expiry of medicines in stock and improving procurement decisions to avoid stock outs (SIAPS, 2014). In Ethiopia, the eLMIS at facility (Health Care Management Information System Facility Edition) and the warehouse management system (HCMIS Warehouse) has brought about improvements in commodity management, data visibility, and overall performance. The system is user friendly users with various backgrounds and ICT skills. (USAID Deliver Project, 2016).

2.2.3 LMIS and institutional support

The efficiency of LMIS depend on institutional factors such as staff training, technological support (availability of software and hardware) and managerial support. Hayat, Abbas, Siddique, and Cheema (2012) conducted a research study to investigate various elements that influence responsiveness to LMIS use. The findings indicated that top-level management involvement is critical to increasing supply chain responsiveness via management decisions and strategies. Decisions regarding resources allocation and technology availability are also made by top management. Positive organizational culture and employee training also influence alignment of staff towards digitization of inventory management systems.

Mathur, Gupta, Meena, and Dangayach (2018) conducted a study on the Indian healthcare supply chain management. The variables in the study were supply chain practices, effective supply chain performance (SCP), and organizational performance (OP). The findings were that the function of supply chain managers could be summed up as thinker, controller and organizer which revealed the opinions and outlook of other stakeholders about the influence of supply chain managers on the operability of inventory management systems in health care.

Salisu and Bakar (2019) conducted research aimed at reviewing and developing a conceptual framework for improving SME innovation strategies in developing African countries. The study concluded that prudent management skills are crucial in designing and implementing effective

institutional strategies that enable SMEs in LMICs in Africa that guide and influence organizational value, which in turn impacts performance.

In summary, senior management is essential to the improved performance of organizations. They are the face of institutional values, culture and norms. In the implementation of a logistics management information system, top management plays a key role in ensuring the success of the system by coordinating all activities related to the implementation process such as training facilities for staff on LMIS.

2.2.4 Impact of technology on Inventory Management

As a result of advances in technology, there is an increase in the volume of data collected i.e. big data. Combined with advances in analytics this has enabled amalgamation of past data with predictive analytics for inventory forecasting to prevent stock outs. The availability of big data and data analytics can then be used to convert data into meaningful information that is critical in inventory management. Data analytics has been useful in gathering data that stakeholders utilize with evidence-based tools to bring about positive change in commodity procurement and tracking. (Jeble et al., 2018)

Machine learning has advanced commodity procurement and tracking using historical data and forecasting models to generate data that gives insight into future demand. (Bousqaoui et al., 2018, Raguseo, 2018). There are two types of machine learning: supervised and unsupervised learning. Supervised machine learning makes use of both inputs and outputs. The algorithm determines the relationship between the input and the output to predict outcomes and identify patterns. Unsupervised learning utilizes only input data to mine patterns to gain information on the given data set (Goodfellow et al., 2016). Both algorithms are to perform various functions such as regression, classification, clustering, and association (Kone and Karwan, 2011)

Currently in Kenya, despite devolution of health to counties, public health facilities face challenges in health commodities availability (Wangu, 2014). With the opportunity to embrace and collaborate with the new and emerging trends in inventory management, the public health care system in Kenya and indeed in many LMICs can eliminate issues such as stock outs and thus improve service delivery and ultimately lead to better health outcomes.

Health systems can be defined as being open, complex, interconnected and nested within other systems. Inventory management falls under the pharmaceutical system, that can be viewed as a system within a system that is to say it is nestled in the overall health system tied to access to medical products and hence service delivery as illustrated in figure 1.2 below.

Figure2.3: A system within a system.

Source: Management Sciences for Health

2.2.5 Impact of COVID on inventory management.

The Corona Virus global pandemic in the year 2019 highlighted the shortcomings of the current systems used in inventory management amid gaps in supply of essential medicines. The pandemic also brought about a new understanding of the health service supply chain as a socio-ecological system whose processes and actors are intermingled with political, economic and other phenomena (Wieland, 2020). The focus has now shifted towards preparation for changes in consumption behavior as seen in the pandemic era. Decision making has also had to adapt to new post pandemic situations such as new determinants of demand and supply and access to different resources.

2.2.6 Trends in LMIS application

In many LMICs entry of health information data in paper form of health is common place in the lower levels of public health facilities. Digitization of the inventory system through LMIS can

improve the inventory management of essential medicines through automation of multiple steps of the supply chain that will result in reduction of stock outs, wastage and supply chain inefficiencies.

A study done in three LMICs namely Tanzania, Ethiopia and Mozambique by Fritz, J et al., (2021) demonstrated that digitalization of LMIS would result in decline in child mortality by improving supply of essential medicines. Figure 1.3 below demonstrates the relationship between digitization of inventory systems and improved health outcomes.

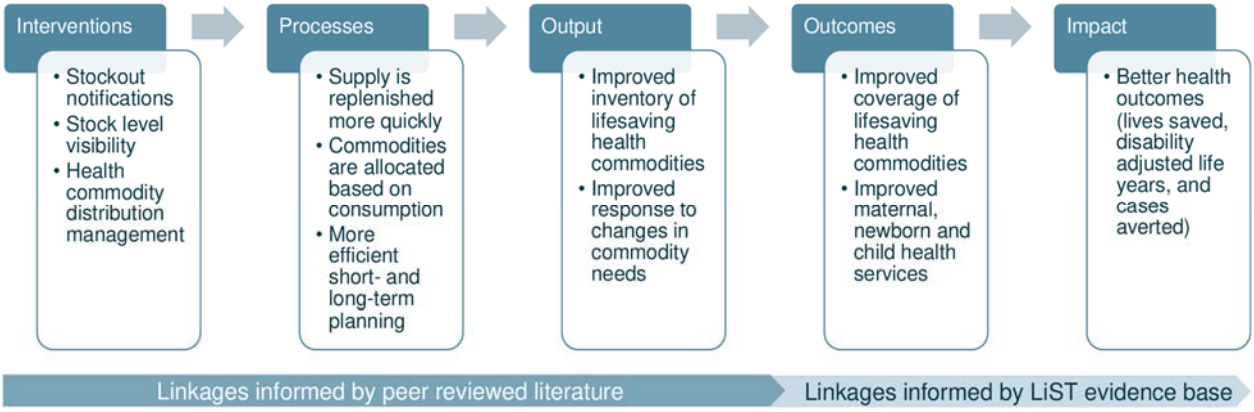


Figure 1.4: Impact model connecting digital health systems and improved health outcomes through LMIS source Fritz J et al 2021

Further, the study, using peer reviewed literature and primary data also demonstrated the impact of LMIS use in India, based on increase in stock availability; in Tanzania based on decreased stock out rates and in Mozambique based on reduced stock out rates one year after implementation of LMIS as shown in the table 2.1 below

Source	Geography	Impact	Timeline of measured change	Absolute magnitude of change	Definition of impact
Peer-reviewed literature	Tanzania (National, deployed only at central level)	Medicine stockout rates	12 months	Decreased by 13%	Measured as the existence of any zero-stock event in one or multiple sessions in a vaccine-facility-month [15]
Peer-reviewed literature	Tanzania (3 regions)	Vaccine stockout rates	12 months	Decreased by 5%	Measured as the existence of any zero-stock event in one or multiple sessions in a vaccine-facility-month [16]
Peer-reviewed literature	India (2 districts in state of Uttar Pradesh)	Vaccine availability	13 months	Increased by 8%	Measured as the percentage of vaccines available at the start of session day on which the evaluation took place [17]
Primary data	Mozambique (4 provinces)	Medicine stockout rates	12 months	Decreased by 14%	Rates measured one year after deployment of LMIS

https://doi.org/10.1371/journal.pone.0258354.t001

Table 2.1 Summary of LMIS on commodity levels.

Source; Fritz, J et al., (2021)

The same study also looked at the results of scaling up of vaccine coverage over a period of 5 years in Tanzania, Mozambique and Ethiopia with a comparison of base figures to conservative and optimistic figures which projected preventable deaths of approximately 4,924 (2,578–6,094), 3,988 (1,621–4,915), and 17,648 (12,656–22,776) in newborns and children under five in Mozambique, Tanzania, and Ethiopia, respectively. Improving the supply of non-vaccine medications provides for a larger proportion of the total lives spared and could prevent approximately 17,044 (8,561–25,392), 21,772 (10,976–32,401), and 34,981 (17,543–52,194) deaths in newborns and children under five in Mozambique, Tanzania, and Ethiopia, respectively as summarized in figure 2.2 below

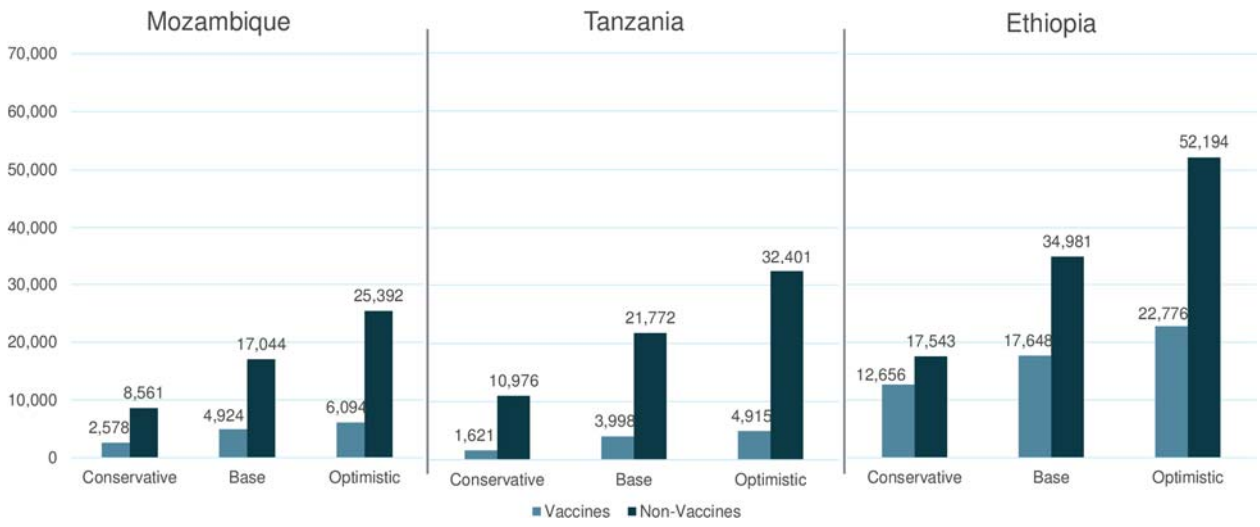


Figure 2.5: Total number of lives saved due to up scaling of commodities using LMIS.

Source: Fritz, J et al., (2021)

However, challenges in LMIS performance in Kenya and indeed many LMICs have been experienced such as inadequate staff training on LMIS use and making of orders via KEMSA, lack of basic infrastructure to support LMIS such as internet connection and computers. Incomplete or delayed reporting on commodity consumption has also hampered LMIS performance compounded by inaccurate information on commodity needs leading to difficulties in vital decision-making assessments leading to stock outs and expiry of available essential medicines.

2.3 Research gap

According to a study conducted by Sandeep, K. (2007) the aim of inventory management is to minimize costs while maintaining a continuous supply of inventory that ensures service delivery and fulfills requirements of the patient. In healthcare settings, service delivery is affected by the availability of essential medicines. A study by Mutale et al.,2013 concluded that the barrier to achieving good health outcomes in LMICs is nonfunctional health systems. This has led to poor service delivery in public healthcare institutions. Inventory management is key to the functioning of the health system by ensuring availability of essential medicines. The study however failed to provide insights as to how to strengthen inventory management systems in LMICs thereby presenting a gap in literature and deserves further empirical studies to address.

A study undertaken by USAID in 2007 determined challenges of LMIS performance in Kenya and cited inadequate staff training on LMIS coupled with inadequate information on commodity needs and uptake. A study by Mwathi, Ben et al in 2014 determined a positive relationship between the problem of stock outs of essential medicines in Kenya's public healthcare facilities and lack of sufficient training of health care workers in LMIS. The study provided a research gap that can be addressed by looking at the attitudes and responsiveness of healthcare workers to adapt to new technologies in inventory management.

Literature pertaining to the usefulness of demand forecasting in healthcare has been on the rise especially after the COVID 19 pandemic highlighted the need for preparedness of the health care supply chain. A study by Subramanian (2021) defined the prediction of the demand for essential medicines as a critical component and a useful insight for foreseeing future health needs. This opens up a research gap in literature through empirical studies to address the effectiveness of demand forecasting in ensuring availability of essential medicines and hence service delivery in public healthcare facilities

2.4 Conceptual Framework

This conceptual framework demonstrates the correlation between the study variables. When appropriate interventions are employed on the independent variables there is an effect on the dependent variable. The independent variables are an inventory management system, staff competency and digitization of the inventory management system while the dependent variable is service delivery.

Independent variables **Dependent variable**

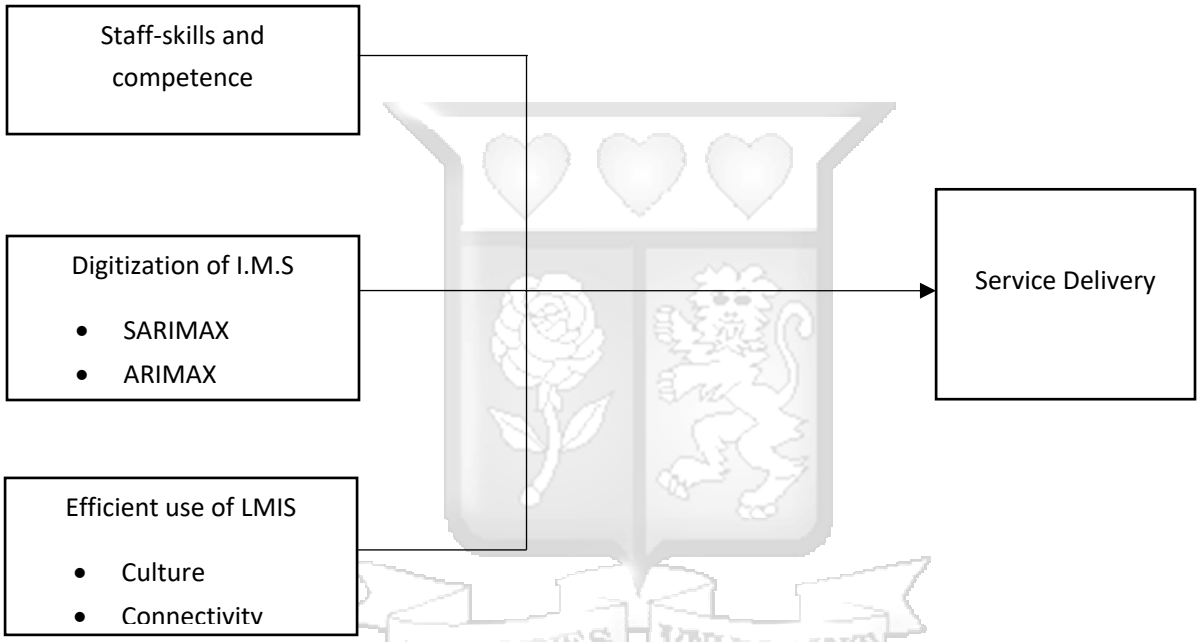


Figure 2.6 Conceptual Framework

2.5 Operationalization of Independent and dependent variables

	Variable	**measurement**	**Source**
Dependent variables	Service delivery	Likert Scale	Osborne et al., (2021)
Independent variables	Inventory management system	Interview Likert scale	Croom, S. & Jones, A. (2010).
	Staff skills and competency	Likert scale	Awanga, H. M. (2018).
	Digitization of inventory management system	ARIMA and SARIMA modelling	Chunwei L et al, (2017)

Table 2.3: Operationalization of variables

Chapter 3 Methodology

This chapter introduces the research methodology used in this study to address the objectives of the study. It is divided into the following areas; research philosophy, research design, population and sampling, data collection methods, data analysis and ethical considerations

3.1 Research philosophy

This was based on the assumptions made in the research and the way in which the data for the study was gathered, analyzed and used. A positivist approach was employed for this study, which according to Creswell J. W., 2014 requires the researcher to be independent, external and objective to the subject of the study. Positivism also puts emphasis on the observation and measurement of data leading to verifiable statistical results. The role of the researcher is therefore limited to data collection and interpretation resulting in a limited influence of bias and thus giving rise to objective results.

According to Hilary (2010) positivism "as a philosophy, is in line with the empiricist view that knowledge stems from human experience. It has an atomistic, ontological view of the world as comprising discrete, observable elements and events that interact in an observable, determined and regular manner. "The researcher will apply both qualitative and quantitative methods of research. Results will then be integrated into the research and inferences drawn (Johnson and Onwuegbuzie, 2006). Hesse-Biber and Johnson (2015), posit that the application of both qualitative and quantitative methods of research and followed by results that are credible ensuring reliable research findings.

3.2 Research design

The research employed a mixed methods approach that combined qualitative and quantitative research methods of data collection and analysis to answer different research questions and thereby provide more in-depth findings. Qualitative research design was concerned with answering research questions while quantitative research design was concerned with establishing the causal relationship between dependent and independent variables.

3.3 Population and Sampling

Population is defined as the entire group the study is concerned with Moussaoui while a sample is a specified part of the population from which the researcher will gather data relevant to the study. In this study the population was the service providers (healthcare workers) at the facility whose service delivery is directly influenced by the availability of essential medicines as provided through the LMIS procurement system. Inclusion criteria was personnel who were involved in inventory management and have worked in the facility for more than one year. Exclusion criteria was personnel who were not involved in inventory management and had not held their current position for more than one year. Assuming a margin of error of 0.05, Slovin's formula, a random sampling technique formula as developed by Slovin (1960) is used to determine the sample. n = N / (1 + Ne^2).

Where;

n = the sample size

N = the population size (107)

e = the margin of error as decided by the researcher (0.05)

Therefore:

$n = 130 / (1 + 130 \times 0.05^2)$

n = 130 / (1 + 130 x 0.0025)

n = 130 / (1 + 0.325)

n = 130 / 1.325

n = 98

3.4 Data Collection Tools

Primary data collection was done by use of a structured questionnaire as indicated in Appendix II. There were four main sections addressing general information of the respondents and the research variables. Likert scales were used to measure the responses (Osborne et al.,2021). After the pilot test stage, the questionnaire was then administered to a sample of the population of health care workers in the facility. A regression equation was derived from the primary data to relate the independent and the dependent variables. Secondary data was derived from data on the patient trends to the dental clinic over a period of ten years which was availed on the DHIS tool. The data

used for forecasting using the ARIMA and SARIMA models was the number of patient visits and dental procedures over the period.

3.5Data Analysis

Data collection was followed by analysis to determine the research findings. Descriptive analysis was used to define the primary data while statistical summaries detailed used the results of quantitative data.

Regression analysis is used in statistics to explain the causal relationship between variables (Hair et al., 2010). It allows us to understand how fluctuation in one variable is comparable with fluctuations in another variable. In this analysis, we have a multiple linear regression model with two independent variables; inventory management and staff competency. The dependent variable is the service delivery at the facility. This model displays the relationship between the dependent and independent variables. Correlation values start from 0 to ±1.0, with the lower value of 0 indicating an absence of a relationship between the dependent and the independent variables. A correlation of ±1.0 indicates a positive or negative relationship (Hair et al., 2010). The regression equation for the primary data in this study was as follows;

$Y = \beta 0 + \beta 1X1 + \beta 2X2 + \varepsilon$

Where Y =Service delivery

X1= Inventory management

X2= Staff competence

0 = Constant Term; β1 and β2 are Beta coefficients which were essential for measurement of the sensitivity of the dependent variable being service delivery denoted as (Y) to a change in a unit of any of the independent variables of the study, being inventory management and staff competence and skills.

ε = Error term

Qualitative data analysis was based on descriptive analysis with thematic and statistical representation of findings in form of tables and charts. Secondary data was analyzed using descriptive analysis, trend analysis, correlation analysis and predictive analysis using ARIMA and SARIMAX forecasting models.

Time series forecasting is a type of analysis that predicts or forecasts based on historical data that in this study is the patient visits over a ten-year period which indicates demand for a service. It

involves evaluating patterns and trends in the data set to make accurate predictions about future values. Time series forecasting has been utilized in finance, economics, weather forecasting, sales forecasting, inventory management, and resource planning.

Chunwei L et al, (2017) describe the use of forecasting models namely ARIMA (Autoregressive Integrated Moving Average) and SARIMAX ((Seasonal Autoregressive Integrated Moving Average with exogenous factors). The ARIMA model aggregates the following; autoregressive (AR), differencing (I), and moving average (MA). ARIMA models successfully aggregate both short-term and long-term dependencies in the data, making them suitable for multiple time series forecasting tasks.

The SARIMAX model is an extension of the ARIMA model that factors seasonality and exogenous variables as added ten-year models are therefore very critical l when the time series data is influenced by seasonality and where external factors play a role.

3.6 Research Quality

The two main criteria in focus under research quality are validity and reliability. Validity refers to the harmony between the research question and the construct under assessment while reliability refers to the whether or not the findings of the study are replicable when similar methodology is used ((Lewis, Saunders &Thornhill, 2009)

Use of both primary and secondary data sources ensured that data sources for the research are trustworthy and the right to access information of any organization was granted. The researcher also maintained lack of bias by not altering any of the study variables. Questionnaires used for this study were subjected to pre-evaluation in a pilot phase through a few healthcare workers at the facility prior to data collection to address the understandability and suitability of the research questions after which feedback was used to restructure the questions. Health care workers who agreed to take part in the study were furnished with an informed consent document referenced in the appendix II below. Participants were assured of utmost confidentiality and that any information was to be used solely for its intended purpose of MBA-HCM dissertation.

Chapter 4: Research Findings

4.1 Introduction

This chapter focuses on optimization of the inventory management system to improve the availability of essential medicines and service delivery. It discusses the interpretation of the primary and secondary data to address the research questions.

4.2 Primary data analysis

The primary data was collected through a questionnaire distributed to a sample of the population Data confidentiality was maintained throughout the process as the personal details of the respondents were not collected. A total of 79 respondents agreed to take part in the study.

4.2.1 Profile of the Research respondents and work experience

This distribution highlights the predominant presence of nurses within the sample, comprising the majority at 60.8%. Clinical officers accounted for a significant proportion at 20.1%, while medical officers and dental officers constituted smaller percentages at 6.3% and 3.8%, respectively. These findings are consolidated with work experience of health care workers at the facility in figure 4.1 below. The medical officers and dental officers included in the survey had work experience ranging from 0 to 10 years. In contrast, the nurses exhibited a notable trend, with a majority having worked for more than 15 years in the organization. This also agrees with the findings of the study on task shifting as posited by (Baine & Kasangaki, 2014) which demonstrated that as a result of task shifting, the nursing cadre now handles medicines and medical products in lower-level facilities.

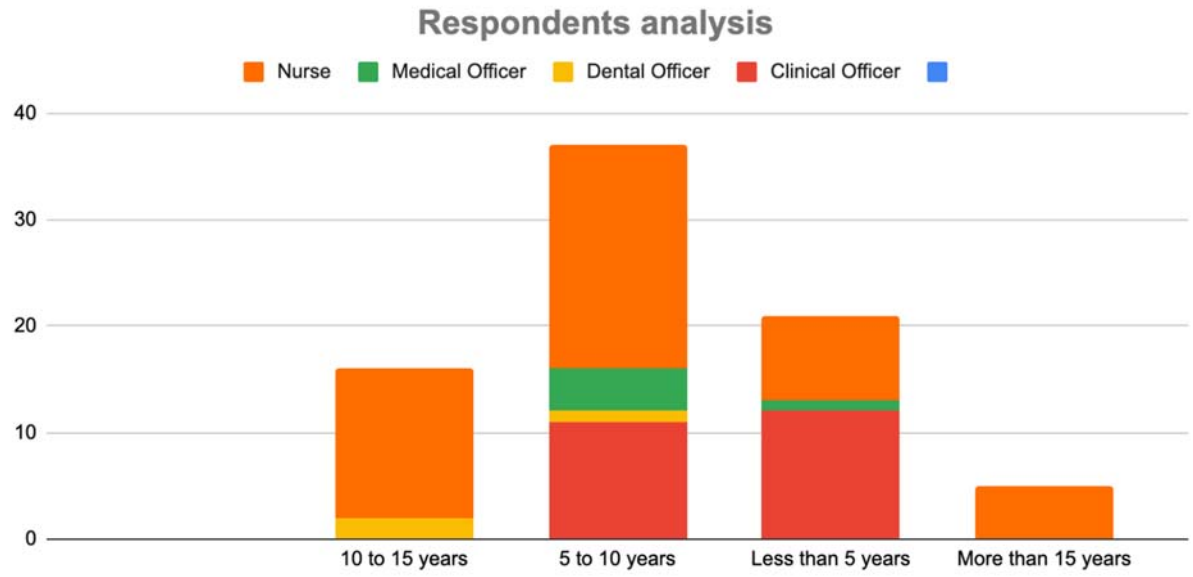


Figure 4.2 respondents' profession and years of work experience

4.2.2 Efficiency of inventory management system and its influence on service delivery

The responses on the efficiency of the inventory management system show that 94% of the respondents had experienced regular cases of stock outs of medicines and medical supplies with 86% of respondents having had an experience of expired drugs and supplies. This implies that the current inventory management system has a direct positive relationship to service delivery by ensuring supply of essential medicines and supplies. 90% of the respondents strongly agree that essential medicines are not always available or accessible when needed in the facility. In addition, a majority of respondents at 99% have had to make emergency orders in an attempt to cater for lack of availability of essential medicines when needed. Also notable is the 59.9% of the respondents who perceive inventory management as having an influence on service delivery as seen in table 4.1 below

Influence Of Inventory Management				
Strongly agree	Agree	Neutral	disagree	Strongly Disagree
59.90%	17.1%	3.10%	3.10%	16.70%

Table 4.1 Influence of Inventory Management

4.2.3 Staff Capacity and skills

There is a consensus among the respondents on the lack of adequate staff involved in inventory management with 95 % of respondents citing the inadequacy in training, the findings are represented in table 4.2 below

Staff Capacity and skills				
Strongly agree	Agree	Neutral	disagree	Strongly Disagree
31%	19%	1.30%	10.40%	38.30%

Table 4.2 Staff Capacity and skills

Furthermore, as seen in figure 3.4 below and all the respondents citing a need for the need for training of staff on use of LMIS

Figure 4.8Need for training in LMIS

4.2.4 Scarcity of medical supplies related to patient visits

The number of patients visiting the facility has reduced due to stock outs of essential medicines and medical supplies as noted by 90% of the respondents. A majority of the respondents at 98% related referral of patients to seek healthcare at other facilities to stock outs at the facility. Past experiences

of service delays and referrals which according to 90% of respondents has led to patients seeking healthcare services in other facilities. This is summarized in the figure 3.5 below.

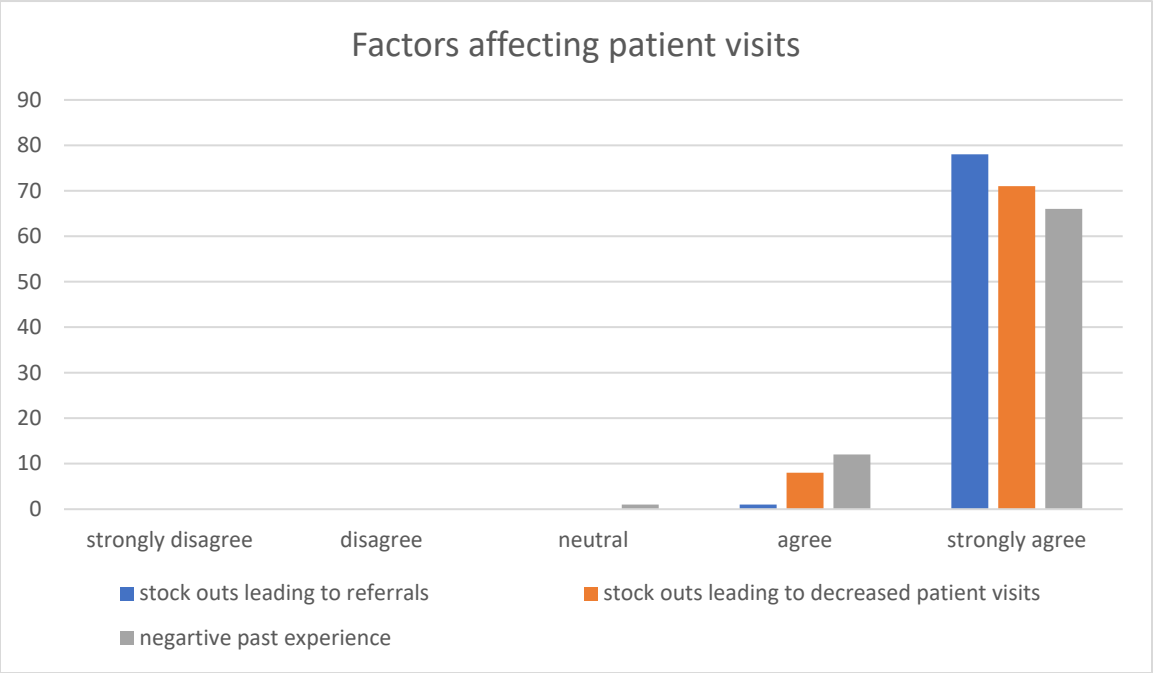


Figure 4.3 Factors affecting patient visits

4.2.5 Regression analysis

Regression summary statistics of the primary data are as shown in table 4.1 Below

	Coefficients	*Standard Error*	*t Stat*	*P-value*
Intercept	4.884368	0.255095	19.14728	8.35E-31
LMIS	0.100761	0.061129	1.648337	0.103412
STAFF COMPETENCE	-0.09497	0.066133	-1.436	0.155106

Table 4.3 Regression summary statistics

The regression equation for the data in the primary data was as follows

$Y = \beta_0 + \beta_1 X + \varepsilon$

Service delivery = 4.88 + 0.10*Inventory Management + (-0.09) *staff competence

The intercept, or the constant, 4.88 representing the expected value of the service delivery when all the independent variables are not factored. The t-statistic is -1.43 and the p-value is 0.15. Since the p-value is greater than 0.05 (level of significance), we fail to reject the null hypothesis

The coefficient for the influence of inventory management is 0.100, indicating that a one-unit increase in the influence of inventory management is correlated to an increase of 0.100units in the dependent variable, being service delivery holding other factors constant. The standard error, which measures the accuracy of this coefficient's estimate, is 0.26. The t-statistic is 1.64, and the p-value is 0.10, a value higher than the level of significance of 0.05. This suggests that the influence of inventory management is a statistically significant predictor of service delivery dependent variable in this model. This implies that any fluctuations in the influence of inventory management are likely to have a significant impact on service delivery.

The coefficient for staff competence is -0.09, suggesting that an increase in these independent variable results in a decrease of 0.09 units in the dependent variable, other factors being equal. The standard error for this coefficient is 0.06. The t-statistic is -1.4, and the p-value is 0.15. The p-value in this model is higher than the level of significance of 0.05 showing that staff competence is a significant predictor of the dependent variable in this study.

4.2.6 Regression Test of Inventory management and staff competence

In this study, a linear regression analysis determined to demonstrate the inventory management and staff competence on service delivery. This is demonstrated in the Table 4.5. below. From Table 4.5, R, the correlation coefficient represented by Elaborates the positive relationship between staff competence and inventory management on service delivery. This is seen in the correlation coefficient of 0.240. The coefficient of determination (R squared) is the percentage of the difference noted in the dependent variable explained using the values of the independent variables. The model had a coefficient of determination (R2) of 0. 057 and which implied that 5.7% of the service delivery was determined by the inventory management and staff competence and skills.

SUMMARY OUTPUT	
Regression Statistics	
Multiple R	0.240656
R Square	0.057915
Adjusted R Square	0.033123
Standard Error	0.146382
Observations	79

Table 4.4 regression statistics

4.2.7 ANOVA Of Inventory management and staff competence

The study investigated the relationship between inventory management and staff competence by use of ANOVA technique. The findings are shown in Table 4.16 below from which the study established that the regression model had a significance level of 0.103%, which is an indicates the that a valid conclusion can be made as the value of significance (p-value) was less than 5%. The calculated value was less than the critical value (3.876> 2.336) an indication that inventory management and staff skills had a significant effect on service delivery.

ANOVA					
	df	*SS*	*MS*	*F*	*Significance F*
Regression	2	0.100113	0.050056	2.33607	0.103614
Residual	76	1.628495	0.021428		
Total	78	1.728608			

Table 4.5 ANOVA analysis Source: Author (2024)

4.2.8 Correlation Analysis of variables

To establish the relationship between the variables, a correlation analysis was performed with the results as shown in table 4. 4 below

	service delivery	*LMIS*	*STAFF COMPETENCE*
service delivery	1		
LMIS	0.179872	1	
STAFF COMPETENCE	-0.15568	0.023123	1

Table 4.4 Correlation matrix of variables Source: Author (2024)

The study established a robust positive relationship between understanding of inventory management and service delivery and a negative correlation between service delivery and staff competence

Regression analysis formula:

$Y = \beta_0 + \beta_1 X + \varepsilon$

Service delivery = 4.88 + 0.10*Inventory Management + (-0.09) *staff competence

Based on this regression analysis inventory management appears to positively influence the service delivery at the facility while staff competence has a negative influence on service delivery.

4.3 Secondary data analysis

The sourced secondary data provides a record of the patient visits to the dental clinic that occurred from July 2012 through to June 2020. The dental clinic was chosen for this source of data due to the use of the essential drug, lignocaine without which no dental procedures can be performed and hence can be used to highlight both the effect of lack of the essential drug on patient visits and also the need to improve procurement to ensure dental services are always available to those seeking such services. The dataset is comprised of the following variables:

Variable name	**Variable description**
Year_Month	Month and year when the patient was seen.
Patients seen	The total number of patients seen.
Male	The total number of male patients seen.
Female	The total number of female patients seen.
Extraction	The number of dental extraction procedures done.
Restorative procedure	The number of restorative procedures done
Full mouth scaling	The number of full mouth scaling procedures done
Minor oral surgery	The number of full minor oral surgery procedures done

Table 4.6: List of variables from the secondary data

4.3.1 Descriptive analysis

Descriptive analysis is instrumental in data analysis as it provides a detailed overview and comprehension of the variables within a dataset.

In table 4.6 below summary statistics of the variables of the dental procedures carried out over the period of 10 years, the mean number of patients seen was approximately 131. Female patients had a higher average of 70, compared to male patients, who had an average of 62 patients. As for dental procedures, extraction was the most common, with an average of 125 procedures performed. The average number of patients receiving restorative procedures was 4, while full mouth scaling and minor oral surgery averaged at 2 and 1, respectively.

The variable of dental extractions can therefore be used as the baseline for the prediction models to predict patient visits and thus the amount of the essential drug, lignocaine to be procured to prevent stock outs and ensure service delivery.

	Patients seen	**Male**	**Female**	**Extraction**	**Restorative procedures**	**Full mouth scaling**	**Minor oral surgery**
Count	96	96	96	96	96	96	96
Mean	130.38	61.31	69.06	125.01	3.36	1.03	0.97
Standard Deviation	56.92	32.50	32.23	55.54	3.26	0.91	0.98
Min	7	2	5	7	0	0	0
25% Percentile	91.25	39.75	49	87.25	1	0	0
Median (50%)	123.5	56.5	63.5	119.5	2	1	1

75% Percentile	163.5	79.75	86.5	158.25	5	1.25	1.25
Max	271	164	174	264	18	4	4

Table 4.7: Summary statistics of the variables

4.3.2 Trend analysis

Trend analysis assists in detecting patterns and comprehending the inherent trajectory and patterns of data over a period. This analysis involves scrutinizing and making sense of data to recognize long-lasting trends, patterns, or changes in one or more variables. The trend in patient visits over the ten-year period is detailed in figure 4.7 below. There is no seasonal trend discernible in the number of patients seen for different dental procedures; the figures have fluctuated over the years. The peak rise in patient visits was documented in Jan 2014, August 2016 and January 2018. There was a decline in patient visits from March 2018 with the most notable decline in patient visits noted in 2020. This decrease was largely due to the cessation of dental services during the COVID-19 pandemic.

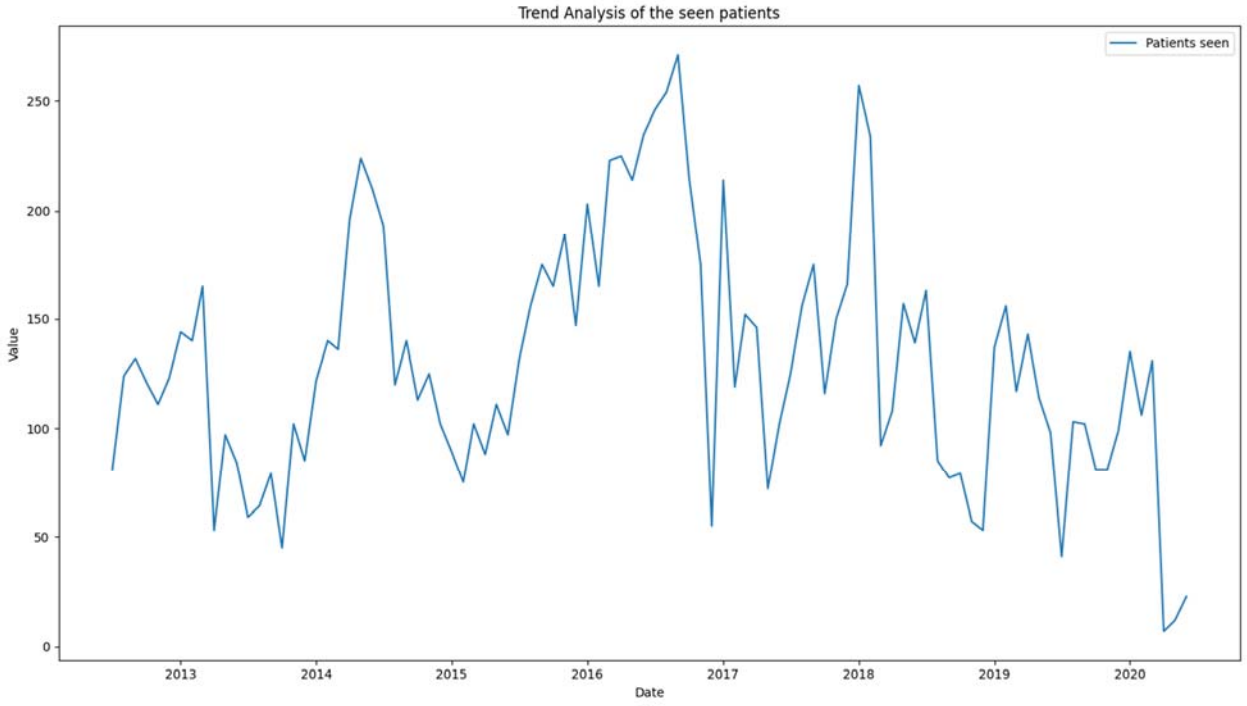


Figure 4.7: Number of patients seen over the years

The number of female patients visiting the dental clinic was higher than that of male patients at 53% and 47% as presented in the figure 4.8 below.

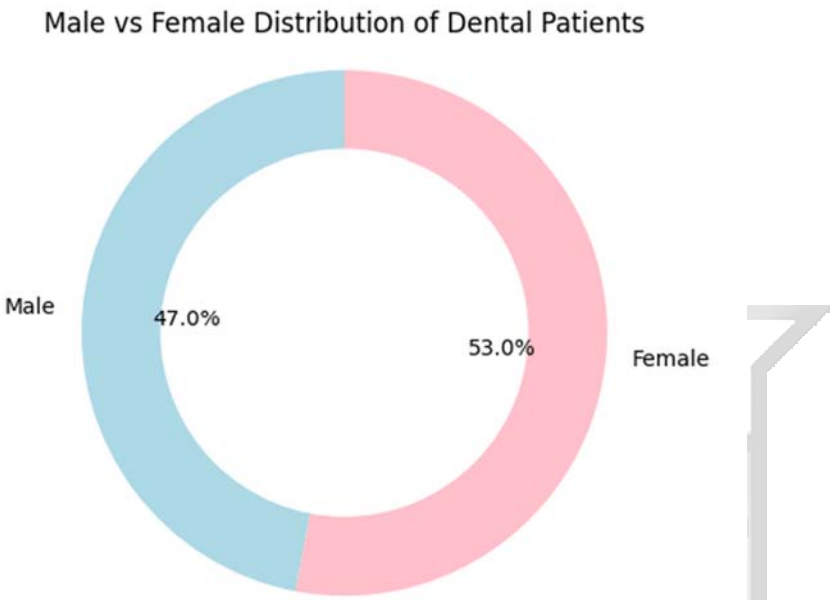


Figure 4.8: Distribution of male vs female patients

The extraction procedure is the predominant treatment provided for dental patients at this hospital. Other procedures, such as restorative treatments, full mouth scaling, and minor oral surgery, are performed less frequently in this facility.

4.3.3 Correlation analysis

Correlation of variables using heat map analysis is a tool in data analysis that examines the relationship between variables. A heatmap analysis is a visual representation of a matrix of data using colors to represent the values. The colors in the heatmap represent the values in the matrix. Typically, a color gradient is used, where the red shades used below show a strong positive association and the blue shades show a weak correlation. The intensity of the color provides a visual cue for the magnitude of the data. As noted in the chart in figure 4.9 below there is a strong positive correlation between the number of patients seen and the extraction procedures performed. This association is anticipated, given that the count of extraction procedures derives from the overall number of patients seen. This can then inform the procurement of the essential drug, lignocaine in the application of forecasting in procurement.

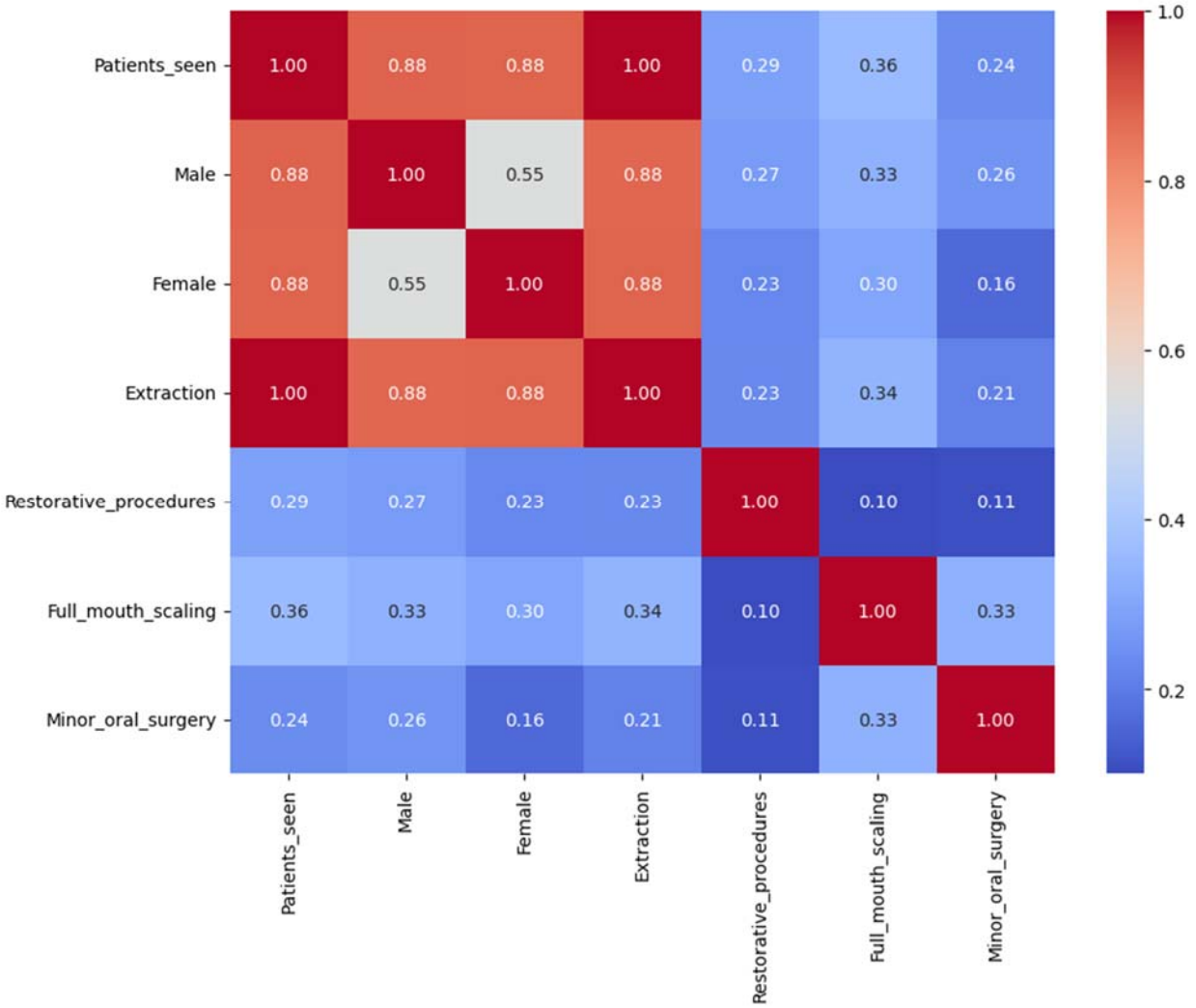


Figure 4.9: Correlation analysis of the variables

4.3.4 Predictive analysis

For the dataset, the ARIMA and SARIMAX models were used for forecasting and the most ideal model was selected for further predictive analytics based on their performance metrics. The variable used for the forecasting model was 'Patients seen'. The performance metrics used to evaluate the model as shown in table 4.8 below were; Mean Squared Error (MSE) that was used to measure the average squared difference between the predicted values and the actual values. Root Mean Squared Error (RMSE), the square root of the MSE that provided a measure of the average difference between the predicted and actual values. Mean Absolute Error (MAE) measured the average absolute difference between the predicted values and the actual values.

Model	MSE	RMSE	MAE
ARIMA	3508.98	59.24	45.64
SARIMAX	2689.74	51.86	46.76

Table 4.8: Performance metrics of the ARIMA and SARIMAX models

Comparing the metrics for the ARIMA and SARIMAX models, we can see that the SARIMAX model has lower MSE, RMSE, and MAE values compared to the ARIMA model. This suggests that the SARIMAX model performs better in terms of predicting the "patients seen" variable. The lower MSE and RMSE values of the SARIMAX model indicate that it has a smaller average squared difference and average difference between the predicted and actual values, respectively. This suggests that the SARIMAX model's predictions are closer to the actual values compared to the ARIMA model. The MAE values of both models are relatively close, indicating that both models have a similar average absolute difference between the predicted and actual values. However, the SARIMAX model has a slightly higher MAE value, suggesting that it may have slightly larger individual prediction errors compared to the ARIMA model.

An analysis of the predicted values of the ARIMA and SARIMAX models versus the actual number of patient visits is seen in the line plot below in figure 4.12. The average percentage error for the ARIMA model is -199.66% while the SARIMAX model is -17.94%. The negative average percentage error indicates that, on average, the model tends to underestimate the actual values. The SARIMAX model has an average percentage error of -17.94% indicating that, on average, the SARIMAX model underestimates the actual values, but to a much lesser extent compared to the ARIMA model. The magnitude of the error in the SARIMAX model is significantly smaller, indicating a better performance overall. This is because the SARIMAX model accounts for seasonal changes in its prediction.

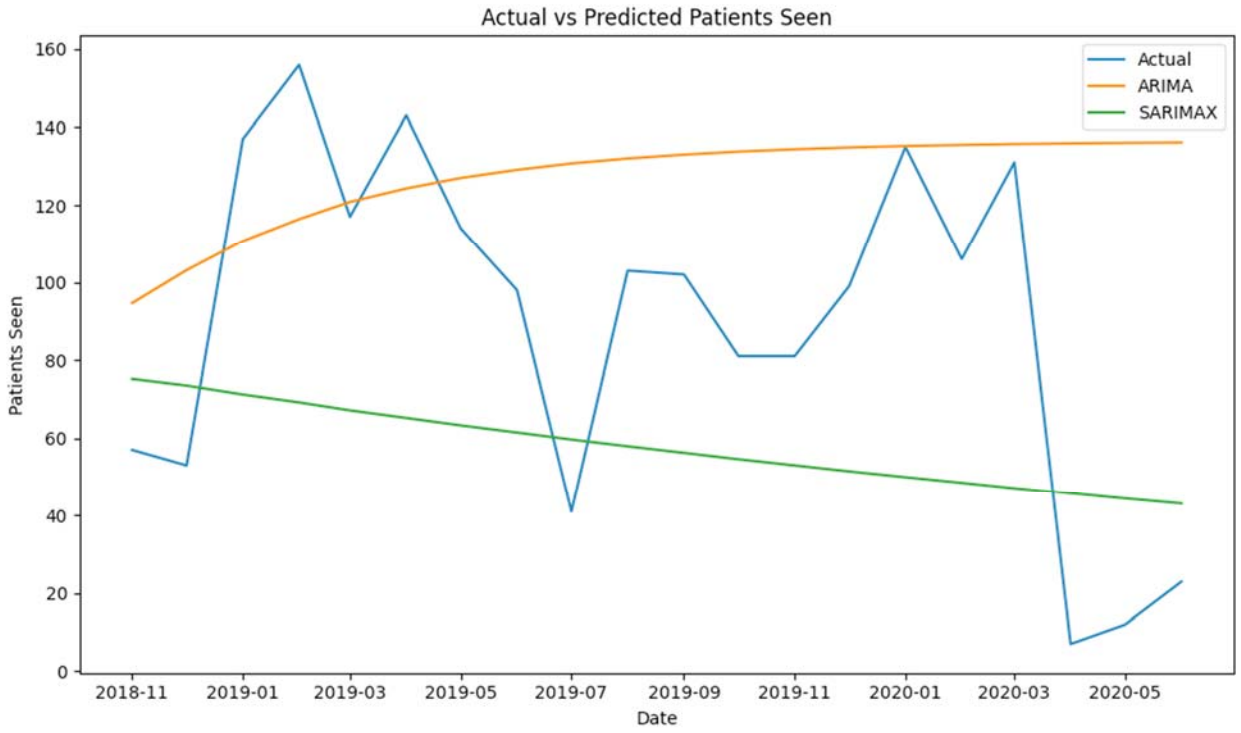


Figure 4.10: Comparison of ARIMA and SARIMAX

SARIMAX Model Forecasting

The SARIMAX model was used to predict the number of patients to be seen based on historical data analysis of the variable of patients seen. The model predicted as noted in figure 4.13 below that the number of patients will decline from July 2020 to December 2020. This was during the COVID-19 pandemic which was a big contributor to this decline due to the restrictions placed. It will therefore be a useful tool for prediction of expected patients which can then be used to aid in improving procurement of lignocaine for the dental clinic while factoring seasonal changes.

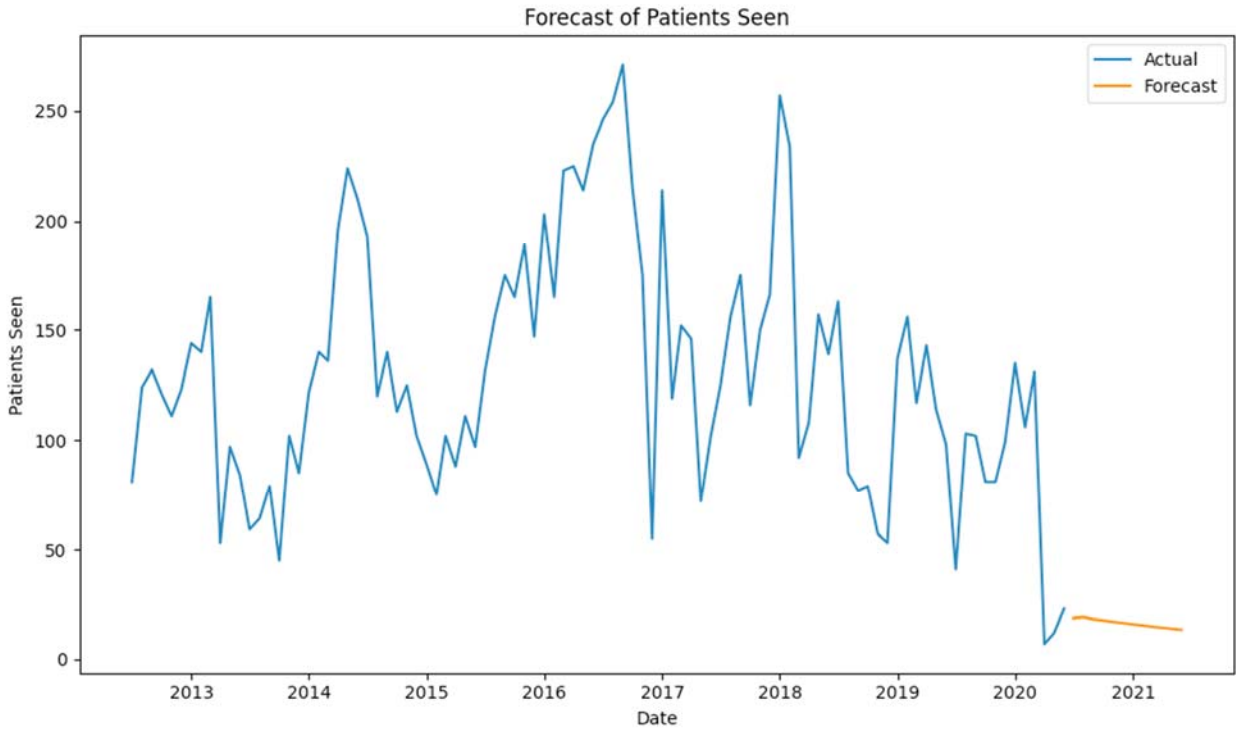


Figure 4.11: Patients Forecasting with the SARIMAX model

o

Chapter 5: Summary, Recommendations and Conclusions

5.1 Introduction

This chapter presents a detailed summation of results, proposals on solutions of results and conclusions of the study hereby undertaken.

This research had an aim to determine how service delivery can be improved by optimization of the inventory system. The research objectives were to assess the efficiency of the LMIS inventory management system in service delivery, to evaluate staff, skill and competency in use of LMIS and to use demand forecasting to ensure availability of essential medicine.

5.2 Discussion

5.2.1 Efficiency of the inventory management system

Access to medicines can be viewed in the scope of ease of access, availability, affordability, acceptability (to both the dispenser and patient) and most crucial, the quality of the medicines (Wirtz *et al.*, 2016). Stock outs of essential medicines contribute towards adverse patient events including treatment delays, clinical complications, associated medication errors and adverse drug reactions. From the analysis above the LMIS system used for inventory management is not efficient enough to ensure service delivery at the facility. This is noted by 94% of respondents who have experienced regular cases of medicines and essential supplies stock outs with 86% of respondents experiencing expiry of drugs and other supplies

90% of respondents in this study reported a notable reduction in patient numbers at the facility due to stock outs. Further,98% reported to having made referrals of patients to other facilities due to stock outs. This implies that the inventory management system needs improvement in its functioning to ensure availability of essential medicines at all times. In addition, stock outs have led to a negative effect on staff motivation with a negative result on service delivery as well. Notably, 76% of respondents agree that an increase in availability of essential medicines can result in improved service delivery

5.2.2 Evaluation of staff, skill and competency in use of LMIS.

95% of the respondent's report that the number of staff involved in inventory management was inadequate while 97% of the respondents also reported to the need for training of staff on LMIS software and its use. The potential of improving inventory management systems to ensure adequate

supply of essential medicines has been explored in a number of studies. As noted from the results if the study, despite there being the use of the LMIS system for inventory management, there are still loopholes that allow for stock outs of essential medicines. Several studies such as that of Kumar (2018) developed models for rural healthcare centers in India that resulted in improved stock of essential medicines by integrating quantity discount and minimum-maximum inventory policies. Gebicki (2014) found that incorporating drug characteristics in procurement decisions enhanced patient safety and reduced costs. These studies can therefore act as a baseline and guide for improvement of the inventory management systems in use currently. However, in another study, Uthayakumar (2013), proposed an inventory model for a hospital considering factors such as lead time and customer service level to optimize the size of inventory and total cost.

Staff competency especially in inventory management and service delivery has been found to impact performance and customer satisfaction. In healthcare, inventory management practices have been found to directly affect service delivery (Osei-Mensah, 2016). Maintaining access to essential medicines which leads to improved healthcare outcomes yields higher job satisfaction and staff motivation. Highly motivated healthcare workers are more likely to provide better health care services quality (Kumurya, 2015). In addition, a study undertaken by Moloto (2005) shows the improvement in inventory management when skilled and trained staff are involved.

5.2.3 To forecast future prediction to ensure availability of essential medicine.

The number of patients visiting the facility has reduced due to stock outs of essential medicines and medical supplies as noted by 90% of the respondents. A majority of the respondents at 98% related referral of patients to seek healthcare at other facilities to stock outs at the facility. Past experiences of service delays and referrals which according to 90% of respondents has led to patients seeking healthcare services in other facilities.

The ideal health system should provide the right products when needed. This ensures access to essential medicines and improved healthcare outcomes with patient satisfaction in service delivery. Public hospitals in Kenya face problems of poor inventory, inaccurate forecasting, poor receptiveness to demands and poor technological application resulting in poor service delivery (Mathura, 2013). Digitization of the inventory management system through methods such as demand forecasting can be invaluable in ensuring adequate supplies of medical supplies and hence

improve service delivery and overall health outcomes in the population seeking health care at a given facility.

5.3 Conclusion

From the results of the study as seen above, patients attended to at the facility have been dropping as a result of stock outs. This is the basis of the application of demand-based forecasting in procurement based on historical data to ensure there is an assurance of service to patients who visit the facility and also consequently reduce the burden on other facilities which have to then provide services to a higher number of patients referred from one facility to another. This will also improve the perception of the public health system by citizens in the county while improving access to health services by removal of barriers to access.

5.4 Recommendations:

5.4.1 Inventory Management

The results confirm that a well-structured inventory management system can be an effective tool in predicting and recommending the restocking of essential medicines. The positive causal effect found between inventory management practices and the delivery of services suggests that an integrated and efficient inventory management system is critical in healthcare service delivery. Implementing such a system can enable the healthcare facility to maintain a constant supply of essential medicines, thereby ensuring uninterrupted service provision to patients

5.4.2 Staff Competency and skills

There is a need to facilitate training opportunities for staff members on developments in inventory management. This is notable in the results of the study that indicated the training gaps in inventory management that has contributed to stock outs and emergency orders. A dynamic, interactive dashboard that displays real-time data on patient visits, medical procedures, and inventory levels could provide valuable insights for hospital staff. This tool could support decision-making processes by offering up-to-date information on the current state of the hospital and potential future trends. Hospital management should provide continuous training facilities for staff involved in inventory management to enhance the efficiency of the Komura should be adequate infrastructure to enable the inventory management system to be efficient. This includes wireless internet connectivity, software upgrades and hardware such as computers

5.4.3 Demand forecasting

The study has shown the viability of using data prediction models, such as the ARIMA and SARIMAX models, to forecast potential stockouts of medical supplies. The predictive ability of these models, as demonstrated in forecasting patient visits, could be extended to predict inventory utilization and subsequently, potential stockouts. By leveraging these predictive analytics models, healthcare facilities can enhance their inventory planning and management, mitigating the risk of stockouts, and ensuring consistent availability of necessary medical supplies.

5.5 Limitations:

Seasonality and external factors: Although the SARIMAX model takes into account seasonality and some external influences, there may be additional factors that it does not capture. For example, unexpected events like a global pandemic can drastically affect patient numbers and inventory demand, potentially skewing our predictions.

Developing and maintaining a sophisticated data system requires considerable resources. These resources include both the technical infrastructure and personnel with the necessary expertise to manage the system. This requirement could present a challenge for hospitals with limited resources.

The results of this study concur with that of a study carried out by Dan Wu et al 2021 which demonstrated that stock outs of essential medicines at a public health care facility negatively impacted the perception of patients on both healthcare workers and public health facilities. A strong positive correlation between inventory management and service delivery provides suggestive evidence of a relationship between patient visits and the availability of essential medicines. This highlights the potential of a stable supply of essential medicines in attracting and retaining patients, which can indirectly contribute to improved patient outcomes. This can also mitigate the negative perception of public health care facilities among the public Future studies could delve deeper into the direct link between patient visits and medical supply availability and investigate the impacts of varying inventory management practices on patient satisfaction and outcomes.

.

REFERENCES

Abu Zwaida, Tarek & Pham, Chuan & Beauregard, Yvan. (2021). Optimization of Inventory Management to Prevent Drug Shortages in the Hospital Supply Chain. Applied Sciences. 11. 2726. 10.3390/app11062726.

African Medical Research Foundation;(2007), Commodity Management for HIV/AIDS. (AMREF), Nairobi. Kenya. Website: www.amref.org.

Agus. A. & Noor, Z. (2010). Supply Chain Management and performance. University of Malaysia, Singapore

Awanga, H. M. (2018). Demand Planning on Supply Chain Performance: A Case Study of FMCGs in Kenya (Doctoral dissertation, United States International University-Africa).

Beal Partyka, R. (2022) "Supply chain management: an integrative review from the agency theory perspective" Revista de Gestao, Vol 29 No 2, pp. 175-198

Bowersox, D. and Closs, D. (2002). Logistical management: the integrated supply chain process. New York: McGraw-Hill.

Cameron A, Ewen M, Ross-Degnan D, Ball D, Laing R. Medicine prices, availability, and affordability in 36 developing and middle-income countries: a secondary analysis. *The Lancet* 2009; 373: 240–249.

Callahan TJ, Guzman DR, Sumeren Ma (2004) Effective demand forecasting in health

Chase, R. B .1981 The customer contact approach to services: Theoretical Bases and Practical Extensions. Operational Research, 29(4), 698-706

Cote, Murray J, Tucker, Stephen L Healthcare Financial Management; May 2001;55,5

Coyle. J. Bard, Edward, J. Langley, C. (2003) The management of business logistics: A supply chain perspective. 7th Edition. South Western Thomson Learning

Croom, S. & Jones, A. (2010). E-procurement: Key Issues in inventory control implementation and operation in the Public Sector

Dabar, D. T; Njoroge, K & Oluoch, M. (2022). Factors Influencing the Implementation of Logistics Management Information System: A Case Study of Garissa County. Journal of African Interdisciplinary Studies, 6(9), 51 – 62.

Dai, Q & Kauffman, R. (2001) An exploratory assessment, a paper presented at the 34th annual Hawaii International conference on systems services, Hawaii

Dan Wu1, Tai Pong Lam1, Kwok Fai Lam, Kai Sing Sun, Xu Dong Zhou (2021) Patients' Coping Behaviors to Unavailability of Essential Medicines in Primary Care in Developed Urban China. International Journal of Health Policy Management 2021, 10(1), 14–21

Dewi, E.K., Dahlui, M., Chalidyanto, D. and Rochmah, T.N. (2020), "Achieving cost-efficient management of drug supply via economic order quantity and minimum-maximum stock level", Expert Review of Pharmacoeconomics and Outcomes Research, Vol. 20 No. 3, pp. 289-294.

Finarelli, Hugo J., Jr., and Tracy Johnson. "Effective demand forecasting in 9 steps: shifts in demand for a hospital's services can occur unexpectedly. Demand forecasting can help you prepare for these shifts and avoid strategic missteps." *Healthcare Financial Management*, vol. 58, no. 11, Nov. 2004, pp. 52

Friday, D., Savage, D.A., Melnyk, S.A., Harrison, N., Ryan, S. and Wechtler, H. (2021), "A collaborative approach to maintaining optimal inventory and mitigating stockout risks during a pandemic: capabilities for enabling health-care supply chain resilience", Journal of Humanitarian Logistics and Supply Chain Management, Vol. 11 No. 2, pp. 248-271.

Fritz J, Herrick T, Gilbert SS (2021) Estimation of health impact from digitalizing last-mile Logistics Management Information Systems (LMIS) in Ethiopia, Tanzania, and Mozambique: A Lives Saved Tool (LiST) model analysis.

Gheware S. D., Kejkar A.S & Tondare S. M. (2014). Data Mining: Tasks, Tools, Techniques and Applications, International Journal of Advanced Research in Computer and Communication Engineering Vol.3, Issue 10, October2014

Grönroos, C. (2019). Reforming public services: Does service logic have anything to offer? *Public Management Review*, 21(5), 775– 788

Gosain, A & Kumar, A. (2009) Analysis of healthcare data mining techniques, Intelligent Agent & Multi Agent Systems, 2009. IAMA 2009, International Conference on, Agent & 1, 6, 22-24 July 2009

Hussam Jawad, Mohamad Y. Jaber, Maurice Bonney, The Economic Order Quantity model revisited: an Extended Exergy Accounting approach, Journal of Cleaner Production, Volume 105,2015, Pages 64-73,

John Snow, Inc.,2017 Supply Chain Manager's Handbook

John Snow, Inc. (2000). The Logistics Handbook: A Practical Guide for Supply Chain Managers in Family Planning and Health Programs. Arlington, VA: JSI

Karamshetty et al., (2021) Private healthcare in LMICs Production and Operations Management 31 (2) pp. 828-846

Kotler, P. (2002) Marketing Management ed 2 The Millenium Edition. New Delhi: Prentice Hill of India

Kenya Health Policy (KHP0 2012-2030 publication

Leite, H., & Hodgkinson, I. (2021). Examining resilience across a service ecosystem under crisis. Public Management Review

McCleary R, Hay RA, Meidinger EE, McDowall D. Applied Time Series Analysis for the Social Sciences. Beverly Hills, Calif.: Sage Publications, 1980.

Ministry of Health (MOH) 2006, Reversing the trends; The second health sector strategic plan of Kenya: Annual Working Plans 2 2006/07. Nairobi. Kenya

Mungu S. (2013, Supply Chain Management practices and Stock levels of essential drugs in public health facilities in Bungoma East-Sub County, University of Nairobi, Kenya

Mutale, W., Bond, V., Mwanamwenge, M. T., Mlewa, S., Balabanova, D., Spicer, N., & Ayles, H. (2013). Systems thinking in practice: the current status of the six WHO building blocks for health system strengthening in three BHOMA intervention districts of Zambia: a baseline qualitative study. BMC Health Services Research, 13, 291–291.

Mwathi and Onyango (2014) Availability of essential medicines in public hospitals: A study of selected public hospitals in Nakuru, Kenya. Academic Journal, 8 (17), 438-442.

Odette, N. (2014). Outpatients' Experiences of Quality Service Delivery at a Teaching Hospital in Guateng. Health SA Gesondheid. 13 (1), 41-57

Orengo P. (2012). Drug shortage hits public hospitals, Standard Newspaper, Nairobi. Kenya 28th March 2012.

Osborne, S. (2021). Public Service Logic. Routledge

Osborne, S., Powell, M., Cui, T., & Strokosch, K. (2021). Appreciate – Engage – Facilitate': The role of public managers in value creation in public service ecosystems. Public Money & Management, 41(8), 668– 671.

Otundo, J.B. and Bichanga, W.O. (2015). The effect of inventory management practices on operational performance of Kisii country government, Kenya. International Journal of Social Sciences and Information Technology

Parasuraman, Zeithaml and Berry (1985) A conceptual Model of Service Quality and Its Implications for Further Research. Journal of Marketing, 49 (4), 41-50

Pasquet A, Messou E, Gabillard D, Minga A, Depoulosky A, Deuffic-Burban S, et al. Impact of drug stock-outs on death and retention to care among HIV-infected patients on combination antiretroviral therapy in Abidjan, Côte d'Ivoire. *PLoS One* 2010; 5: e13414 10.1371/journal.pone.0013414 [

Riungu, J. M. (2010). Managing health supply chains in Africa. Africa Christian Health Associations Update. (11). Retrieved from www.africahap.org

Rushton, A., Croucher, P., & Baker, P. (2014). The handbook of logistics and distribution management: Understanding the supply chain. Kegan Page Publishers

Sandeep, K. (2017) Supply Chain Management: New Trends and Strategies, information systems

Schmenner, R. W (1986) How can service business survive and prosper? Sloan Management Review, 27 (3), 21-32

Skålén, P., Pace, S., & Cova, B. (2015). Firm-brand community value co-creation as alignment of practices. European Journal of Marketing, 49(3/4), 596– 620

Stephen. Osborne Public Management Review Vol 12 Issue 1 2010-10

The constitution of Kenya. (2010).

Transparency International, (2011), Kenya health sector integrity study report. TI. Nairobi. Kenya.

USAID/DELIVER PROJECT, JSI (2010) The Logistics Handbook: A Practical Guide for the supply chain management of health commodities, Arlington, Va.

USAID | DELIVER PROJECT, (2011). The Logistics Handbook: A Practical Guide for The Supply Chain Management of Health Commodities 2nd Edition, Arlington, Va.: USAID | DELIVER PROJECT

Vargo, S. L., & Lusch, R. F. (2008). Service-dominant logic: Continuing the evolution. Journal of the Academy of Marketing Science, 36(1), 1– 10

Walkowiak, H., and M. Gabra, with G. Sangiwa and Y. D. Mukadi., (2008). A Commodity Management Planning Guide for the Scale-Up of HIV Counseling and Testing Services. Submitted to the U.S. Agency for International Development by the Rational Pharmaceutical Management Plus Program. Arlington, VA: Management Sciences for Health.

Wangu M, (2014) Availability of essential medicines in public hospitals; A study of selected public hospitals in Nakuru, County, Kenya. Kenya Methodist University, Nairobi, Kenya.

Wirtz VJ, Kaplan WA, Kwan GF, Laing RO. 2016. Access to medications for cardiovascular diseases in low- and middle-income countries. Circulation133: 2076–85

World Bank (2015). Managing Records as the Basis for Effective Service Delivery and Public Accountability in Development: An Introduction to Core Principles for Staff of the World Bank and Its Partners. International Records Management Trust. World Bank Publication

Zeithaml, Parasuraman and Berry (1990) Delivering Quality Service: Balancing Customer Perceptions and Expectations. New York: The Free Press

.

ANNEXES

A: INFORMED CONSENT FORM

Dear participant;

RE: REQUEST FOR DATA COLLECTION

I am a Masters student from Strathmore University. As a part of my coursework, I am conducting a study to determine the "APPLICATION OF DEMAND FORECASTING IN OPTIMIZING THE INVENTORY MANAGEMENT SYSTEM TO IMPROVE AVAILABILITY OF ESSENTIAL MEDICINES AND SERVICE DELIVERY" with this Ishiara Level 4 Hospital as a case study.

You have been selected to participate in this research that is largely expected to improve the knowledge of healthcare providers on the importance of embracing and adopting demand forecasting in inventory management to improve access to essential medicines.

With your consent, participation in this study will require that I ask some questions and your responses will be recorded for purposes of analysis. It is also voluntary to participate in this study. Therefore, you can leave the study whenever you are not comfortable or leave some questions unanswered at your will. There are no consequences when you leave the study. It is also my pleasure to inform you that the interviews/survey will be conducted at your convenient time. Confidentiality will be assured and your responses will be kept in a safe and private place.

Thank you for your participation and cooperation.

_____ _____

Participant's Signature Date

B. SURVEY QUESTIONNAIRE

The purpose of this research is to explore the effect of inventory management system on medical supplies and its impact on service delivery at Ishiara Level 4 Hospital. Information provided in your responses will be treated as confidential. Please note that participation in this study is voluntary. Kindly answer all questions

Section 1 Background Information

1. Please tick the health care cadre you fall under
    a. Medical officer
    b. Dental officer
    c. Clinical officer
    d. Nurse
2. Please indicate how long you have worked in this hospital
    a. Less than 5 years
    b. 5 to 10 years
    c. 10 to 15 years
    d. More than 15 years

Section 2

This section contains questions on your understanding on the influence of inventory management on service delivery. Kindly indicate your level of agreement with the statements provided as follows 1- strongly disagree 2- disagree 3- Neutral 4- Agree 5- Strongly agree

No	Statement	1	2	3	4	5
1.	There are regular cases of medicine and supplies stock outs in this facility					
2.	The facility rarely experiences cases of expired drugs and supplies.					
3.	Distribution of medicines to different departments is based on need					
4	Stock out of essential medicines negatively affects staff motivation and service delivery					
5.	Stock out of essential medicines has led to referral of patients					
6.	Stock out of essential medicines has led to reduced patient numbers in the facility					

Section 3

This section contains questions based on the delivery of services at the facility. Kindly indicate your level of agreement with the statements provided as follows 1- strongly disagree 2- disagree 3- Neutral 4- Agree 5- Strongly agree

No	Statement	1	2	3	4	5
1.	Essential medicines in this facility are ALWAYS accessible when needed					
2.	Increased availability of essential medicines can result in improved service delivery at this facility					
3.	Past experiences of delays and or referrals have led to patients seeking healthcare services in a different facility					

Section 4

The questions in this section are based on your understanding of inventory management practices. Kindly indicate your level of agreement with the statements provided as follows 1- strongly disagree 2- disagree 3- Neutral 4- Agree 5- Strongly disagree

No	Statement	1	2	3	4	5
1.	There was primary training on LMIS and computer software use for inventory management					
2.	There are adequate number of staff dealing with inventory management at the facility					
3.	There is a need for further training on LMIS and ICT use for inventory management					
4.	Do you sometimes place emergency orders					

Strathmore UNIVERSITY

16th May 2023

Dr Waneno Nicole Sharon,
nicole.waneno@strathmore.edu

Dear Dr Waneno,

RE: Application of Demand Forecasting in Optimizing the Inventory Management System to Improve Availability of Essential Medicines and Service Delivery- A Case Study of Ishiara Level 4 Hospital

This is to inform you that SU-ISERC has reviewed and **approved** your above **SU-masters** research proposal. Your application reference number is **SU-ISERC1759/23.** The approval period is from **16th May 2023 to 15th May 2024.**

This approval is subject to compliance with the following requirements:

i. Only approved documents including (informed consents, study instruments, MTA) will be used.
ii. All changes including (amendments, deviations, and violations) are submitted for review and approval by SU-ISERC.
iii. Death and life-threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to SU-ISERC within 72 hours of notification.
iv. Any changes anticipated or otherwise that may increase the risks or affected safety or welfare of study participants and others or affect the integrity of the research must be reported to SU-ISERC within 72 hours.
v. Clearance for the export of biological specimens must be obtained from relevant institutions.
vi. Submission of a request for renewal of approval at least 60 days prior to the expiry of the approval period. Attach a comprehensive progress report to support the renewal.
vii. Submission of an executive summary report within 90 days of completion of the study to SU-ISERC.

Before commencing your study, you will be expected to obtain a research license from National Commission for Science, Technology, and Innovation (NACOSTI) https://research-portal.nacosti.go.ke/ and obtain other clearances needed.

Yours sincerely,

for: **Mr Ambrose Rachier,**
Chairperson; SU-ISERC

STRATHMORE UNIVERSITY INSTITUTIONAL SCIENTIFIC AND ETHICAL REVIEW COMMITTEE
(SU-ISERC)
16-May-2023
Email:ethicsreview@strathmore.edu
P.O BOX 59857-00200
NAIROBI-KENYA

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **135876**

Date of Issue: **05/June/2023**

RESEARCH LICENSE

This is to Certify that Dr.. nicole sharon waneno of Strathmore University, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Embu on the topic: APPLICATION OF DEMAND FORECASTING IN OPTIMIZING THE INVENTORY MANAGEMENT SYSTEM TO IMPROVE AVAILABILITY OF ESSENTIAL MEDICINES AND SERVICE DELIVERY- A CASE STUDY OF ISHIARA LEVEL 4 HOSPITAL for the period ending : 05/June/2024.

License No: **NACOSTI/P/23/26198**

135876

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Verification QR Code

NOTE: This is a computer generated License. To verify the authenticity of this document, Scan the QR Code using QR scanner application.

See overleaf for conditions

THE SCIENCE, TECHNOLOGY AND INNOVATION ACT, 2013 (Rev. 2014)
Legal Notice No. 108: The Science, Technology and Innovation (Research Licensing) Regulations, 2014

The National Commission for Science, Technology and Innovation, hereafter referred to as the Commission, was the established under the Science, Technology and Innovation Act 2013 (Revised 2014) herein after referred to as the Act. The objective of the Commission shall be to regulate and assure quality in the science, technology and innovation sector and advise the Government in matters related thereto.

CONDITIONS OF THE RESEARCH LICENSE

1. The License is granted subject to provisions of the Constitution of Kenya, the Science, Technology and Innovation Act, and other relevant laws, policies and regulations. Accordingly, the licensee shall adhere to such procedures, standards, code of ethics and guidelines as may be prescribed by regulations made under the Act, or prescribed by provisions of International treaties of which Kenya is a signatory to
2. The research and its related activities as well as outcomes shall be beneficial to the country and shall not in any way;
    i. Endanger national security
    ii. Adversely affect the lives of Kenyans
    iii. Be in contravention of Kenya's international obligations including Biological Weapons Convention (BWC), Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO), Chemical, Biological, Radiological and Nuclear (CBRN).
    iv. Result in exploitation of intellectual property rights of communities in Kenya
    v. Adversely affect the environment
    vi. Adversely affect the rights of communities
    vii. Endanger public safety and national cohesion
    viii. Plagiarize someone else's work
3. The License is valid for the proposed research, location and specified period.
4. The license any rights thereunder are non-transferable
5. The Commission reserves the right to cancel the research at any time during the research period if in the opinion of the Commission the research is not implemented in conformity with the provisions of the Act or any other written law.
6. The Licensee shall inform the relevant County Director of Education, County Commissioner and County Governor before commencement of the research.
7. Excavation, filming, movement, and collection of specimens are subject to further necessary clearance from relevant Government Agencies.
8. The License does not give authority to transfer research materials.
9. The Commission may monitor and evaluate the licensed research project for the purpose of assessing and evaluating compliance with the conditions of the License.
10. The Licensee shall submit one hard copy, and upload a soft copy of their final report (thesis) onto a platform designated by the Commission within one year of completion of the research.
11. The Commission reserves the right to modify the conditions of the License including cancellation without prior notice.
12. Research, findings and information regarding research systems shall be stored or disseminated, utilized or applied in such a manner as may be prescribed by the Commission from time to time.
13. The Licensee shall disclose to the Commission, the relevant Institutional Scientific and Ethical Review Committee, and the relevant national agencies any inventions and discoveries that are of National strategic importance.
14. The Commission shall have powers to acquire from any person the right in, or to, any scientific innovation, invention or patent of strategic importance to the country.
15. Relevant Institutional Scientific and Ethical Review Committee shall monitor and evaluate the research periodically, and make a report of its findings to the Commission for necessary action.

National Commission for Science, Technology and
Innovation(NACOSTI),
Off Waiyaki Way, Upper Kabete,
P. O. Box 30623 - 00100 Nairobi, KENYA
Telephone: 020 4007000, 0713788787, 0735404245
E-mail: dg@nacosti.go.ke
Website: www.nacosti.go.ke

RESEARCH BUDGET

Item	particular	Quantity	Unit cost	Duration	Amount
1.Personnel	coordinator	1	20,000	-	20,000
2. Equipment	Tablet	1	15000	-	15,000
	USB Drive	1	500	-	500
3. Printing	Printing ink	5 cartridges	2000	-	2000
	Printing paper	3	1500	-	1500
4.Supplies	Internet services	-	5000	-	5000
5. Travel	Transport and accommodation		15000	1 week	15000
6. Registration	Nacosti		1000		1000
TOTAL					She 60,000