

**TOWARDS A DIGITAL HEALTH INFORMATION FRAMEWORK FOR
MANAGEMENT OF ESSENTIAL MEDICINE SUPPLY CHAIN IN PUBLIC
HEALTHCARE FACILITIES IN KENYA**

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FOR THE CONFERMENT OF THE DEGREE OF DOCTOR OF PHILOSOPHY IN
HEALTH SYSTEMS MANAGEMENT IN THE SCHOOL OF MEDICINE AND
HEALTH SCIENCES OF KENYA METHODIST UNIVERSITY**

DECLARATION AND RECOMMENDATION

I declare that this thesis is my original work and has not been presented for a degree or any other award in any other university.

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DEDICATION

This study is dedicated to my mentor, Prof. George W. Odhiambo-Otieno, PhD

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“For there is no more essential duty than that of returning kindness received” Marcus Tullius Cicero (106-43 BC).

ABSTRACT

A digitized health information system for managing the “essential medicine supply chain” is an electronic information system capable of electronically gathering data, processing, and disseminating information for decision-making in the supply chain process. Globally, Wales, Slovenia, Scotland, Estonia, the United Kingdom, the Netherlands, Finland, Denmark, Norway, and Sweden have successfully developed digital health information systems capable of collecting, processing, and disseminating information across other information systems; however, gaps in the early realization of scarcity of essential medicine persist. Vital medicine stockouts in public healthcare facilities in Kenya persist due to incomplete, inaccurate, unreliable, and untimely information flow, poor information processing, insufficient ICT infrastructure, a lack of digitally literate personnel, and the absence of an e-health policy. These issues lead to delays in information sharing, decision-making, access to medicine, and service delivery. The study aimed to develop a “digital health information framework for managing the essential medicine supply chain” in Kenya’s public healthcare facilities. The development of a digital health framework was driven by the need to enhance the use of “digital health information” in managing the vital medicine supply chain as a measure to prevent essential medicine stockouts. The study utilized both quantitative and qualitative research methods, including individual and key informant interviews, in the Counties of Mombasa, Makueni and Kajiado from August to October 2023. To gather information from personnel involved in health information and medical products and supply chain, 150 Healthcare Workers and 14 key informants (Medical Superintendents of Health, Procurement Officers, Health Records and Information Officers and Medical Stores Officers) from a sample frame of 437 health workers in 14 public hospitals. Data was analyzed both descriptively and by inferential statistics. From the multiple linear regression: (i) quality of “digitised health information has a significant influence” on the management of “essential medicine supply chain”; (ii) there is a significant relationship between the digitised health information processing strategy factor and the management of “essential medicine supply chain”; (iii) a “significant relationship exists between ICT infrastructure factor support for health information and management of “essential medicine supply chain”; (iv) there is a significant relationship between workforce skills and management of vital medicine supply chain. The results also showed that the digital health policy affects the relationship between the quality of digitised health information, the strategy for processing digitized health information, ICT infrastructure support, workforce skills, and the management of “essential medicine supply chain” in public healthcare facilities in the three counties. Findings revealed that most of the information available for making decisions regarding managing “essential medicine supply chain” in level 4 and 5 hospitals in Mombasa, Makueni and Kajiado counties is often untimely, incomplete, incorrect, and unreliable. The findings led to the development of a digital health information framework for managing “essential medicine supply chain” in public healthcare facilities in Kenya. The goal is to improve the timely management of “essential medicine supply chain,” increase essential medicine stock availability, and enhance overall healthcare service delivery.

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ABBREVIATIONS AND ACRONYMS

AHB	Africa Health Business
ANOVA	Analysis of variance
CCC	Comprehensive Care Centre
CDSS	Computerised Decision Support System
CIDP	County integrated development plan
CIS	Clinical Information System
CVS	Comma, Separated Values
DG SANTE	Directorate General for Health and Food Safety
DHIS	“Digital Health Information System”
DHP	Digital Health Platform
DIS	“Digital Information System”
eHIS	“Electronic Health Information System”
EMHS	Essential medicine and health supplies
EMR	Electronic Health Record
EXPH	Expert Panel on Effective ways of investing in Health
FEAM	Federation of European Academies of Medicine
FHIR	Fast Healthcare Interoperability Resources
GSMA	Group Speciale Mobile Association
HER	Electronic Health Record
HIE	“Health Information Exchange”
HIS	“Health Information Systems”
HISMSS	“HealthCare Information Management Systems Society”
HIT	“Health Information Technology”
HL7	“Health Level 7”
HMIS	“Health Management Information Systems”
HMT	“Hospital Management Team”
HPT	Health Products and Technologies
HRIO	Health Information and Records Officer
ICT	Information Communication and Technology
ICU	Intensive Care Unit
IDT	Innovation Diffusion Theory

IHMIS	Integrated Health Management Information System
IT	Information Technology
KEMSA	Kenya Essential Medicine Supplies Agency
KHFA	Kenya Health Facility Assessment
KHIS	“Kenya Health Information System”
KHISF	“Kenya Health Information Systems Interoperability Framework”
KHSSIP	“Kenya Health Sector Strategic & Investment Plan”
KMO	Kaiser-Meyer-Olkin
KNH	Kenyatta National Hospital
LAN	Local Area Network
LMIC	Low- and Middle-Income Country
MFL	Master Facility List
MoH	Ministry of Health
MPCU	Model of Personal Computer utilization
MSH	Management Science for Health
MTRH	Moi Teaching and Referral Hospital
NACOSTI	National Commission for Science and Technology Institution
ODK	Open data kit
OECD	“Organization for Economic Cooperation and Development”
PAHO	“Pan American Health Organization”
PC	Personal computer
SDG	Sustainable Development Goals
SERC	Scientific Ethics Research Committee
SMS	“Short Message service”
SPSS	“Statistical Package for Social Science”
SSA	“Sub Saharan Africa”
TAM	“Technology Acceptance Model”
TFHC	Task Force +Healthcare
TOE	Technological Organization and Environment
UHC	Universal health Coverage

UK	United Kingdom
UNDP	“United Nations Development Programme”
UNFPA	United Nations Population Fund
UTAUT	“Unified Theory of Acceptance and Use of Technology”
VIF	Variance inflation factor
WHO	“World Health Organization”
Wi-fi	Wireless Fidelity

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Health systems encompass six building blocks, including the health information systems (“health workforce, access to essential medicines, leadership and governance, health information systems, healthcare service delivery, and health systems financing”). These blocks are essential for the management of “essential medicines supply chain” (Aila & Kithuka, 2021; Oreni et al., 2021; World Health Organization [WHO], 2021). Access to safe and effective essential medicines is regarded as a fundamental human right and a key priority within Kenya's Vision 2030 development plan (Adebisi et al., 2022; Ministry of Health [MoH], 2020a). However, there is still a critical concern globally about the stockouts of essential medicines (MOH, 2020a; WHO, 2019). Significantly, drug shortages have a major impact on “middle- and low-income countries,” leading to serious health and economic challenges (Shukar et al., 2021).

The digitization of health information systems significantly enhances the overall performance of the healthcare sector, particularly in the management of medical products and essential medicines. Digital systems streamline the tracking, ordering, and distribution of medical supplies, enabling healthcare providers to monitor stock levels in real time, forecast demand accurately, and prevent stockouts or overstocking. Furthermore, digital health systems provide better transparency and accountability in the supply chain process (Beaulieu & Bentahar, 2021). By recording and analyzing data digitally, healthcare facilities can track the movement of medicines from

procurement to dispensing, reducing the risk of pilferage, fraud, or wastage. In countries like Rwanda, the use of digital platforms for managing medicine stocks has been associated with significant improvements in service delivery, as facilities can ensure that essential medicines are always in stock. The digital transformation also aids in regulatory compliance and reporting, as systems can generate accurate reports on medicine usage, helping health authorities make informed policy decisions and respond more effectively to shortages or surpluses (WHO, 2021). These examples highlight the critical role of digitization in driving efficiency, transparency, and better patient outcomes in the health sector.

The success of digital health initiatives hinges on several key factors, including the availability of human and technological resources, a well-defined strategy, and strong organizational leadership (WHO, 2021). Human resources, such as skilled healthcare workers trained in digital systems, and reliable technological infrastructure are critical to ensure that digital health activities function smoothly. Without these, even the most advanced systems can underperform or fail to achieve their intended outcomes. Additionally, a robust and clear strategy provides a roadmap for implementing digital health solutions effectively, aligning them with broader healthcare goals. Leadership plays an equally vital role by ensuring that these initiatives are properly funded, supported, and aligned with organizational priorities. Furthermore, effective coordination of digital health efforts is essential to avoid fragmentation, where uncoordinated initiatives may lead to inconsistent information flows and hinder efficient service delivery (WHO, 2021). A well-coordinated approach ensures that digital health systems are integrated, fostering better communication across various health departments and improving overall patient care outcomes. Uptake and

application of digital technologies, including AI systems, IoT devices, and cloud infrastructure, in the healthcare sector are hindered by human limitations, including poor or lack of training of healthcare personnel in digital health technology applications (Karijo et al., 2021).

Information and communication technology (ICT) is used in health products and technologies to collect and process information for the day-to-day management of essential medicines (MoH, 2020a). Digital Information systems (HISs) such as electronic health records (EHR), clinical information systems (CIS), and master patient indexes (MPI) use electronic devices that collect, store, process, and send health data and information to support healthcare service delivery (Bagayoko et al., 2020 and Khubone et al., 2020). The digital information systems mentioned in this study are fully electronic and utilize ICT technology to collect, process, and disseminate data. Concerning ““essential medicine supply chain”” systems, a digital system is an electronic information system that is capable of electronically aggregating, analyzing, and sending information to support the supply chain process (MoH, 2020a).

Significant global investments have been directed towards digital health information systems to improve evidence-based healthcare service delivery (Tulu et al., 2021). Countries such as Wales, Slovenia, Scotland, Estonia, the United Kingdom, Finland, the Netherlands, Denmark, Norway, and Sweden have successfully adopted the District Health Information System (DHIS), showcasing its effectiveness in streamlining health data management and enhancing decision-making processes (Community Interest Company [CIC], 2021). These implementations highlight the

potential of digital systems to transform healthcare by providing reliable, real-time data that supports better resource allocation, patient care, and overall health system performance. The success of these countries in integrating DHIS underscores the importance of technological infrastructure, policy support, and training in realizing the benefits of digital health systems (Stoumpos et al., 2023).

Developing countries have strived to implement DHISs to enable real-time information sharing. However, many HIS initiatives, particularly those focused on essential medicine management at healthcare facilities, have faced challenges due to inadequate planning, fragmentation, and lack of system integration (Bagayoko et al., 2020). Due to this, around two billion people worldwide continue to suffer from preventable illnesses and deaths due to delayed access to essential medicines (Ozawa et al., 2019).

In Africa, more than 800,000 children die annually from malaria, a preventable and treatable disease, primarily due to delays in accessing effective essential medicines (WHO, 2021). Despite the availability of affordable treatments, many children and adults in developing countries continue to suffer and die from conditions that could be managed with timely interventions. Diseases such as malaria, pneumonia, and diarrheal illnesses—among the leading causes of death and disability—persist because of systemic barriers to essential medicine access, including supply chain inefficiencies, poor healthcare infrastructure, and insufficient healthcare funding (Toroitic et al., 2022). Addressing these challenges through improved management of medicine supply chains and expanding access to necessary treatments could drastically reduce mortality and improve health outcomes across the continent (Yusuf et al., 2022).

In Sub-Saharan Africa, shortages of essential medicines significantly affect both public healthcare facilities and patients, leading to widespread consequences (Toroitich et al., 2022). For healthcare facilities, such shortages disrupt service delivery, impairing their ability to provide adequate care and maintain consistent treatment regimens, especially for chronic conditions like HIV, tuberculosis, and malaria (Shukar et al., 2021). The lack of essential medicines also strains healthcare workers, forcing them to make difficult decisions about patient care and often resort to less effective or more expensive alternatives. For patients, these shortages can result in delayed treatments, worsening of medical conditions, increased out-of-pocket costs, and, in severe cases, death. Additionally, such shortages erode trust in the healthcare system, particularly in rural and underserved areas where access to alternative sources of medication is limited (Shukar et al., 2021). This creates a cycle of health inequities, further marginalizing vulnerable populations in the region.

Regarding the suitability of DHIS mechanisms to prevent medicines stockouts in Africa, evidence depicts that such initiatives suffer lack of integrated DHIS, insufficient internet connectivity, inaccessible electricity and insufficient workforce skills (WHO, 2019). Other limiting factors include low data quality, insufficient technical infrastructure and uncoordinated supervision (Beaulieu & Bentahar, 2021; Ibeneme et al., 2022; Khubone et al., 2020; Nandikove, 2020).

Within the East African Region, DHIS are marked by disintegration, duplications, information errors, and insufficient information to support “essential medicine supply chain” management (Neumark & Prince, 2021; Ibeneme et al., 2022). However, some

countries such as Uganda have succeeded in applying mTrac mobile device to collect medical data, carry out analysis, and ensure seamless communication among health personnel.

Hospitals require adequate essential medicines to deliver quality healthcare services (Tiyé & Gudeta, 2018). However, the continuous availability of adequate quantities of essential medicine in hospitals requires a digital information system that can effectively collect, process, and produce quality, correct, and timely information to enhance “essential medicine supply chain” management (*ibid*). Studies in Tanzania, Malawi, Ghana, and Lesotho show that quality management of essential medicines in public healthcare facilities was hampered by incorrect quantification in stock cards, incomplete information, delayed information submission, inaccessibility of information by supply chain managers, weak reporting systems, inaccurate and untimely information on essential medicines, poor supervision and monitoring and lack of management support leading to frequent essential medicines stock out (Tiyé & Gudeta, 2018). In a study of health facilities in Nairobi County, Kenya, all healthcare facilities experienced both drug shortage and drug expiry, with 75% of the healthcare facilities due to poor information and lack of proper visibility of essential medicine inventory (Ganatra et al., 2020).

Kenya has made significant strides and investments in digital health solutions (MoH, 2021a). However, these efforts remain fragmented, with many initiatives not fully integrated into the country's health information system network (Nyangena et al., 2021). The Kenya Health Information System (KHIS) struggles with issues such as

unreliable and delayed data, which hinder the effective management of the “essential medicine supply chain” at the facility level. A study conducted in Kitui County found that healthcare facilities are not effectively using the health information they generate to detect stockouts of essential medicines (Karijo et al., 2021). Despite the availability of data, it is not being leveraged to monitor or address shortages in critical drug supplies. This underutilization of health data contributes to ongoing gaps in medicine availability.

Many studies have highlighted deficiencies in the digitalization of health information systems that are crucial for managing the essential medicines supply chain and preventing stockouts (Kanfe et al., 2020; Nandikove, 2020; WHO, 2008). It is suggested that transforming digital health information technology within hospitals could greatly enhance the quality and timeliness of data for managing the “essential medicine supply chain”, thereby reducing the risk of stockouts (Kim & Song, 2022). While numerous studies have examined aspects of health product and technology supply chains, such as access, availability, and cost, there is a lack of research specifically addressing the integration of digital health information with “essential medicine supply chain” management to prevent stockouts. This study aimed to assess the influence of digital health information on the management of “essential medicine supply chain” and develop a framework for using digital health in this area in Kenya’s public healthcare facilities.

1.2 Statement of the Problem

Essential medicine stockout in public healthcare facilities in Kenya persists despite implementing the Kenya Health Information System and other electronic health information systems. In 2017 and 2018, millions of patients in Kenya were faced with delays or cancellation of care, longer hospitalization, disabilities, and death due to essential medicine stockout in 44 per cent of public healthcare facilities (Hellen et al., 2021; MoH, 2020a; Toroitich et al., 2022). Priority gaps causing essential medicine stockout in public healthcare facilities in Kenya include manual system of management of “essential medicine supply chain”, poor data quality in public facilities, inaccurate information on essential medicines consumption, inadequate essential medicine data analysis at facility, poor quantification of essential medicines and lack of or inadequate supervision of staff charged with quantification and sharing of information on supply chain. The timely availability of essential medicine stock is affected by inadequate quality information flow within the hospital, poor consumption data, and poor information processing on medicines visibility within the hospital (MoH, 2020a). The Ministry of Health shows that essential medicine quantification requirements at the hospitals are not based on correct information processing and actual hospital requirements. The lack of enough health staff with proper digital health information skills and inventory management skills has been implicated by the Ministry of Health as a contributing factor to medicine stockout in hospitals. Additionally, lack of or poor ICT infrastructure, lack of written policies or inadequate enforcement of policies on “digital health information for essential medicine stock and inventory management at the public healthcare” facility level contributes to poor quantification of medicines, inaccurate orders in the supply chain and essential

medicine stockout (MoH, 2021a). Inefficient or absence of supportive supervision of personnel charged with documenting medicine and medical products causes inferior quality information, resulting in medicine stock out (MoH, 2020b). Persistence of the above gaps in mitigating essential medicine stockout means the continuation of detrimental effects on patient care: delays or cancellation of care, longer hospitalization, disabilities, or death (Ganatra et al., 2020; Federation of European Academies of Medicine [FEAM], 2021; Shukar et al., 2021 & Toroitich et al., 2022). The study aimed to develop a digital health information framework for managing the “essential medicine supply chain” in public healthcare facilities in Kenya to mitigate perennial essential medicine stockouts in public healthcare facilities. The study conveys valuable information for future research in digital health information systems.

1.3 Purpose of the Study

The study aimed to create a digital healthcare information framework to manage the supply chain of essential medicines in Kenya's public healthcare facilities. The development of a digital health framework was driven by the necessity to enhance the use of digital health information for managing the supply chain of essential medicines, which would reduce stockouts of essential medicines in public healthcare facilities in Kenya.

1.4 Objectives of the Study

The objectives of this study were:

1.4.1 To determine the “influence of the quality of digitized health information on essential medicine supply chain management in public healthcare facilities in Kenya.”

1.4.2 To determine the “influence of digitized health information processing strategy on essential medicine supply chain management in public healthcare facilities in Kenya.”

1.4.3 To determine the “influence of ICT infrastructure support for essential medicine supply chain management in public healthcare facilities in Kenya.”

1.4.4 To examine the influence of workforce skills on essential medicine supply chain management in public healthcare facilities in Kenya.

1.4.5 To develop a framework for using digital health to manage essential medicine supply chain in Kenya’s Public hospitals.

1.5 Hypotheses of the Study

The study evaluated the following null and alternative hypotheses:

H01: Quality of digitized health information does not significantly influence “essential medicine supply chain” management in public healthcare facilities in Kenya.

H1: The quality of digitized health information significantly influences “essential medicine supply chain” management in public healthcare facilities in Kenya.

H02: There is no significant relationship between the digitized health information processing strategy factor and “essential medicine supply chain” management in public healthcare facilities in Kenya.

H2: There is a significant relationship between digitized health information processing strategy factors and “essential medicine supply chain” management in public healthcare facilities in Kenya.

H03: There is no significant relationship between ICT infrastructure support for health information and “essential medicine supply chain” in public healthcare facilities in Kenya.

H3: There is a significant relationship between ICT infrastructure support for health information and “essential medicine supply chain” management in public healthcare facilities in Kenya.

H04: There is no significant relationship between Workforce skills and “essential medicine supply chain” management in public healthcare facilities in Kenya.

H4: There is a “significant relationship between Workforce skills and essential medicine supply chain management in public healthcare facilities in Kenya.”

1.6 Justification of the Study

There has been little progress in providing timely, evidence-based quality information for efficient supply chain management of essential medicines in public healthcare facilities in Kenya. According to the Ministry of Health, Kenya, essential medicines stockout stockouts at public healthcare facilities have become common and frequent due to incorrect, incomplete, and untimely information for decision-making for managing medicine supply chain processes. The Ministry of Health, Kenya, promotes digitalization in the health sector, including the management of medical products and technologies; hence, recommendations on how digital health information could support mitigating essential medicine stockout are paramount. Several studies have been undertaken around “essential medicine supply chain” focusing on access, availability, and costing; however, studies that explore the use of digital health information linked to the management of “essential medicine supply chain” to mitigate essential medicine stockout are inadequate. This study was therefore important for

finding out how digital health information influences the timely management of “essential medicine supply chain” to mitigate stockout in Kenya's public healthcare facilities (WHO, 2021; Organization for Economic Cooperation and Development [OECD], 2019; World Bank, 2018).

1.7 Limitations of the Study

This study had several limitations. Only a small subset of individuals from the sampled public healthcare facilities in 3 of 47 counties were included in the study. Although a sizeable sample was selected to ensure representation of the three counties, there was no control that all the targeted respondents would participate. It was also noted that not all the respondents would equally be knowledgeable and skilled about digital health information systems and health information dissemination within their facilities. This was also confounded by the fact that the study was designed to focus on level 4 and 5 public healthcare facilities leaving out the faith-based and private health facilities. Because of that situation, the study anticipated that the selection of the study respondents might not meet the target for generalization.

The participants in the study were selected from Pharmacists, Medical Officers/Clinicians, and Health Records Information Officers working in level 4 and 5 facilities in the 3 Counties of Mombasa, Kajiado, and Makueni. The respondents were selected based on their engagement and role in the facility's pharmacy, medical stores, and health information systems. Because of the inadequate deployment of Health Records Information Officers in all public health facilities in Kenya, it was envisaged that the study could be faced with limited access to research respondents in some healthcare facilities to respond to critical questions. Secondly, it was anticipated

that during the rainy season or because of logistical challenges, the interviewer would face limited access to appropriate participants or geographic limitations to a health facility. Due to this possibility, the study was designed in a way so that the healthcare facility in charge, the County Health, or the county Records Information Officer would have to respond to the research question to cover the health facilities facing such limitations. The interpretation of the study findings was limited to digitized health Information in level 4 and 5 healthcare facilities in Kajiado, Makueni, and Mombasa. It was also noted that Information generated in the routine care of patients would be limited in its use for analytical purposes because it could be inaccurate, incomplete, and transmitted in ways that undermine its meaning (Hoyt et al., 2014). Finally, the researchers lacked control over facility personnel deployment to implement the information system, leaving the possibility of residual confounding factors.

1.8 Delimitation of the Study

The study took place in Kenya in Kajiado, Makueni, and Mombasa counties to investigate the influence of digital health information on the management of the “essential medicine supply chain.” Research design: The study used mixed methods of research, including semi-structured interviews and statistical analysis. The sample population and respondents were drawn from 11 levels 4 and 3 level 5 public healthcare facilities in the three counties. 164 sample size was selected 14 key informants (Medical Superintendent of Health, Health Records and Information Officers, Procurement Officers, Medical Stores Officers) through purposive and 150 semi-structured interview respondents (Health Records and Information Officers, Procurement Officers, Medical Stores Officers, Clinical Officers, Nurses,

Pharmaceutical Technologists, and Medical Officers) through simple random sampling.

1.9 Significance of the Study

The findings of this study are important to all stakeholders (The government of Kenya, Ministry of Health, Ministry of ICT & innovation, international donors, health informatics organizations, civil societies, research institutions and academicians from universities) because it provides evidence-based recommendations and solutions to improve the use of digital information systems in the management of essential medicines supply chain to mitigate against essential medicine stock out in public healthcare facilities in Kenya. The Ministry of Health acknowledges that timely quality information is essential for the management of the “essential medicine supply chain” and mitigation against medicine stock out in the delivery of quality health care (MoH, 2020b). It also benefits the Ministry of Health in Kenya, and the County Health Departments by strengthening the digitization of health records and information processing and sharing to support effective “essential medicine supply chain” management.

Academic Institutions: - the study provides literature to scholars for reference and future research in digital health information systems.

The digital health information framework for managing the “essential medicine supply chain” in Kenya’s public healthcare facilities will contribute to improved mitigation measures against essential medicine stockouts. This study's report conveys valuable information for future research in digital health information systems.

1.10 Assumptions of the Study

The following were the study assumptions:

- i. Public healthcare facilities were willing to share information about disseminating digitized information captured in their information systems.
- ii. The health workforce in public healthcare facilities understands the use and collection of digitized information to facilitate the smooth dissemination of information within and between health facilities and KHIS.
- iii. there existed a shared trust and willingness between public healthcare facility staff and healthcare facility management to share information on the system within the facility.
- iv. Digitized information dissemination within the public healthcare facility and between different HIS was already happening.
- v. Healthcare workers have good insights into the ICT environment in their facilities.
- vi. Data collected from the health information system were relevant.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter reviews the literature related to the study. Under it, the chapter breaks down the literature into the following segments: Quality of digitized health information for use in the management of essential medicine supply chain; Digitized health information processing strategy for use in managing essential medicine supply chain; ICT infrastructure support for management of essential medicine supply chain; Workforce skills in digital health information for the management of essential medicine supply chain; Policy on Digital Health Information in management of “essential medicine supply chain; and Management of Essential Medicine Supply Chain. The chapter also presents a theoretical and a conceptual framework.

2.2 Quality of digitized health information for use in the management of essential medicine supply chain

A digitized health information system refers to an electronic information system that uses ICT technology and is capable of electronically gathering data, process (aggregating, analyzing, and disseminating information and, in the case of essential medicine, supporting supply chain processes (MoH, 2020b). An operational information system results in fast, correct, reliable and quality production, analysis, and “dissemination of information on health system performance, health determinants, and health status to enhance healthcare service delivery” (Koumamba et al., 2021; Lemma et al., 2020; Nkanata et al., 2018; Pan American Health Organization [PAHO], 2021; WHO, 2007). Quality data encompasses consistency, accuracy, timeliness and completeness, which are essential for effective information processing and

dissemination at health facilities (Rumisha et al., 2020). As Lugada et al. (2022) presuppose, high-quality and reliable data is vital for enhancing supply chain planning at the facility level. Despite this, the WHO (2021) reports that many countries' HIS fall short in providing the necessary data to support effective “management of the essential medicine supply chain.”

Universally, approximately 40% of data quality in many countries does not meet the standards requisite for effective service delivery (WHO, 2021). In the UK, for example, Goundrey-Smith (2019) asserts that the high-rate accessibility of medicines in hospitals is closely tied to the quality of data from medicine management systems. This includes accurate information on medicine dispensing, administration, and the documentation of medication transfers within facilities. Goundrey-Smith (2019) emphasizes that the data should enhance evidence-based medicine management and patient care. Additionally, Goundrey-Smith (2019) notes that “electronic transfer of medication information in England has facilitated greater connectivity between different information systems.” According to (WHO, 2018), the lack of thorough evaluation of essential medicine data quality in Kenyan healthcare facilities undermines the effectiveness of managing the “essential medicines supply chain.” Lugada et al. (2022) highlight that accurate information on medicine consumption is crucial for those managing inventories and procurement to effectively forecast needs and prevent stockouts. They further note that digitalization offers significant benefits to the “essential medicine supply chain” by enhancing information generation, accuracy, and dissemination. However, Lugada et al. (2022) also identify persistent

issues at health facilities, such as insufficient availability of information, unreliable reporting, and inaccuracies, which hinder effective inventory management.

2.2.1 Reliability of health information for use in the management of “essential medicine supply chain”

United Nations Development Programme [UNDP] (2022) and WHO (2021) urge nations to enhance the dependability of “information systems to better support evidence-based procurement and distribution of essential medicines.” Ngusie et al. (2022) underscore that timely, accurate, and reliable data is crucial for providing “high-quality healthcare services.” Aila and Kithuka (2021) and Kuyo et al. (2018) highlight that while there is a global commitment to enhancing the timeliness, quality, and relevance of health information, many Sub-Saharan African countries continue to face challenges due to reliance on “paper-based data collection and storage systems,” which often result in errors and data gaps. Waithira et al. (2019) emphasize that reliable and accurate data is crucial for effective information sharing. According to Meloan and Lacopino (2017), the predominant use of paper-based methods in many African nations for managing medicine stocks contributes significantly to issues of stock-outs. Odekunle et al. (2017) opine that reliance on paper-based recording in hospitals in Africa, which has hindered the adoption of digitalization in hospital health information systems, is an outcome of several factors, among them lack finance, poor electricity, limited computer skills among users, internet connectivity, and procurement and maintenance of ICT infrastructure. Ibeneme et al. (2022) argue that some health facilities rely on paper-based systems because, where electronic health records systems exist, they are fragmented, do not support interoperability, and cannot capture and share real-time data across different sectors. Ibeneme et al. (2022) also observed that

low governance and management capacity to coordinate digital health information systems also contribute to continued reliance on paper-based systems and gaps in the ability of digital health information systems to support health service delivery. The MoH (2020b) underscores the importance of establishing a dependable system for collecting, consolidating, and reporting data on consumption. Such a system is essential for achieving a more precise alignment between the demand and supply of medical commodities in healthcare facilities.

The Life Program has successfully utilized a Short Messaging Service (SMS) to enhance the monitoring and management of essential medication supplies, including those used for malaria treatment, at primary healthcare centers (Signé, 2021). By enabling real-time communication and reporting, this SMS-based system has proven effective in ensuring the availability of critical drugs, reducing delays in replenishment, and improving overall supply chain efficiency. This approach has been particularly beneficial in resource-limited settings where timely access to essential medicines is vital for patient care. Despite these advancements, Koumamba et al. (2021) underscores the challenges faced by numerous African countries in obtaining high-quality information due to issues with data timeliness, reliability, consistency and completeness. Similarly, PAHO (2021) reports that 62% of countries in the Caribbean region lack adequate technology and basic tools—such as ICT hardware, software, and internet connectivity—necessary for generating reliable information.

Management Sciences for Health (MSH, 2012) highlights the importance of reliable data for effectively coordinating the flow and distribution of medical supplies. The

organization notes that essential data on medicine movement and needs—whether stored in digital databases, card files, ledgers, or physical folders—must be consistently managed within healthcare facilities. Regularly updated reports on medicine usage are crucial for forecasting needs, evaluating usage patterns, and tracking trends (MSH, 2012). Training for health personnel on the use of medical information forms is essential for ensuring the accuracy of recorded data and reliable quantification (MSH, 2012).

However, MoH (2021b) acknowledges challenges related to the accuracy and reliability of health product data. It also notes that discrepancies between annual quantifications of health products, procurement plans and budget estimates result in significant mismatches between expected and actual medicine availability. This misalignment has led to a 46% quantification gap in several counties, including Lamu, Nairobi, Mandera, Homabay, Kilifi, and Marsabit, causing stockouts and service disruptions (MoH, 2021b). The strategy further indicates that the use of fragmented information systems for reporting various health commodities results in inconsistent report generation.

2.2.2 Timeliness of health information for use in the management of “essential medicine supply chain”

Effective management of “essential medicine supply chain” relies heavily on the timeliness of health information. Timely data enables healthcare facilities to forecast medicine needs accurately, make informed procurement decisions, and avoid stockouts. As outlined by Kuyo et al. (2018) the ability to promptly gather, analyze, and report medicine consumption data is crucial for optimizing inventory levels and ensuring that essential medications are available when needed. Studies emphasize that

delays in reporting or data processing can lead to significant gaps in the supply chain, impacting patient care and leading to avoidable shortages (Tiye & Gudeta, 2018).

Digital health information systems have emerged as key tools in enhancing the timeliness of health information. According to WHO (2021), the integration of digital technologies such as electronic health records and real-time reporting systems has the potential to streamline data collection and dissemination processes. For instance, the implementation of automated systems can reduce human error, expedite data transfer, and facilitate more accurate and timely updates on stock levels. However, despite advancements in digital technology, challenges persist, particularly in low-resource settings where infrastructure and access to technology may be limited (Koumamba et al., 2021).

The significance of timely health information is further supported by studies in specific regions. In East Africa, for example, Ibeneme et al. (2022) highlight that fragmented information systems and inconsistent data reporting can undermine efforts to manage the “essential medicine supply chain” effectively. On the other hand, successful implementations such as Uganda’s mTrac system have demonstrated the benefits of using mobile technology to enhance the timeliness of health data reporting, thus improving medicine availability and management (Signé, 2021). These examples underscore the critical role that prompt and reliable information plays in mitigating the risks of stockouts and ensuring continuous supply chain efficiency.

Despite these advancements, several studies point to persistent issues with data timeliness and accuracy. For example, the Kenya Health Information System (KHIS)

faces challenges in providing reliable and timely information, which is essential for managing essential medicines effectively (Nyangena et al., 2021). These findings illustrate that while digital systems can offer improvements, ongoing efforts are necessary to address infrastructure limitations and ensure that data remains timely, accurate, and actionable across various healthcare settings.

2.2.3 Completeness of health information for use in the management of essential medicine supply chain

The completeness of health information plays a pivotal role in the management of “essential medicine supply chains” across various global contexts. In Europe, countries like the Netherlands have set benchmarks for data completeness with their integrated health information systems (WHO, 2021). The Netherlands has developed a robust electronic health record (EHR) system that consolidates data from different healthcare providers into a unified platform. This system enhances the completeness of medicine inventory records and facilitates accurate forecasting and distribution, thereby minimizing the risk of stockouts. The Dutch model highlights how comprehensive data integration can lead to more efficient supply chain management and better health outcomes.

In the United States, the Centers for Disease Control and Prevention (CDC) emphasizes the importance of complete and timely data for managing the medicine supply chain. The CDC's National Healthcare Safety Network (NHSN) collects detailed data on medication use and safety, which is crucial for monitoring trends, detecting shortages, and managing inventory (Kanfe et al., 2022). The NHSN's approach ensures that healthcare facilities have access to complete data, enabling them

to make informed decisions about procurement and distribution. This example underscores how thorough data collection and reporting contribute to effective supply chain management and improved patient care.

Asia presents a diverse range of experiences with health information completeness in supply chain management. In India, the National Health Mission has implemented the eSanjeevani platform, which integrates data from various health services to provide a comprehensive view of medicine usage and availability. This digital platform has been instrumental in improving the completeness of health information, allowing for better management of essential medicines and timely responses to shortages. However, challenges remain in rural areas where data collection may be less consistent, highlighting the need for ongoing improvements in data completeness.

In Africa, the situation varies significantly across countries. In Kenya, for instance, the Kenya Health Information System (KHIS) has faced challenges with data completeness, as highlighted by Toroitich, et al. (2022). Incomplete and inconsistent reporting has led to discrepancies between actual medicine availability and reported needs, affecting supply chain efficiency (Nyangena et al., 2021). Conversely, countries like Rwanda have made strides in improving data completeness with their electronic health information systems, which have enhanced the management of essential medicines and reduced stockouts (Ngusie et al., 2022).

The experiences in Latin America also provide valuable insights. In Brazil, the Sistema de Informação de Insumos Estratégicos (SIES) is a comprehensive system that tracks

medicine supplies and usage across the country (Kharbanda et al., 2020). The SIES platform integrates data from multiple sources, ensuring completeness and accuracy in inventory management. This system has been effective in addressing medicine shortages and optimizing supply chain operations. The Brazilian example illustrates how complete data reporting and integration can enhance the management of essential medicines in diverse healthcare settings.

2.3 Digitized health information processing strategy for use in managing essential medicine supply chain

Meloan and Lacopino (2017) declare that reliance on paper-based processes or inadequate investments in ICT may cause problems with the supply chain management of essential medicine and stockouts. Meloan and Lacopino (2017) assert that transitioning from paper to digitizing supply chain management and medicine inventory is key in addressing essential medicines stockout. Bwana et al. (2014) state that digital technologies offer opportunities for improvement in data collection, quantification, forecasting, and dissemination in many areas of the medicine supply chain. Bwana et al. (2014) further add that the digital dissemination of information can improve the management of essential medicine supplies within the facility.

Fahy et al. (2021) state that digital health technology has been used in numerous countries to ensure quality and timely information for monitoring any adverse response to a vaccine during mass vaccination. Some countries utilize digital technologies to support the distribution of essential medicines to health facilities (Fahy et al., 2021). Fahy et al. (2021) also cite the case in Israel where digital surveillance was used to track Pfizer vaccines from US factories to the time of distribution in health facilities

in Israel during the pick-in COVID-19 cases. Fahy et al. (2021) further argue that adopting digital technologies requires shifting from paper-based recording to electronic record keeping, data entry by health workers, and the involvement of managers and administrators at all levels of support for planning and service delivery. Kharbanda, et al. (2020) state that the first stage of digitization system of facilities' information systems should involve the modernization and digitization of systems that are used to gather, share, and analyze vast amounts of complicated (confidential) patient and other clinical data. WHO (2008) claims that information is only produced after data have been gathered, managed, and analyzed.

2.3.1 Data Analysis into information for use in the essential medicine supply chain management

UNDP (2022) states that in many countries the capacity to analyze the data for the management of essential medicine into information that can effectively be used to manage the supply chain and inventory at health facilities is inadequate. UNDP (2021) observes that should be the work of trained personnel to conduct data analysis through a digital solution. WHO (2021) states that a standard process for analyzing data accuracy, completeness, consistency, and processing should be in place within a facility-based health information system. The World Health Organization raised concerns in 2021 that over 40% of health facilities worldwide lack the capacity to provide evidence of data quality analysis and the processes behind it. This points to significant gaps in HIS, which are critical for ensuring the availability, accessibility, and reliability of health data. Data quality is essential for effective decision-making in healthcare, including supply chain management of essential medicines, patient care, and overall health system planning.

Without the ability to assess and demonstrate the quality of their data, many health facilities may be relying on incomplete, inaccurate, or outdated information. This can result in poor forecasting, understocking, or overstocking of essential medicines, and ineffective responses to public health challenges (WHO, 2021). The inability to analyze data quality suggests that these facilities are not adequately equipped with the necessary tools, infrastructure, or training to manage and monitor health information effectively. Furthermore, the lack of evidence on data quality processes indicates that health facilities may not be following standardized protocols for data collection, validation, and reporting (WHO, 2021). This could contribute to errors in the information flow, leading to inefficiencies in healthcare delivery and resource allocation. For example, inaccurate data on medicine consumption or stock levels could lead to stockouts or wastage, negatively impacting patient care and health outcomes.

The WHO's concern emphasizes the need for global efforts to strengthen health information systems by improving data quality, training health workers on data management, and investing in infrastructure that enables data analysis. Ensuring that health facilities can verify the quality of their data is essential for improving the management of “essential medicine supply chains,” supporting evidence-based healthcare decisions, and ultimately enhancing the resilience of health systems globally. MoH (2020a) states that once data on essential medicine is reported, it paves the way for monitoring, aggregation, and analysis. MoH (2020a) notes that analysis of data on different essential medicine indicators should be conducted to guarantee

consistent aggregation, and dissemination of information to support “planning, supply chain, and service delivery.” Data should be analyzed to produce correct, timely, complete, reliable, and consistent to support the “management of the essential medicine supply chain” (MoH, 2020a).

The WHO (2008) remarks that data analysis is necessary to guarantee quality comparable information for planning and service delivery. WHO (2021) observes that quality processed information should be available to all users to encourage transparency, accountability, openness, and good planning and service delivery. Nkanata et al. (2018) observe that delays by information systems to produce timely analysis information affect meaningful evidence-based planning and delivery of service.

MoH (2020a) observes that data collected through digital solutions may be analyzed daily to assess essential medicine stock status, on a monthly or quarterly basis, to decide on resupply or order and track medicine quantities. Stobierski et al. (2022) argues that when information processing (analysis) is flawed decisions based on such flawed information risk producing incorrect information that affects planning and service delivery. Beaulieu and Bentahar (2021) opines that the current electronic health records relied upon by many health systems are limited because they cannot analyze (process) and aggregate multiple data sources and organize and communicate “information that can support the planning and management of the essential medicine supply chain.” Although information products are developed in “low- and middle-income countries (LMICs),” deficiencies exist in systematic and uniform methods for

information processing (analysis) and presentation from various project-specific systems (*ibid*). Mulaki and Muchiri (2019) also note that there is a dearth of statisticians and epidemiologists at the county and sub-county levels, which makes it difficult to analyze essential medicine consumption data to support “essential medicine supply chain” management. OECD (2019) notes that the lack of analytical capacities in most countries' health information systems is the key obstacle to using information for supply chain management.

2.3.2 Data processing (extraction) into information to manage essential medicine supply chain.

In 2012, MSH (2012) stated that digitized information systems process data much faster due to digital formula programming. This automation makes the quantification and forecasting of medicines more effective and readier to support supply chain management. MSH (2012) further notes that if the data formula and entry are correct digital solutions will process correct estimates of the needed essential medicines. MSH (2012) opines that while manual extraction of the quantities of essential medicines in the facility takes a long time through typing or rewriting tables, quantification, forecasting, and printing take place at the touch of a button in a digitized system. Toroitich et al. (2022) shows that health facilities in Kenya have a problem with inadequate essential medicine data processing (extraction) and visualization of essential medicines at the facility to support supply chain management.

The WHO (2008) claims that the extraction of data is the fundamental part of data processing and compilation. WHO (2008) points out that data from many sources must be extracted, quality verified, and conformance achieved through data transformation

before it can be combined with data from other sources. Data extraction and transformation processes, according to the WHO (2008), are important because they enable the rectification of errors and missing data. The goal of data extraction (processing) is to deliver reliable and quality data (WHO, 2008). Jen et al. (2023) opine that the digitization of healthcare information systems progresses the data extraction process by all health sector stakeholders. Jen et al. (2023) further notes that when a health information system is digitized, data can automatically be collected, processed, and presented in meaningful real-time visibility through figures, graphs, and dashboards. Onyango (2024) notes that digitizing information on a single platform is important for essential medicine monitoring and coordinating multiple source information for supply chain management.

Jen et al. (2023) state that although electronic medical records (EMRs) can retrieve data instantaneously from an electronic data warehouse, unfortunately, EMRs across several providers cannot electronically send information between them. Jen et al. (2023) further note that efforts are underway to construct a digital solution to expedite the retrieval of patient information generated across different health information systems. Ogbuju and Obunadike (2020) note that “digital data are easier to extract, and process compared to textual data.” They further observe that while a manual review of textual medical data is “time-consuming and labor-intensive, digital extraction of information from it makes vital information usually buried within more accessible for planning and service delivery.”

Reiner (2015) states that healthcare professionals face challenges in extracting and retrieving medical information due to the lack of integration of health information systems. Miljković et al. (2020) noted that due to the use of a paper-based system, the extraction of essential medicine data sometimes leads to delays or poorly disseminated essential medicine “information for planning and service delivery.” Miljković et al. (2020) observed that some professionals are unable to know that the medicines they are prescribing are not in stock because of the use of non-digital systems that are not able to process correct information in time. Miljković et al. (2020) explains that in 2020, six European hospitals experienced stockouts of antibiotics because they lacked timely information on medicine stockouts. Miljkovic et al. (2020) state that timely dissemination of processed essential medicine information is important for managing the “essential medicine supply chain” and inventory management. Miljković et al. (2020) allude that the lack of timely processing and sharing of information on essential medicines in hospitals is one of the main barriers to the “management of the essential medicines supply chain.” Miljković et al. (2020) further indicate that a lack of adequate digital solutions, a lack of human resources, and poor workforce skills are associated with poor sharing of information on essential medicine management.

Onyango (2024) posits that a lack of data integration and interoperability impedes clinical decision-making, affecting the healthcare sector's capacity to obtain accurate information about population and individual health. Onyango (2024) argues that inequities and inequalities in access to quality healthcare are due to a lack of clarity on the use of digital health technologies, lack of interoperability, inefficient funding for the purchase and maintenance of digital health technology, uneven distribution or

shortages of healthcare personnel and inefficient procurement system. Cory and Stevens (2020) argue that the interoperability of data that allows information to flow between different facilities and countries is essential for harnessing healthcare data. Cory and Stevens (2020) posit that a lack of technical expertise and the understanding of standards, regulations, and tools to facilitate interoperability are the main barriers to data sharing in low and middle-income countries.

2.3.3 Data Collection for information for use in the management of the essential medicine supply chain

UNDP (2022) opines that globally efficient health information systems are crucial to producing quality information to inform timely planning and service delivery. WHO (2021) states that because of poor quality of information health care interventions rarely address the needs of people at the right time. WHO (2021) further observes that poor data collection negatively affects health policies, service delivery and public health including the “essential medicine supply chain.” WHO (2021; OECD 2019) and World Bank (2018) argue that while most developed nations invest between “2 and 4% of the total health expenditure to improve information systems, most low- and developed countries invest less than 1% of the total health expenditure on health system hence poor investment in digitized data collection tools.” Rubio-Rivas et al. (2021) argue that HIS systems in Latin America and Africa have poor data associated with a lack of or inadequate implementation of digital HIS strategies.

PAHO (2021) states that 55% of the Caribbean Region, to a larger extent, use paper-based data collection methods and as such data have limited use at the facility. PAHO

(2021) further notes that 44% of the Caribbean Region countries do not collect data but rely on international organizations' estimation. Tull (2018) sees data collection processing skills as being important to the production of information that is relevant for the improvement of health service delivery. Tull (2018) and Kariuki et al. (2016) state that due to varying skills, measurement errors, human error, and missing data in several LMICs a large volume of health data reaches the collected national level without verification. Sanjuluca et al. (2022) notes that health information systems weaknesses start at the data collection stage. Rubio-Rivas et al. (2021) argue that without correct, complete, and accurate data collection on essential medicine consumption and availability at the facility level for supply chain management, HIS information will only be for use at the National Level.

Koumamba et al. (2021) observe that specific context-specific Health Information Systems solutions make the collection and dissemination of information to the National level, yet the non-digital solutions undermine the facility-level capacity to collect data. Cory and Stevens (2020) opine that it is important that the data collected is representative and addresses the emerging needs of the population. Aila and Kithuka (2021) observed a disconnect between data collection and usage of information because data are not converted into valuable information that can be easily used for planning and service delivery. The “management of public health facilities at various levels in Kenya is more concerned about collecting and reporting health data” through HIS. However, little is known about how individual facilities analyze, report, and give information for use at the facility level. Muinga et al. (2020) state that short notice

changes in data collection templates occasioned by MoH in Kenya Public Hospitals are challenging to implement digital health systems.

MSH (2012) observed that in a fragmented system, incomplete and inaccurate data collection causes the entire process to take several months to produce data that is useful for quantification, forecasting, and “essential medicine supply chain” management. MoH (2020a) states that reliable, steadfast tools for information collection, collation, and reporting are essential for ensuring the right linkage between the demand and supply of essential medicines. Muinga et al. (2020) state that essential medicines consumption data in level 4 public hospitals in Kenya are produced at a specific time using either computerized or manual systems. Muinga et al. (2020) posit that manual systems are much slower and have a high error rate. Muinga et al. (2020) allude that digital information systems for essential medicine involve the electronic collection of data to reduce errors and cost of operation and increase efficiency in the control and planning of “essential medicines supply chain management.” Muinga et al. (2020) further note that digitized supply chain “information systems should be connected to various service delivery units” in the facility to produce accurate, timely information and increase efficiency in reporting and service delivery.

United Nations Population Fund [UNFPA], 2020) states that health facilities' data collection on medicines helps managers monitor medicine stock levels in the inventory. OECD (2019) notes that a large volume of data routinely collected in the facilities is not well used to inform essential medicine availability and stockout rate. OECD (2019) further observes that because of the essential medicine monitoring gap

in hospital management, the supply chain lacks correct information that can help to address the challenges of essential medicine stockout.

2.4 ICT infrastructure support for management of essential medicine supply chain

The MoH (2021b) acknowledges that while there has been a growing “use of information and communication technologies (ICT) to enhance the management of the essential medicine supply chain in public health facilities across counties, the full benefits of digitalization are yet to be realized.” Several barriers continue to hinder the full implementation of ICT systems in managing essential medicines. One significant challenge is the inadequacy or poor state of ICT infrastructure in many counties, which limits the ability to fully digitize and automate processes in the supply chain. This insufficient infrastructure includes outdated hardware and software that are unable to support the advanced features required for a more efficient digital system.

Another obstacle to the comprehensive digitalization of the “essential medicine supply chain” in Kenya is the frequent breakdown of these systems. System failures and downtimes disrupt the continuity of healthcare services, making it difficult for healthcare providers to track the supply and demand of essential medicines effectively (MoH, 2021b). These interruptions often result in delays in the timely delivery of medicines and other health products to the patients who need them. Moreover, the lack of reliable internet access further complicates the situation. Many health facilities, particularly in rural and underserved areas, experience shortages of internet bundles or unstable connections, making it challenging to maintain consistent communication and data transfer between healthcare facilities and central supply systems (MoH, 2021b).

In addition to infrastructure challenges, the lack of adequate digital skills among healthcare personnel is a major hurdle in the digitalization process. Many health workers do not possess the necessary training or expertise to fully utilize ICT tools for managing the “essential medicine supply chain” (Toroitich et al., 2022). This lack of technical knowledge impedes their ability to efficiently use digital platforms for tracking, ordering, and managing medicine inventories. Consequently, the overall effectiveness of the ICT systems is diminished, and the potential for streamlining the supply chain remains largely untapped. To address these challenges, there is a need for investment in ICT infrastructure, continuous training for health workers, and more reliable internet access to fully leverage the benefits of digitalization in managing essential medicines in Kenya’s health system.

2.4.1 Computer use in information for the management of “essential medicine supply chain”.

Meloan and Lacopino (2017) highlights that the limited or inefficient use of information and communication technology (ICT) in managing essential medicine data is a significant contributor to frequent stockouts in healthcare settings. The lack of digital tools for processing and tracking medicines leads to inadequate visibility into stock levels, which in turn results in delayed or inaccurate forecasting and replenishment of essential drugs. This situation is particularly problematic in low-resource settings, where manual processes are still prevalent, making it difficult to respond swiftly to shortages. As a result, healthcare facilities are often unable to meet patient needs, causing treatment delays and interruptions in care. The report underscores that addressing this issue requires an urgent shift towards the adoption of ICT to streamline medicine management processes.

In response to these challenges, Meloan and Lacopino (2017) observe that both pharmaceutical companies and governments have begun exploring the potential of digital ICT solutions to enhance the management of essential medicines. By integrating digital tools, stakeholders aim to improve the quantification and visibility of medicines within the supply chain, ultimately reducing the occurrence of stockouts. These efforts focus on ensuring that timely and accurate information is available to health professionals, enabling better planning, forecasting, and requisition of medicines. The implementation of such technologies is expected to improve the efficiency of supply chains by enabling real-time data sharing between different actors, from pharmaceutical manufacturers to healthcare facilities, thereby improving access to essential medicines for patients.

The adoption of ICT in healthcare systems brings numerous advantages, particularly in the realm of essential medicine management. Meloan and Lacopino (2017) highlight the benefits of digitalization, including real-time monitoring of medicine availability, which allows for the continuous tracking of stock levels. This visibility supports proactive decision-making regarding drug requisition and resupply, reducing the chances of shortages. Moreover, Ali (2011) and Abdullah et al. (2017) emphasize that computerized health information systems can significantly improve pharmacy inventory management by automating various processes, including stock tracking, order placement, and record-keeping. As ICT continues to evolve, the global healthcare sector is increasingly leveraging these technologies to solve long-standing challenges related to the supply and availability of essential medicines.

Agarwal et al. (2018) argue that the swift expansion of information technology worldwide presents scalable solutions that can be adapted to address specific challenges in medicine supply chains, ensuring a more reliable supply of essential medicines. Bwana et al. (2014) show that ICT facilitates information on medicine consumption demands and stockouts between departments. Meloan and Lacopino (2017) observe that paper-based processing causes issues with drug stock management (insufficient stock allocation, no medicines available) because most facilities are not ICT-equipped. Because of this situation, health facilities are battling to meet the need for essential medicine (Meloan & Lacopino, 2017).

Nkanata et al. (2018) emphasize that the use of ICT in hospitals significantly improves the collection and broadcast of high-quality information, which is essential for effective planning. By integrating ICT tools into healthcare systems, facilities can streamline data capture, ensuring that accurate and reliable information is available for decision-making processes. This enhanced data collection allows health administrators to better manage resources, forecast needs, and make informed choices about medicine procurement and distribution. As ICT adoption continues to grow, the impact on the management of essential medicines becomes increasingly evident, particularly in improving data accuracy and responsiveness within the healthcare system.

The adoption of ICT within the healthcare sector also fosters the digitization and connectivity of various healthcare processes, as noted by Tortorella et al. (2022). This integration spans across medical supplies, patient care, and administrative functions, creating a more interconnected and efficient system. By leveraging ICT, healthcare

organizations can ensure that critical processes, such as the management of medical supplies and patient data, are digitized, reducing the reliance on manual systems. This connectivity enables seamless communication between different departments and healthcare actors, resulting in more coordinated and effective healthcare delivery. The digitization of these processes is particularly beneficial in the supply chain, where accurate and real-time data is crucial for maintaining “the availability of essential medicines.”

Moreover, Tortorella et al. (2022) highlight that “an ICT-driven approach provides reliable real-time management of digital information systems” for various healthcare functions, including the supply chain, medical supplies, patient diagnosis, and treatment. The ability to manage these functions in real time ensures that healthcare providers can respond quickly to emerging needs and challenges, such as medicine shortages or patient care requirements. For instance, real-time monitoring of medical supplies allows for timely replenishment, preventing stockouts and ensuring the continuous availability of essential medicines. Additionally, real-time data on patient diagnoses and treatments supports more personalized and effective care, enhancing patient outcomes. The integration of ICT into healthcare systems thus represents a significant advancement in the management of both medical supplies and patient care, offering a more efficient and responsive approach to healthcare delivery.

Michalski et al. (2015) highlight the significance of automation in the healthcare sector, particularly in enhancing the overall efficiency of a country's healthcare system. The introduction of computerized systems allows for better management and organization of health data, making it easier to store, access, and analyze vital

information. This digital transformation reduces reliance on outdated manual processes, resulting in quicker data retrieval, more accurate records, and better-informed decision-making. With computerization, healthcare systems can offer more streamlined and effective services, improving patient care and resource management across the board.

Panth and Charya (2015) further emphasize how crucial computers are in “data collection and the processing of health information.” By automating these processes, computer systems help health professionals, educators, and decision-makers access the necessary information more efficiently. This accessibility is key in ensuring that health professionals have real-time data to make informed decisions regarding patient care, resource allocation, and overall healthcare strategies. Computer systems not only facilitate the accurate recording of patient and medicine data but also allow for more complex analyses, which are crucial for monitoring trends, evaluating outcomes, and forecasting future needs in healthcare.

Moreover, Toroitich et al. (2022) argue that the implementation of computerized systems in healthcare is essential for improving information management. In an era where healthcare is increasingly data-driven, the ability to efficiently collect, store, and process large volumes of health data is critical for ensuring the smooth operation of health services. Computerization helps in creating a more connected and integrated health system where information can flow seamlessly between departments, facilities, and professionals. This improved information management leads to more coordinated care, better management of health supplies, including essential medicines, and

ultimately a more responsive healthcare system capable of meeting the growing demands of public health.

Selcuk (2023) and Muinga et al. (2020) highlight several challenges that hinder the effective use of digital information systems in Kenyan healthcare facilities, including the theft of computers, insufficient supplies of computers and peripherals, frequent power outages, and damage to network equipment. These issues create significant obstacles for healthcare providers attempting to implement and utilize digital systems for managing patient records, essential medicine supplies, and other critical health information. The lack of adequate technological resources further exacerbates these challenges, making it difficult for health facilities to fully transition from paper-based to digital systems. These infrastructure-related limitations are not unique to Kenya but are common across many low- and middle-income countries (LMICs), where healthcare systems struggle with similar technological deficits.

Akhlaq et al. (2016) further emphasize that infrastructure deficiencies, such as the absence of essential components like computers, printers, and alternative power sources, significantly “hinder the successful implementation of digital health solutions in LMICs.” One of the critical barriers in these regions is the unreliability of electricity, which disrupts the smooth operation of digital systems. Without a stable power supply, healthcare facilities face constant interruptions, limiting their ability to manage essential medical data and ensure that information flows efficiently across the supply chain. The lack of infrastructure also complicates the storage and retrieval of health

data, making it difficult for health workers to access up-to-date information when needed.

Tull (2018) adds that technical barriers that encompass the absence of standardized data, “restrictive data formats, and a lack of technical ICT solutions, further complicate the dissemination and use of health information within facilities.” These technical constraints can result in fragmented data systems, where information cannot be shared or accessed seamlessly across different platforms. This lack of standardization impairs the ability of healthcare providers to accurately track medicine inventory, assess consumption patterns, and make informed decisions about restocking essential medicines. Consequently, the inability to efficiently share and utilize health data hampers the overall management of the “essential medicine supply chain”.

On a more positive note, the WHO (2008) points out that recent advances in information and communication technology (ICT) have provided new solutions for presenting and processing complex health information. These advancements include improved data visualization tools, cloud-based storage systems, and mobile health applications, which have the potential to enhance data accessibility and real-time monitoring of health systems. However, despite these technological innovations, the adoption of these tools in LMICs remains slow due to the ongoing challenges with infrastructure and the technical capacity of health facilities. In many cases, health facilities lack the expertise and resources needed to integrate these advanced ICT solutions into their daily operations.

Tull (2018) also highlights how poor ICT capacity at both the county and facility levels hinders the effective management of the “essential medicine supply chain”. Frequent system breakdowns, inadequate internet connectivity, and insufficient ICT infrastructure, such as computers and network systems, prevent healthcare facilities from fully utilizing digital health systems to manage medicine inventories. Furthermore, the lack of internet bundles and unreliable connectivity disrupt the flow of information between facilities and the central supply chain, leading to delays in the requisition and distribution of essential medicines. These infrastructural challenges, combined with the need for more comprehensive ICT training for health workers, continue to obstruct the development of a more efficient, digitally driven supply chain for essential medicines in Kenya.

2.4.2 Electricity connectivity to support information dissemination in managing “essential medicine supply chain”

Moner-Girona et al. (2021) and Chen et al. (2019) emphasize the critical importance of reliable electricity in the operation of information and communication technology (ICT) systems, medical devices, and other essential equipment in healthcare settings. Without a stable power supply, healthcare facilities cannot effectively operate the technological tools that are necessary for modern healthcare service delivery, such as those used in patient monitoring, diagnostics, and the management of essential medicines. ICT systems, which play a pivotal role in managing health data and supporting decision-making processes, require a constant supply of electricity to ensure smooth operation. Therefore, in settings where electricity is unreliable, the functionality of these systems is significantly compromised, leading to inefficiencies in healthcare delivery.

Moner-Girona et al. (2021) extend this argument by highlighting the specific challenges faced by healthcare facilities in rural Sub-Saharan Africa (SSA), where electricity supply is often inconsistent or entirely absent. These facilities face significant operational difficulties due to frequent power outages, which impede the use of ICT infrastructure and medical equipment. The lack of reliable power not only affects the capacity to maintain electronic health records but also hinders the timely processing of data necessary for managing the “essential medicine supply chain”. Cahill (2021) supports this view by revealing that “only 28% of healthcare facilities in eight SSA countries have reliable access to electricity,” a statistic that illustrates the widespread nature of this problem. Such limitations have far-reaching consequences, particularly in rural areas, where health facilities are already underserved and heavily reliant on digital systems to ensure efficient service delivery.

Signé (2021) further underscores the adverse effects of power outages in rural SSA hospitals and clinics, emphasizing how frequent interruptions in electricity can severely affect the functioning of digital information systems. These systems are vital for managing essential medicines, and any disruption in their operation compromises the entire supply chain. Without the ability to accurately monitor medicine stock levels, predict shortages, or request timely resupply, healthcare providers in these areas struggle to maintain adequate supplies of life-saving medications. The impact of unreliable electricity extends beyond stock management, affecting overall service delivery and potentially endangering patients who rely on continuous treatment for chronic and acute conditions.

In Malawi, for instance, Suhlrie et al. (2018) report that “public health facilities are often connected to off-grid electricity systems,” which are more prone to interruptions

compared to those operated by private or non-governmental entities. These off-grid systems lack the capacity to support the continuous operation of medical equipment and digital health infrastructure, leading to frequent downtimes that disrupt health services. As a result, the capacity to manage the “essential medicine supply chain” is significantly reduced, and healthcare providers are unable to make data-driven decisions on restocking and medicine distribution. In regions where off-grid solutions are the primary source of power, ensuring the reliability of electricity supply remains a significant challenge that needs to be addressed to improve healthcare outcomes.

Aila and Kithuka (2021) also note that consistent issues with electricity supply affect the broader functioning of computers and data analysis systems in healthcare facilities. Without a stable power source, data collection and processing become unreliable, which, in turn, impairs health information systems' ability to support essential functions such as planning, inventory management, and forecasting in the medicine supply chain. This inefficiency trickles down to other aspects of service delivery, as healthcare providers cannot access the information they need to make informed decisions. The lack of dependable electricity thus has a cascading effect on all aspects of healthcare management, highlighting the need for sustainable solutions to ensure uninterrupted power supply in low-resource settings.

Therefore, the lack of reliable electricity in rural healthcare facilities across SSA severely limits the effective use of ICT systems and medical devices, with far-reaching implications for the management of essential medicines. As Chen et al. (2019) and others have pointed out, addressing these infrastructural challenges is critical for ensuring the smooth operation of health services. Without it, digital systems that are crucial for improving healthcare outcomes cannot be fully utilized, and the overall

efficiency of the healthcare system remains compromised. Therefore, improving electricity access in healthcare facilities, particularly in rural areas, is an essential step towards enhancing the capacity of these facilities to manage their medicine supply chains and deliver high-quality care to patients.

2.4.4 Internet connectivity for dissemination of digital health information in the management of essential medicine supply chain

In many healthcare facilities, especially in low-resource environments, weak internet infrastructure limits the ability of staff to access real-time data needed for informed decision-making (Muinga et al., 2020). Without reliable internet access, critical health information systems are unable to function optimally, resulting in delayed data transmission and disruptions in the “essential medicine supply chain”. This affects not only inventory management but also the timely delivery of medical services, as healthcare providers struggle to make data-driven decisions without up-to-date information. Thus, the lack of consistent internet access poses a significant barrier to the full utilization of digital health information.

Kuyo et al. (2020) further highlight the specific challenges faced by hospitals in Uasin Gishu County, Kenya, in relation to the use of information from the District Health Information Software 2 (DHIS2) platform. According to their study, 47.1% of these challenges stemmed from unreliable internet connectivity, while 48.6% were due to inadequate user skills, 36.7% resulted from non-connected computers, and 34.3% were attributed to insufficient management support. This combination of factors undermines the effective use of DHIS2 for planning and service delivery. The lack of adequate internet connectivity, coupled with low digital literacy among healthcare staff, leads

to poor utilization of health data, which in turn compromises healthcare delivery. Additionally, the absence of necessary infrastructure, such as connected computers, further limits the capacity of healthcare facilities to leverage digital tools for effective planning.

Although Kenya has made significant strides in the adoption of information and communication technology (ICT), internet connectivity, and mobile phone usage, the full potential of digital health information systems remains unfulfilled. Toroitich et al. (2022) note that factors such as “low levels of digital literacy and the high cost of internet data continue to impede the effective use of digital health information for planning and informed service delivery.” Even in a country that is considered a regional leader in ICT, many healthcare facilities still face obstacles in fully integrating digital systems into their operations. As a result, healthcare workers cannot make the most of the digital tools at their disposal, further exacerbating inefficiencies in managing essential medicine supply chains and delivering timely medical services. These barriers highlight the need for continued investment in internet infrastructure, digital literacy programs, and management support to fully unlock the potential of digital health information systems in healthcare.

Omona (2005) notes that the Internet allows computers to exchange data and information regardless of their hardware or operating systems. Omona (2005) adds that the Internet is useful for communication as and for accessing and exchanging information; however, in most cases, it is not regulated by any government or institutional body. Cline and Haynes (2001) note that wide access to health information via the Internet can increase widespread connection and dissemination of health

information. MSH (2012) posits that good internet and telecommunication networks save and reduce personnel time and cost on data processing and reporting on essential medicines and supply chain management. WHO (2021) states that access to the internet, broadband, equipment, and literacy in information technologies are more essential as digital health becomes more established to support essential medicine data and supply chain management. MSH (2012) also states that internet connectivity in the facility improves information delivery time and saves resources for better planning and service delivery. Konduri et al. (2018) allege that limited computer infrastructure, poor internet connectivity, and intermittent electricity can deter digital health technologies from supporting planning and service delivery.

2.5 Workforce skills in digital health information for the management of essential medicine supply chain

Tulu et al. (2021) notes that developing countries have invested significant personnel and financial resources to increase the quality of information that comes from HIS. However, HIS in these countries still produces inadequate quality information. Tulu et al. (2021) adds that some of the reasons contributing to inadequate quality information include unskilled personnel, high workloads, and weak data at the health facility. The HIS in Ghana and Tanzania faced significant implementation challenges due to inadequate training of personnel, poor staff involvement, and increased workload (Tull, 2018). Nkanata et al. (2018) state that the major challenge with the health sector in most developing countries is the lack of trained human personnel. Nkanata et al. (2018) note that low investment in personnel training contributes to poor ICT implementation in planning and service delivery in the health sector in Kenya. Tulu et

al. (2021) further observes that training aims to equip and improve health facility staff with skills to perform their tasks.

At both the national and county government levels in Kenya, the supply chain management of medicines and medical products is primarily handled by pharmacists and pharmaceutical technologists. These professionals are responsible for overseeing the procurement, storage, distribution, and overall management of the “essential medicine supply chain”. Their role is crucial in ensuring that medicines and medical products are always available and accessible across healthcare facilities within their jurisdiction. Toroitich et al. (2022) emphasize the importance of these roles in maintaining an efficient and reliable supply chain for essential medicines, which is necessary to prevent stockouts and ensure continuous healthcare delivery.

At the health facility level, however, supply chain management responsibilities are distributed across a wider range of healthcare professionals. Medical laboratory technologists, clinical officers, nurses, pharmacists, and pharmaceutical technologists all contribute to the management of essential medicines within their respective facilities. Each of these professionals plays a unique role in the supply chain process, whether it is in the ordering, storage, or distribution of medicines. Their collective efforts ensure that the health facility runs smoothly, and that patients have timely access to the medications they need. The MoH (2021b) recognizes that a multidisciplinary approach to supply chain management at the facility level is vital for addressing the complex needs of healthcare delivery in the country.

Despite the involvement of multiple healthcare professionals, challenges remain in ensuring the effective management of medicine and medical products at the facility level. The MoH (2021b) highlights gaps in training and coordination among these healthcare workers, which can result in inefficiencies in the supply chain. For instance, the absence of clear communication and defined roles between the various professionals involved in the supply chain can lead to delays in medicine requisition and stock management. Additionally, the lack of specific training in supply chain management for non-pharmaceutical staff, such as clinical officers and nurses, may result in improper handling or recording of essential medicines. Strengthening the capacity of all healthcare workers involved in supply chain processes is therefore crucial to ensuring the seamless operation of the supply chain at the facility level.

Notably, procurement and procurement planning are the work of supply officers and supply chain officers (MoH, 2021). In programs, these functions are carried out by a different cadre of staff within the programs (ibid). The Pharmacist coordinates medicine and medical products supply chain functions at the county government level and receives quality assurance reports and facility data. In contrast, the head of the supply chain or procurement officer does the procurement (MoH, 2021). At levels 4 to 6 facilities, the pharmacist coordinates the dispensing of medicine and medical products, while at levels 2 and 3, nurses and clinical officers' conduct that task, including supply chain functions. Oreni et al. (2021) observe that most staff that perform the medicine and medical products supply chain functions learn on the job and through attending courses sponsored by pharmaceutical supply chain management development programs.

2.5.1 Staff training for the use of digital health information in the management of essential medicine supply chain

WHO (2008) notes that poor training in data processing produces inadequate quality information that cannot support evidence planning and service delivery. Duncan et al. (2022) notes that the following indicators, education and training, data and digital literacy, individual competence and technology use, and the workforce skills factors, evaluate the degree to which hospital personnel are competent to use digital health technology to support planning and service delivery. The education and training index reflects the hospital's initiatives to give people chances to gain experience and hone their skills and abilities to work together (ibid). Khubone et al. (2020) state that research in Botswana and Uganda has demonstrated the importance of a workforce with a strong background in health information systems. Aila and Kithuka (2021) note that poor use of information at the facilities results from staff members' lack of technical knowledge and capacity to gather and combine data into useful information. Ohia et al. (2021) observe that restricted access to technological tools and lack of technology literacy hinder the “acceptance of digital health solutions in low- and middle-income countries.” Uasin Gishu Hospitals, for instance, illustrates the crucial digital literacy gap and usage of information from DHIS2 (Kuyo et al., 2018). In the Marsabit County assessment of the healthcare institutions, Aila and Kithuka (2021) reported that 78.5 per cent of healthcare professionals lacked training in the use of information. 4.15 per cent of the healthcare workers had no computer skills, which may have made it difficult for them to manipulate raw data to produce information appropriate for planning and service delivery (ibid). Most healthcare workers (74.61%) had basic computer abilities (Aila & Kithuka, 2021). Ganatra et al. (2020) observe that

there is a deficit in essential medicine inventory management due to inadequate ICT skills.

African health workers' low adoption of digital health technology results from a lack of skilled digital health employees (Olu et al., 2019). Cory and Stevens (2020) note that providing digital training to unskilled workforce in the health sector could improve digital skills in line with WHO's "Global Strategy on Digital Health 2020–2024" objectives. Cory and Stevens (2020) further contend that few low- and middle-income countries have workforce training in digital skills capacity building. Few African institutions of higher learning in public health provide pre- or in-service courses in digital health, contributing to the decision-makers' and healthcare professionals' lack of awareness and comprehension of digital health (Olu et al., 2019). Cory and Stevens (2020) suggest that the key digital health skill gaps include those for nurses, doctors, administrators, and policymakers. To adopt, run, and effectively utilize eHealth technologies to enhance health, Kenya's National eHealth Policy 2016–2030 recognizes the need for a larger workforce that is trained in these skills (MOH, 2020). Ohia et al. (2021) note that healthcare personnel with the necessary information technology skills and expertise are more likely to be open to using modern technologies like digital health information technology applications. Users with access to ICT are determined by network administrators, developers, designers, and general end users (Kyalo et al., 2018). Digital technology adoption “is a complicated process that is influenced by several elements at the human level, including perceived usefulness and ease of use, training, supporting circumstances, personality attributes, computer fear, and self-efficacy” (Jacqueline et al., 2020). Beaulieu and Bentahar

(2021) suggests that through encouraging data literacy, health systems can enhance team members' use of information. Beaulieu and Bentahar (2021) add that healthcare organizations are more likely to be information-driven if team members respect and prioritize data use. Health organizations cannot become information-driven if team members lack confidence in data (Beaulieu & Bentahar, 2021). Team members can improve data literacy and the possibility that users will use information in everyday decisions (*ibid*). A basic digital skills shortage is evident among the health workforce, especially in rural and remote areas of LMICs (Cory & Stevens, 2020). Measure Evaluation (2019) observes that human resource capacity in terms of county leadership and health professionals with adequate digital health initiatives to support digitalization is weak at the county level.

Measure Evaluation (2018) highlights the need to offer skills and knowledge to health facility staff through mentoring and training. MoH (2020) stipulates that staff responsible for keeping essential medicine records should be adequately trained in the collection and processing of data. Lugada et al. (2022) observe that hospital stockouts are caused by ineffective supervision and oversight, inadequate supply chain system management skills, and poor inventory management. On the other hand, Lugada et al. (2022) opine that a skilled workforce and adequate competence in quantification, recording, and monitoring of stock support better essential medicine visibility and control.

WHO (2021), OECD (2019) and World Bank (2018) advocate for countries to modernize the curricula for pre-service training and in-service education of health

workers to improve core competencies in nursing and medicine. WHO (2021), OECD (2019) and World Bank (2018) further stress that healthcare workers should receive continuous professional development to improve their skills and knowledge. Kariuki et al. (2018) stresses the empowerment of health workers to visualize and analyze data in Kenya's Health Information System to ensure the availability of essential medicines in all facilities in Kenya. The World Bank (2021) acknowledged the importance of nurses, skilled doctors, pharmacists, and other healthcare practitioners, to deliver better quality healthcare.

2.5.2 Management support for the use of digital health information in the management of essential medicine supply chain

Effective management support is crucial for the successful operation of essential medicine inventory and supply chain management within healthcare systems. This support encompasses several key elements, including comprehensive staff training and ongoing supervision, which ensure that personnel are well-equipped with the knowledge and skills necessary to manage medicine inventories efficiently (Rubio-Rivas et al., 2021). Additionally, adequate financial resources are essential to maintain and improve the infrastructure required for effective supply chain operations. Without sufficient funding, it becomes challenging to procure and maintain the necessary equipment, manage stock levels, and handle unexpected demands or shortages. Furthermore, accurate and reliable data is indispensable for effective planning and decision-making in medicine inventory management. Accurate data helps in forecasting needs, tracking inventory levels, and identifying potential issues before they escalate into critical problems.

In addition to training and financial support, management support also involves the implementation of robust data systems and processes that facilitate the accurate recording and analysis of information. Reliable data systems enable healthcare facilities to monitor stock levels in real-time, anticipate supply needs, and make informed decisions about procurement and distribution (Rubio-Rivas et al., 2021). This is essential for preventing stockouts and ensuring that essential medicines are consistently available. By investing in staff development, providing necessary financial backing, and ensuring access to accurate data, healthcare management can significantly enhance the efficiency and effectiveness of the medicine supply chain. This holistic approach to support not only improves inventory management but also contributes to the overall quality of healthcare delivery.

Globally management support interventions intend to reinforce organizational values, rules, and culture for usage of information for planning and efficient service delivery. Rubio et al. (2021) add that good management support is beneficial for establishing and strengthening HIS architecture and infrastructure to support efficient planning and service delivery. Goundrey-Smith (2019) argues that management support is needed to implement information systems across organizational boundaries to support hospitals to implement information technologies that support medicine supply chain management. Rubio-Rivas et al. (2021) note that in Europe, good management support has stimulated technological advances in basic information systems improvements for planning and service delivery. WHO (2019) opines that Managers can project and respond to essential medicine stock shortages with timely access to digital information

on essential medicine stock availability. WHO (2021); OECD (2019) and World Bank (2021) state that globally, management support for efficient information management is still weak in several health systems. Muthuri et al. (2021) observe that poor management support in Meru County resulted in the delay in the delivery of medical supplies, inadequate stock of essential medicines, and patient complaints.

Tull (2018) observes that in Botswana weak management support, weak policy, and regulatory framework hinder the progress of the national HIS. Tull (2018) states that good management support can help solve the facility's challenges of poor data quality. Tulu et al. (2021) notes that some studies suggest that management support, supportive supervision, and feedback can influence the use of health information in the facility. Tulu et al. (2021) also observes that in Ethiopia, managers who received training on information management and supervision were 3.7 times more likely to supervise and use health information in planning than those who did not receive the training. Koumamba et al. (2021) observe that the main factors that often threaten the stability of HIS in developing countries are weak management support.

Laukka et al. (2020) point out that healthcare managers in health information technology implementation were found to diffuse information when they performed their roles as change managers and facilitators. Healthcare leaders, top management, clinical leaders, and middle managers support their subordinates and colleagues in training and health information technology usage in the organization. However, Laukka et al. (2020) also note that some healthcare leaders lack an understanding of health information technology and, therefore, lack an understanding of how to provide management support to subordinates. Tull (2018) points out that management support

is important for fostering norms for improving data processing and usage of information at the facility level and beyond. Hospital Management Team (HMT) in Kenya provides management support through planning, advocating for resources, budgeting, supervision, and implementation of policies (Muthuri et al., 2021). Tull (2018) notes that high-level manager's familiar with data collection, entry, and management within the EMR and HIS system can provide management support in improving information produced in the facility; however, the level of support from the senior manager is insufficient.

Konduri et al. (2018) argue that healthcare management teams are important for checking information on the quality and availability of medicines in supply chain management. Konduri et al. (2018) state that managers are better equipped by using digital information systems to forecast and manage the supply chain to mitigate against medicine stockout compared to using paper-based systems. WHO (2021), OECD (2019) and World Bank (2021) opine that consistency of management support is a key ingredient for fostering vibrant “essential medicine supply chain” management.

2.5.3 Supervision for using digital health information in managing the essential medicine supply chain.

Avortri et al. (2019) note that many studies show poor supportive supervisory procedures in several LMIC countries. Avortri et al. (2019) add that supportive supervision in LMICs is affected by small numbers of the workforce and inadequate skills. Avortri et al. (2019) further point out that supervisory mechanisms in several low- and middle-income countries are irregular, unsupportive, and demotivating. Tull (2018) cites Ethiopia as a country without a supervisory checklist for data and health

information quality checks. Tulu et al. (2021) affirms that supportive supervision, feedback, and training are elements that promote the usage of health information. Teklegiorgis et al. (2016) posit that 80 per cent of the facilities in Ethiopia did not use information because of low quality of supervision and feedback. Shiferaw et al. (2017) comment that health workers in Ethiopian government facilities who were regularly supervised and received feedback were highly motivated to utilize health information compared to those who were neither supervised nor received feedback.

Khubone et al. (2020) opine that obstacles to digital information system implementation in LMICs include a lack of supportive supervision, an inadequate number of staff, and staff's ability to conduct tasks. Kuyo et al. (2018) observe that lack of supervision and feedback were among the biggest obstacles to using information in Uasin Gishu hospitals. MSH (2012) argues that automation and application of modern technologies alone, without closer supervision and personnel training, is not easy to achieve better accuracy in information management.

2.6 Policy on Digital Health Information in management of “essential medicine supply chain”

Koumamba et al. (2021) note that developing strategies and policies on HIS is important in Africa because it assures HIS implementation even without external support. “Kenya National Pharmaceutical Policy,” sessional paper 4 of 2012, aims to ensure that Kenya achieves access to essential pharmaceutical services, health technologies, and quality essential medicines (MoH, 2020a).

MSH (2012) states that successful pharmaceutical management is anchored on legal framework and policy that support and set up people's commitment to essential medicine supply. Toroitich et al. (2022) observe that health commodities management systems policy guidelines outline the type of information system infrastructure, procedures for appropriate use, collection of accurate commodities consumption data, ways of “data analysis and dissemination of information for planning and service delivery.”

Regulatory and legislative barriers limit data sharing and linkages and prevent the use of data in many countries (OECD, 2019). OECD (2019) notes that obstacles to data sharing could be addressed by implementing digital technology surmise that a fit-for-purpose policy and ICT infrastructure are the main enablers of Africa's future competitiveness and prosperity.

MSH (2012) advises that a national medicine policy should have a human resources management element that spells out the roles of different healthcare practitioners, including a plan for the education and training of personnel. Ministry of Health Kenya formulated regulations on the use of health information for health products and technologies (HPT); however, efficient support for the HPT supply chain is hindered by fragmented health systems (MoH, 2021b).

The regulatory framework for health products and technologies in Kenya is primarily guided by the Kenya Health Policy, National Pharmaceutical Policy, and the Health Act of 2017. These documents are designed to ensure the quality and accessibility of

essential medicines throughout the country (MoH, 2021b). Despite these robust guidelines, the effective implementation of “essential medicine supply chain” management remains a challenge. The country struggles with significant gaps, as evidenced by the low average availability and accessibility rates for essential medicines and basic diagnostic tools, which stand between 45% and 41%, respectively (Karijo et al., 2021).

Additionally, although the Ministry of Health has established guidelines for the quantification and forecasting of essential medicines, progress at the health facility level has been notably slow (MoH 2021a). Kariuki et al. (2016) highlight ongoing issues with the availability and accessibility of timely information regarding the stock and consumption of essential medicines. This lack of comprehensive data at the national, county, and facility levels continues to hinder effective supply chain management and exacerbates the challenge of preventing stockouts.

Toroitich et al. (2022) raises concerns that despite the “availability of regulations on the use of information systems” for monitoring “essential medicine supply chain”, “utilization of quality and timely information to support supply chain management is still inadequate to mitigate against the perennial essential medicine stockout.” An unintegrated information management system affects the availability of accurate and reliable data or delays in essential medicines supply chain management. Even with the regulatory framework, the information system to support “essential medicine supply chain” management is fragmented, creating challenges with data collection, sharing, visibility, and incomplete reporting (ibid).

MoH (2020a) observes that efficient and reliable supply chain management in the facility ensures “availability and access of essential medicines to patients when they need them.” Sanjuluca et al. (2022) observe that while in developed nations, information from HIS is used in hospitals for managing medicine orders and inventory, paper-based systems are still rampantly used in developing nations.

MSH (2012) alludes that, based on regulation, medicine lists provide specifications of each medicine needed and become the principal component of the quantification process. Toroitich et al. (2022) argue that despite the availability of health commodities management system guidelines, public hospitals in Kenya still experience weak hospital commodities management information and essential medicine stockouts.

2.7 Management of Essential Medicine Supply Chain

The global problem of essential medicines stockouts is increasing in developing countries because of supply chain failures WHO (2015) argues that notification reporting of medicine stockout in many low- and middle-income countries is poorly implemented and regulated. A fragmented national supply chain created by parallel donor programs negatively affects real-time data availability, data quality, data accuracy, reliable quantification, and forecasting and mitigation against essential medicine stockout or shortages.

The hospital supply chain can be defined as “a set of activities, planning, procurement, manufacturing, and delivery of medicine and medical products in hospital driven by

information flow within the supply chain and the need to provide optimal service to patients” (Habib et al., 2022). Arora and Gigras (2018) define Healthcare Supply Chain as a “series of processes, workforce across different teams and movement of surgical equipment, medicines and other products required by healthcare professionals to fulfil their work”. George and Elrashid (2023) opine that the medical and medical products supply chain aims to ensure that essential medicines are delivered to the right point at the proper time. Arora and Gigras (2018) observe that “the role of supply chain management in a hospital pharmacy is to ensure prompt availability of essential medicines at the right place and a lower purchasing price.” Supply chain activities in the Health Products Management Cycle involve product selection, distribution, procurement, use, and management support (MoH, 2020a). A successful supply chain is achieved by generating accurate essential medicine consumption data, quantifying, forecasting, procurement according to plan, and monitoring available stocks to mitigate against shortages (MoH, 2020a).

2.7.1 Quantification of Essential Medicines

Digital quantification reduces the time spent on various levels of supply chain and data types. MSH (2012) opines that the advantages of computerized quantification include speed, flexibility, and accuracy. Essential medicines supply chain management involves four functions, namely quantification, procurement, selection, use, and distribution (MoH, 2020b). In the essential medicine procurement process, quantification, a process of estimating costs and quantities of the products, is the first step to ensure that the right essential medicine is available at the required quality, reasonable price, and quantity (MoH, 2020a). Quantification of medicines should be

supported by quality information on medicine availability versus the needs, stock-out rates, and informed decisions for restocking (UNFPA, 2020).

Arora and Gigras (2018) argue that because of the difficulty of predicting the actual demand for medicines, the availability of accurate and reliable medicine consumption data becomes vital for proper quantification and forecasting. Arora and Gigras (2018) opine that because of the lack of understanding of the supply chain principles, hospitals end up with either low availability, oversupply, or expiry of medicines.

MoH(2021b) states that quantification is a core element function of the essential medicine supply chain. Quantification and forecasting based on consumption data of essential medicines is a function to be undertaken at national, county, and facility levels. Poor record keeping of Bin Cards and Daily Activity Registers leads to inaccurate summary data (*ibid*). Essential medical data visibility on stocks and analysis at facilities in Kenya is poor, resulting in inappropriate stock levels (MoH, 2021b). In addition, most facilities in Kenya lack a commodity-based dashboard that can inform distribution, stocking level, and restocking (*ibid*). Karijo et al. (2021) notes that the reliability and accuracy of quantification outputs in Kenya is challenging. Inadequate quantification at the county level results in weak procurement plans, weak annual budget estimates, or underestimation of expired essential medicines, stockouts, and service disruptions (MoH, 2021b).

Iqbal et al. (2017) observe that quantification includes using consumption data, Essential Drug List (EDL), morbidity data, maximum and minimum stock levels,

prescription patterns, procurement cycle length, and stock-out frequency. Iqbal et al. (2017) also illustrate that proper analysis of consumption patterns, real-time data, effective inventory management, and forecasting could cut waste of essential medicines and medical products. Iqbal et al. (2017) emphasize that trained pharmacists could use weekly, quarter, and annual essential medicine consumption data to estimate demand.

2.7.2 Product Selection of Essential Medicines

Product selection involves determining which medicines and health products should be available at the facility based on health needs (MoH, 2020). Proper quantification is required to ensure the proper use of limited resources for essential medicine selection (MoH, 2020a). To achieve proper product selection, public facility quantification of essential medicine in Kenya is normally based on the Kenya Essential Medical Supplies list, Kenya Essential Diagnostic list, and Kenya Essential Medical list (MoH, 2020a).

Iqbal et al. (2017) state that medicine and medical product selection is a function executed by well-trained and qualified hospital pharmacists whose decisions should be based on product specification, supply source, and quantities. Iqbal et al. (2017) note that pharmacists who select products should consider the quality of the products, price, packaging, returned goods policy, and transportation. Iqbal et al. (2017) opine that essential medicine selection, a vital step for ensuring availability and access to essential medicines, should be based on the Essential Drug List. Iqbal et al. (2017) allude that using a specific and brief list of essential medicines is much easier to manage and procure within available resources.

2.7.3 Procurement of Essential Medicines

Iqbal et al. (2017) define public procurement as “the purchase of services and goods by state-owned enterprises and governments”. Iqbal et al. (2017) opine that prompt procurement and supply of essential medicines of excellent quality are crucial in any health system. Procuring essential medicine entails obtaining a list of quantified essential medicines, forecasting (quantifying determination) each required health product, and preparing a supply plan (MoH, 2020). Procurement planning involves the identification of suppliers, a process which is detailed in “Public Procurement and Asset Disposal Regulations and Procurement Manual of Health Commodities in Kenya” (MoH, 2021b). The Public Procurement and Assets Disposal Act of 2015 demands that entities keep an updated list of registered suppliers on their website, although such a list is neither on the MoH Kenya website nor the County government website.

Supply planning entails deciding the costs and total product quantities considering forecasted consumption, maximum and minimum stock level, lead times, order, and logistics (MoH, 2020a). Effective planning of procuring and stocking essential medicines in the facility depends upon timely, accurate, and reliable quantification and forecasting information. MoH (2021b) requires public entities to prepare procurement plans that are aligned with the “medium-term fiscal framework, fiscal policy objectives, planning, and budgeting cycle.” The government procurement funding goes through the county revenue fund and the combined fund; therefore, quantification for essential medicines procurement at the facility sometimes does align with the government-funded procurement plan. Toroitich et al. (2022) note that challenges of

unavailability of essential medicine consumption data and stock at the national, county, and facility level in Kenya result in inaccurate and unreliable quantification of essential medicines, poor planning, and inaccurate procurements at all levels. Poor data timeliness, data inaccuracy, and poor-quality data affect “essential medicine supply chain” “planning and management at all levels of the health system” (MoH, 2021a). The essential medicine procurement process is hampered by poor product section, poor quantification information, poor consumption data, inadequate ability of the facilities “in ICT infrastructure, poor workforce skills to support procurement planning across all levels of the health system” (MoH, 2021b).

2.7.4 Distribution of Essential Medicines

The distribution of essential medicines and medical products entails effective delivery of the procured or stored health commodities from one point within the facility to another or from one facility to another (MoH, 2020a). Iqbal et al. (2017) state that the distribution and delivery of essential medicines to different points is impossible without timely information on available stock and inventory control. Iqbal et al. (2017) note that distribution in the essential medicines supply chain aims to ensure a steady supply of essential medicines to facilities. Iqbal et al. (2017) opine that monthly or quarterly information on order processes drives essential medicine distribution; however, inadequate information sharing with the facility affects the distribution of essential medicine for stocking and restocking within the supply chain.

2.7.5 Inventory Management of Essential Medicines

George and Elrashid (2023) state that essential medicine inventory management is the main asset of a hospital pharmacy that ensures that available essential medicine stocks

satisfy the current and future needs of patients and the hospital. George and Elrashid (2023) argue that proper management of essential medicine inventory should be maintained, failure to which improper control of stock could affect patients' health and service delivery. UNFPA (2020) notes that good management of medicines inventory in the facility requires that health workers should be trained, supervised, and have access to the information system regarding medicine status in the facility.

George and Elrashid (2023) state that essential medicine inventory management faces challenges with distribution and delivery during seasonal fluctuations and unexpected demand. George and Elrashid (2023) consider a good relationship between the distributor and hospital, good visibility of inventory among supply chain stakeholders, inventory scheduling and planning, correct ordering of medicines and medical products, accurate and reliable data, and staff trained in inventory management as contributing factor to successful inventory management. George and Elrashid (2023) emphasize that hospital pharmacy management teams must implement appropriate inventory management practices to improve supply chain management and hospital performance.

Iqbal et al. (2017) warn that health facilities run a risk of missing much-needed stock of essential medicines if those charged with the responsibility of managing essential medicines do not adhere to pharmacy inventory management practices. Iqbal et al. (2017) state that an effective essential medicines information system for tracking consumption enables pharmacists to make correct entries in the inventory for proper accountability and support to the supply chain management. MSH (2012) states that

poor inventory monitoring and management for essential medicines in public pharmaceutical supply chain in most countries cause shortages of essential medicines, waste of funds, expiry, and decline in quality of healthcare services. Poor inventory monitoring and management systems portray themselves through inaccurate stock records, ad hoc quantity of medicine ordered, and inefficient systemic monitoring (*ibid*).

2.8 Developing a Framework for the use of digital health in the management of essential medicine supply chain.

Fadahunsi et al. (2021) suggest that digital health technologies drive improved access to quality healthcare service delivery. Yadav (2015) state that a study on the supply chain in healthcare in Rio de Janeiro showed that corporate social responsibility improved the implementation of intelligent technologies in the healthcare supply chain in healthcare facilities. Cory and Stevens (2020) allude that some pharmaceutical companies promote data sharing; unfortunately, some countries have created barriers to health data flow across borders. Manyazewal (2017) argue that although the World Health Organization (WHO) has developed an established framework linking the six health systems building blocks (healthcare financing; leadership and governance; health workforce; information and research; service delivery; and medical products and technologies) with critical functions of the health systems (creating resources, delivering services, stewardship and financing) the framework fails to account sufficiently for the multi-model and disruptive effect of digital innovations and transformation along the building blocks. Manyazewal (2017) propose the need to update and develop a new framework corresponding to technological innovations and transformation in digital health technology in healthcare. On the other hand, Yadav

(2015) argues that developing countries lack a comprehensive framework to evaluate the impact of technological transformation and innovations in supply chain management in the healthcare sector.

2.9 Theoretical and Conceptual Frameworks

2.9.1 Theoretical Framework

A theoretical framework refers to a direction for research connected to the study's hypothesis (Adom & Hussein, 2018; Grant & Osanloo, 2014). The theoretical frameworks clarify the study's course, aiming to increase the significance and acceptability of the research findings to the relevant theoretical constructs to ensure generalization (Adom & Hussein, 2018). Adom and Hussein (2018) further suggest that both theoretical and conceptual frameworks provide direction for research and serve as a solid foundation for establishing the validity of that study.

To assess the influence of digitized health information on the management of “essential medicine supply chain” at the level 4 and 5 public health facilities in Kenya, this study employed two (2) complementary theories of the “Unified theory of acceptance and use of technology (UTAUT),” of Venkatesh et al. (2003); Nel and Boshoff (2020) and Knowledge-based view of the firm model, formulated by Grant (1996). The nature of the study required the use of the two theories in the sense Unified theory of acceptance and use of technology (UTAUT). Ghalavand et al. (2024) address acceptance and the behavioural intention for the use of technology, and since it does not strictly focus on organizational learning (identity, employees, culture, policies, and systems), human capital in organizational performance, strategy, goals, and transfer of

knowledge the Knowledge-based view of the firm model was used to address health workforce skills, training and policy on digital “health information influence on the management of essential medicine supply chain.”

2.9.1.1 Unified Theory of Acceptance and Use of Technology (UTAUT)

Advances in ICT drive the implementation of digital technologies in healthcare facilities globally. The application of these digital technologies depends on the organization’s technology adoption, investment in ICT infrastructure, skilled personnel, and technology utilization, among others (Marikyan & Papagiannidis, 2021). This study was hinged on the Unified theory of acceptance and use of technology (UTAUT). Developed by Venkatesh et al. (2003) this theory informs the use of independent variables (quality of digitized health information, digitized health information processing, ICT infrastructure, and workforce skills). UTAUT was applied to explain the intentions of personnel working in the health sector “to use digital health information systems to manage “essential medicine supply chain” in the public health facility.” UTAUT is based on four basic constructs that explain behavioral intentions of the perceived likelihood of personnel to adopt the use of technology: 1) "the degree to which an individual believes that using the system will help him or her to attain gains in job performance (Performance expectancy)". Venkatesh et al. (2003), Mudaly (2012) "the degree of ease associated with the use of the system" (Effort expectancy) , 3("the degree to which an individual perceives that important others believe he or she should use the new system" (Social Influence) 4) "the degree to which an individual believes that an organization and technical infrastructure exists to support the use of the system" (Facilitating conditions) (Venkatesh et al., 2003). UTAUT's contributions to several kinds of the literature

suggest that this model offers stronger empirical insights into technology acceptance compared to other technology theories such as the “combined technology acceptance model (TAM) and Theory of planned behavior (TPB) model (C-TAM-TPB) (Osman et al., 2022) technology acceptance model (TAM), Model of PC utilization (MPCU) and Innovation Diffusion Theory (IDT)” (Jayasingh et al., 2022; Marikyan & Papagiannidis, 2021). UTAUT model has been applied to study technology acceptance in the healthcare sector such as understanding the acceptance of utilization of technology in clinical decision support systems (Marikyan & Papagiannidis, 2021). Performance “expectancy, effort expectancy, social influence, and facilitating conditions (Cheung et al., 2016) constructs are useful for examining how healthcare workers in health facilities believe and use digital health information to generate quality and timely essential medicine and products data to support quantification for efficient supply chain management.” The UTAUT model proposes that “Performance expectancy, effort expectancy, social influence, and facilitating conditions have direct (Wichean & Sungsanit, 2022) considerable influence on behavior and acceptance to use technology” (Venkatesh et al., 2003).

The dominant model for describing the effects of technology acceptance, in this case for the digital information system, is the “Unified theory of acceptance and use of technology (UTAUT),” which has been utilized extensively in the field of technology acceptance and in line with the conceptual framework of the study. UTAUT was used to evaluate “the implementation of a digital health information system and the use of information in managing essential medicine supply chain” in public health facilities. UTAUT means that acceptance and utilization of information, communication, and

technology are considered while analyzing the understanding of the acceptance of technologies in the health sector. The workforce skill elements in this study were used to assess if participants' skill levels apply to digital health information systems, support digitalized health information, and digital health information processing strategy. UTAUT has been utilized in several studies to examine the implementation of digital information technologies, including telemedicine, mobile applications, electronic health records, and others (Khobi et al., 2020). It was essential to comprehend the variables that affect the digital health information systems to produce information for the “management of “essential medicine supply chain” in public health facilities.”

2.9.1.2 Knowledge-Based View of the Firm Theory

Knowledge-based view of the firm theory formulated by Grant (1996) is a management model that recognizes knowledge and organizational learning (identity, employees, culture, policies, systems) through increased transfer of knowledge and human capital involvement in organizational strategy, goals, and performance as being key for achieving competitive advantage (Gautam & Prabhakar, 2019). The knowledge-based view of firm theory advocates for knowledge sharing. It can be applied in different dimensions, including organizational learning, innovation, modern technology development, information digitization technologies, organizational competencies, and capabilities (*ibid*). Knowledge-based view of firm theory is relevant to this study, based on its support for knowledge acquisition and sharing. In this case, knowledge and data on essential medicine consumption quantification and visibility of available essential medicine inventory are shared for internal and external supply chain management (Gautam & Prabhakar, 2019). The knowledge-based view model, therefore, informed the use of the independent variable (workforce skill, management

support, training, and supervision), mediating variable (policy on digital health information) and the dependent variable (“essential medicine supply chain” management). Hult et al. (2004), Ketchen and Guinipero (2004) explain the effect of knowledge sharing across supply chain on organizations' outcomes in their studies; Knowledge-based view of the firm model was applied to knowledge development and information processing in organizational supply chain and to the strategic management of organizational supply chain management, respectively.

Health facility Supply chain management requires knowledge and skills to manage substantial amounts of medicine and medical product data for internal and external use (Onyango, 2024). This knowledge includes strategic plans and skills in different technical areas manifest in resources, including physical, capital, technical, and human capital (organizations workforce). There is connectivity between individual knowledge and the organization’s knowledge system within its structure (*ibid*). An organization's strategic decision to integrate ICT in supply chain management requires knowledge sharing between health facility management, information technology personnel, and pharmacists to improve data management for the “management of the essential medicine supply chain” (Onyango, 2024). Through the knowledge-based view of the firm model, the study examined how health facility workers’ knowledge and skills in digital health information systems influence the management of the “essential medicine supply chain” at the facility level.

2.9.2 Conceptual Framework

This refers to a network of linked concepts resulting from qualitative theorization processes to examine the independent and dependent variables (Jabareen, 2009). The

conceptual framework used in this study was based on UTAUT and the knowledge view of the firm model. The conceptual framework was utilized to examine how independent variables (quality of digitized health information, digitized health information processing strategy, ICT infrastructure support for health information, and workforce skill) influence the dependent variable (“essential medicine supply chain” management). The framework also depicts the effect of the mediating variable (policy on digital health information) on the relationship between dependent and independent variables.

The Unified Theory of Acceptance and Use of Technology (UTAUT) was employed to explore the factors influencing technology acceptance and the use of digital health information systems within “essential medicine supply chain” management at public health facilities in Kenya. This theory provides a comprehensive framework for understanding how various elements—such as performance expectancy, effort expectancy, social influence, and facilitating conditions—affect the adoption and utilization of digital health technologies. In the context of levels 4 and 5 public health facilities, UTAUT helps to identify the determinants that influence healthcare personnel's willingness to embrace and effectively use digital tools for managing essential medicines.

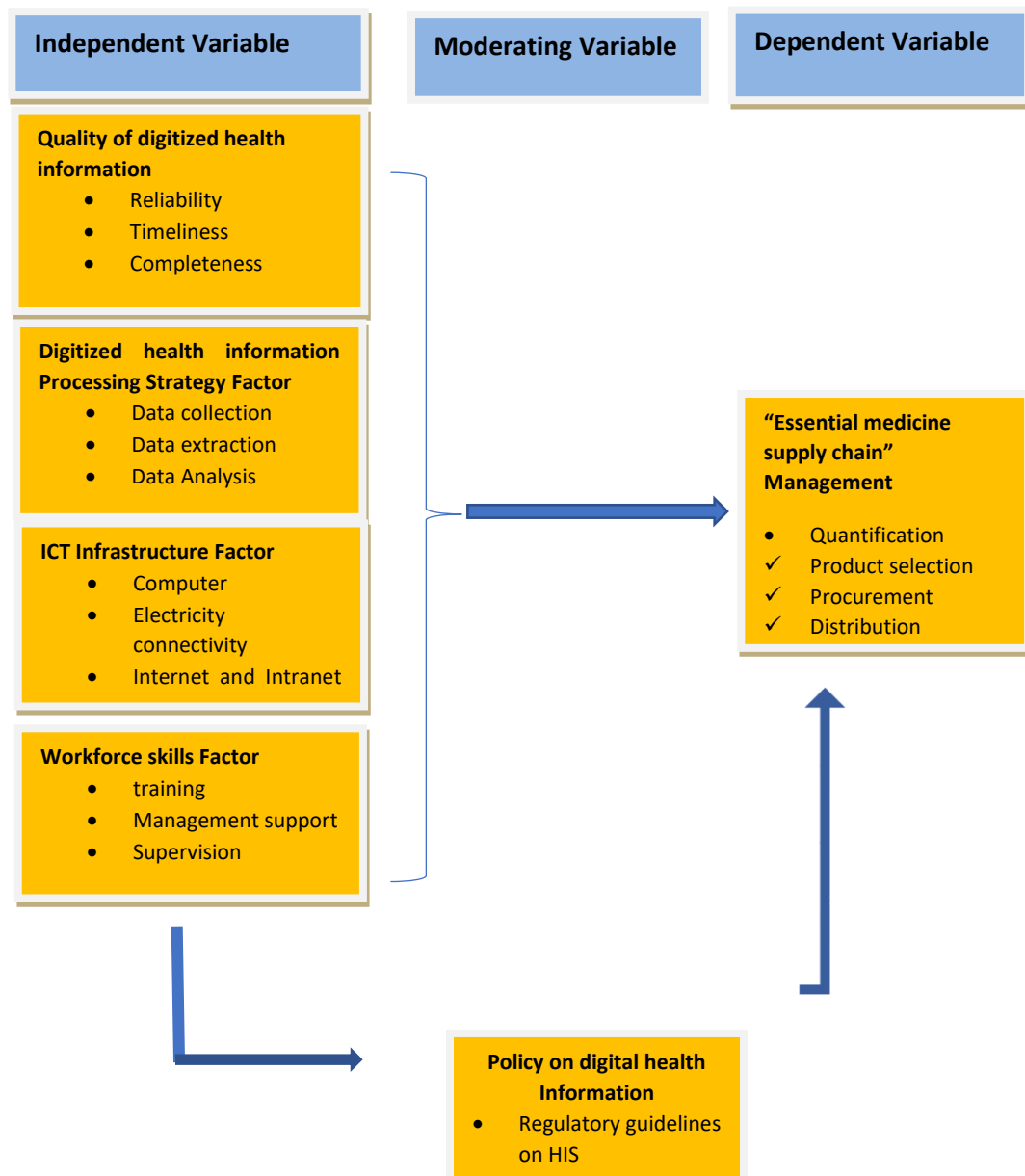
In conjunction with UTAUT, the Knowledge-Based View of the Firm (KBV) model was utilized to examine how independent variables and mediating factors, such as policies, impact the utilization of digital health information. KBV emphasizes the importance of organizational knowledge, competencies, and capabilities in shaping

technology adoption and implementation. By applying this model, the study investigated how organizational knowledge, capabilities, and the sharing of information influence the effective use of digital health systems in managing the supply chain of essential medicines.

These theoretical frameworks were instrumental in developing a digital health information framework tailored for managing “essential medicine supply chains” in public healthcare facilities in Kenya. UTAUT informed the design of the framework by addressing behavioral intentions related to the use of digital health information, including aspects such as the quality of digitized data, information processing, and ICT infrastructure. Meanwhile, the KBV model contributed insights into organizational competencies and the role of modern technology in enhancing digital health practices. Together, UTAUT and KBV provided a robust basis for understanding and improving the use of digital health information systems. By integrating these theories, the digital health framework aims to address the challenges of essential medicine stockouts and enhance overall management efficiency. This approach underscores the importance of both individual and organizational factors in leveraging digital health technologies to optimize “essential medicine supply chains.”

Figure 1. 1

Conceptual Framework



CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter presents the study area, research methods, philosophy, procedures, research design, data collection methods, target population, sampling procedure, instrumentation, operationalization of variables, analysis and presentation, and research model aligned to the research aims, goals, and research questions.

3.2 Research Philosophy

Mixed methods research integrates different paradigms, enabling both inductive and deductive approaches within a single study, which facilitates hypothesis testing alongside theory development (Jogulu & Pansiri, 2011). Research paradigms encompass methodologies, epistemological beliefs, and validity criteria (Thanh & Thanh, 2015). In this study, the interpretivism paradigm was employed to address the research question and explore the influence of health information on “essential medicine supply chain” management. This approach focuses on understanding the subjective experiences and perceptions of respondents, such as clinical officers and pharmacists, by interpreting data in its social and contextual framework (Thanh & Thanh, 2015). The interpretivist approach underscores that reality is socially constructed, and the context of research is crucial for meaningful data interpretation.

Qualitative methods within this study used interpretive and narrative analysis to complement the quantitative findings, providing a comprehensive view of the data. The qualitative component aimed to capture the experiences and perceptions of healthcare professionals regarding the use of health information systems in managing

essential medicine supply chains. This approach sought to gain in-depth understanding of how health information impacts supply chain management. Due to the nature of qualitative data, which is detailed and context-specific, the study used focused questions to gather pertinent insights, with subsequent data analysis involving categorization and coding to identify key themes.

In addition to qualitative insights, the study employed a quantitative research design to analyze numerical data and examine correlations “between digital health information and the management of essential medicine supply chains.” The goal was to assess the strength and direction of relationships between independent and dependent variables without manipulating them. Data collection involved semi-structured standardized questionnaires administered to a representative sample population, and the results were analyzed using correlation and regression techniques to determine the impact of digital information systems on supply chain management.

The research utilized the Unified Theory of Acceptance and Use of Technology (UTAUT) and the Knowledge-Based View of the Firm to explore the effects of “digital information systems on the management of essential medicine supply chains” in public health facilities. These theoretical frameworks guided the examination of how technology adoption influences supply chain practices. The correlation research design enabled predictions about the relationships between variables, providing insights into how digital tools and systems affect medicine management.

3.3 Research Design

A mixed-methods research approach, integrating both qualitative and quantitative methods, was employed to provide a comprehensive and nuanced understanding of complex phenomena. This approach allowed for a more thorough exploration of the research problem by combining detailed qualitative insights with empirical quantitative data. Qualitative methods contributed rich, contextual information and deeper insights into the nuances of the subject, while quantitative methods offered robust numerical data that supports generalizability and statistical analysis. By leveraging both types of data, the research was able to address the intricacies of the issue more effectively and draw well-rounded conclusions.

The use of this combined methodology ensured a holistic examination of the research problem, allowing for a more complete analysis. Qualitative data provided depth and context, capturing the subtleties and complexities of the phenomena under study, whereas quantitative data added breadth and precision through measurable metrics. This integration of qualitative and quantitative insights not only enhanced the validity of the findings but also helped in triangulating results, thus offering a richer and more comprehensive understanding of the research topic. The mixed methods research method supported deductive and inductive logic, enabling the researcher to undertake hypothesis testing and theory generation to make good inferences without compromising (Jogulu & Pansiri, 2011). Mixed research methods involved merging thematic and statistical approaches, comparison of data from multiple sources, processing, and triangulation to support findings (*ibid*). A nested approach mixed method research where quantitative and qualitative data collection is performed

concurrently was applied to this study to address qualitative and quantitative questions and to reveal deeper insights into the effects of information produced by HIS “on the management of “essential medicine supply chain” in public healthcare facilities in Kenya.” The nested approach was applied because of scarce resources and limited time. The mixed method research approach was appropriate because the research questions employed both “qualitative and quantitative techniques” to collect numerical data and deeper contextual insights.

The World Bank (2021) observes that because of disparities in access to services between Kenya's urban, peri-urban, and rural areas, urban residents benefit from broader availability and better access to services. Peri-urban has comparatively better infrastructure, such as roads, electricity, and the creation of new economic/business opportunities and jobs, compared to rural areas, which are characterized by deficient basic infrastructure (Mandere et al., 2010; Dadashpoor & Ahani, 2021). Based on the differences in development stages, and cultural and historical contexts, this study sought to explore the influence of digitized information systems on the management of “essential medicine supply chain” to mitigate against essential medicine stockout in the three categories (urban, peri-urban, and rural). Consequently, the following counties were purposefully selected to participate in the study: Mombasa County (urban), Kajiado County (peri-urban), and Makueni County (rural). The choice of Mombasa County was informed by the recommendation by Sumbi (2016) and Mwangombe (2021) for more research on the barriers and challenges of EMR systems adoption and interventions. The choice of Makueni County followed the recommendation by Matheka (2018) for a study on completeness, accuracy,

timeliness, availability, and security of health data in Makueni County. Matheka (2018) further recommended a study on the effects of information technological advancement in health facilities in Makueni. Finally, the choice of Kajiado was a follow-up to the recommendation of Matiangi et al. (2022) to focus on upscaling health information literacy to ensure sustainable delivery of quality services.

Data collection occurred between August and October 2023, focusing on level 4 and level 5 public health facilities in Kajiado, Makueni, and Mombasa. This period allowed for a thorough investigation of the interplay between technology use and supply chain management. By combining qualitative and quantitative methods, the study aimed to deliver a comprehensive understanding of the effectiveness and challenges associated with digital health information systems in managing essential medicines.

3.4 Study Population

The study population included medical superintendents of health, clinical officers, health records and information officers, pharmacists and medical officers from level 4 and 5 public healthcare facilities in Mombasa, Makueni and Kajiado counties. The selection of participants for this study was based on their relevance to the research topic and their specific roles within the healthcare facility concerning health information and the management of essential medicines. Each participant's involvement and responsibilities were critical in providing insights into the study's focus, ensuring that their contributions were pertinent to understanding the dynamics of health information systems and supply chain management. A list of the health workers in public healthcare facilities levels 4 and 5 was obtained from the Makueni County Integrated Development Plan (CIDP) 2018-22, Human Resources for Health

Information, Mombasa County, and the Kajiado County Health Sector Strategic & Investment Plan (KHSSIP); while a sample frame of 20 levels 4 (sub-county hospitals) and 3 level 5 (county referral hospitals) public healthcare facilities in the three counties was taken from the Kenya Ministry of Health Master Facility List 2021.

3.5 Inclusion and Exclusion Criteria

3.5.1 Inclusion Criteria

Personnel charged with the responsibility of data collection, processing, and use were included in the study. Only health personnel working in Level 4, and 5 in the sampled public healthcare facilities in the Counties of Kajiado, Makueni, and Mombasa participated. Participation in the study was voluntary. Only participants above the age of 18 years who consented were included in the study.

3.5.2 Exclusion Criteria

Nonconsenting medical officers, clinical officers, pharmacists, and health records and information officers (Kariuki et al., 2016) and those who at the time of the study were not working within the sampled counties of Kajiado, Makueni, and Mombasa or who had no role in the health information management or those who sought for payment of whatever nature or compensation to participate were excluded from the study. Children and people under the age of 18 years did not participate in the study.

3.6 Sampling Procedure

3.6.1 Sampling Frame

The sample frame included 23 (20 levels 4 and 3 level 5) public health facilities that satisfy the following conditions: (i) they were public health facilities, (ii) level 4 and

5 facilities, (iii) found in the counties of Kajiado, Makueni, and Mombasa (iv) they were health workers who take part in health information gathering and dissemination. The sample frame composed of 20 (level 4) and 3 (level 5) public healthcare facilities from Kajiado, Makueni, and Mombasa was drawn from the Ministry of Health Master Facility List 2021. The sample frame for the health workforce was from the Mombasa County Annual Work Plan 2020-2021, Kajiado County Health Sector Strategic & Investment Plan (KHSSIP), and Mombasa County Health Quality Management Policy 2022-2027.

Table 3. 1

Sample Frame: Level 4 and 5 Public Healthcare Facilities (MoH)

County Name	Category	
	Names of level 4 Public Facilities per county	Names of Level 5 Public Facilities per county
Kajiado County	Kitengela Sub County Hospital	Kajiado County Referral Hospital
	Loitoktok Sub County Hospital	
	Ngong Sub County Hospital	
	Ongata Rongai Sub County Hospital	
Mombasa County	Bomu Medical Hospital	Coast General and referral Hospital
	Tudor Sub County Hospital	
	Likoni District Hospital	
	Port Reitz Sun County Hospital	
Makueni County	Kambu Sub County Hospital	Makeuni County Referral Hospital
	Sultan Hamud Sub County Hospital	
	Kilungu Sub County Hospital	
	Mbooni Sub County Hospital	
	Mukuyuni Health Centre	
	Mutyambua Hospital	

	Kibwezi Sub County Hospital	
	Kisau Sub County Hospital	
	Tawa Sub County Hospital	
	Matiliku Sub County Hospital	
	Makindu Sub County Hospital	
	Mtito Andei Sub County Hospital	
Total number of public health facilities per facility level in the three counties.	20	3

Table 3.1 presents a list of level 4 and level 5 public health facilities in Makueni, Kajiado, and Mombasa counties.

Health Workers in 11 Levels 4 and 3 Level 5 Public Healthcare Facilities in Kajiado, Makueni, and Mombasa Counties

Table 3. 2

Sample Frame

Cadre	Makueni	Kajiado	Mombasa	Total
Medical Officers	30	12	92	134
Pharmacist	06	8	32	46
Clinical Officer	72	36	132	240
Health Records & Information Officer	06	03	08	17
Total	114	59	264	437

Table 3.2. Presents the number of Public Healthcare Personnel who are directly involved with essential medicines and health information systems in levels 4 and 5 in the counties of Mombasa, Makueni, and Kajiado.

3.6.2 Sampling Technique

A multistage sampling method was employed to select public healthcare facilities at levels 4 and 5 for the study. Initially, the facilities were categorized into clusters based on their operational level and county location. To maintain consistency, facilities were grouped as either level 4 or level 5 within their respective counties. Simple random sampling was then used to choose specific facilities: 4 from Kajiado County; 4 from Mombasa County; and 12 level 4 facilities from Makueni County. Each of these three counties also had one level 5 facility, which was selected purposively for inclusion in the study.

The sampling process was conducted in multiple stages. In the first stage, health facilities were divided by county into distinct clusters. The second stage involved randomly selecting the level 4 facilities within each county. The third stage focused on identifying the number of healthcare personnel. This allowed for the calculation of the total sample size required for interviews. In the final stage, specific personnel for interviews were randomly selected, ensuring a representative sample from each category.

Key informants, including Medical Superintendents of Health, Procurement Officers, Health Records and Information Officers, and Medical Stores Officers, were purposively chosen from the sampled facilities. Participants were chosen due to their key responsibilities in managing health information, leadership, and overseeing the supply chain of essential medicines at the facility level. The criteria for selecting individuals for both structured and semi-structured questionnaires focused on their

roles in processing health data, procurement, and managing the supply chain within public healthcare facilities classified as levels 4 and 5.

The probability sampling method was applied to a sample frame of 20 level 4 public healthcare facilities (sub-county hospitals). Since there are only 3 level 5 public healthcare facilities (County referral hospitals) in each of the three counties, purposive sampling was used to enrol all the 3 public healthcare facilities in the study. Participating level 4 public healthcare facilities (County Referral hospitals) in the 3 counties were selected through simple random sampling. Probability sampling was also applied on a sample frame of 437 human resources for health (pharmacists, HRIOs, medical officers, and clinical officers) from 4 and 5 public healthcare facilities to select respondents to the semi-structured interviews. Purposive sampling was used to identify 8 Medical Superintendents of Health, 2 Procurement Officers, 2 Health Records and Information Officers, and 2 Medical Stores Officers as key informants. Kothari (2004) states that a study's sample is assessed by how it represents the entire population under study. Sample size calculation formulae “are obtained from Nassiuma (2000) in the formulae, N, population, C, coefficient of variation (0.5), e, level of precision (0.05), and n is the sample size.”

$$n = \frac{NC^2}{1 + (N - 1) e^2}$$

(i) Kajiado County

The number of level 4 Public healthcare facilities in Kajiado is 4. Based on the sample formulae below, the number of the sampled level 4 public healthcare facilities in Kajiado was 3. Kajiado County has one level 5 public healthcare facility, which

qualified it to be included in the study under level 5. The total number of level 4 and 5 public healthcare facilities in Kajiado County was 4.

Formula.

$$n = \frac{NC^2}{1 + (N - 1) e^2}$$

$$= \frac{4 (0.5)^2}{(0.5)^2 + (5 - 1)(0.05)^2} = 3$$

(ii) Makueni County

The number of level 4 Public healthcare facilities in Makueni County is 12. Based on the sample formulae below, the number of the sample level 4 public healthcare facilities in Makueni County was five. Makueni County has one level 5 public healthcare facility, which qualified to be included in the study under the level 5 tier. The total number of level 4 and 5 public healthcare facilities in Makueni County was six.

Formula.

$$n = \frac{NC^2}{1 + (N - 1) e^2}$$

$$= \frac{12 (0.5)^2}{(0.5)^2 + (12 - 1)(0.05)^2} = 5$$

(iii) Mombasa County

The number of level 4 Public healthcare facilities in Mombasa County is 4. Based on the sample formulae below, the number of the sampled level 4 public healthcare facilities in Mombasa County was three. Mombasa County has one level 5 public healthcare facility, which qualifies to be included in the study under the level 5 tier.

The total number of level 4 and 5 public healthcare facilities under study in Mombasa County was four.

Formula.

$$n = \frac{NC^2}{1 + (N - 1) e^2}$$

$$= \frac{4 (0.5)^2}{(0.5)^2 + (4 - 1)(0.05)^2} = 3$$

The total number of level 4 and 5 public hospitals in Mombasa, Makueni and Kajiado counties that were to participate in the study was 14 (11 levels 4 and 3 level 5).

(iv) Respondents Selection

From a sample frame of 437, Nassiuma (2000) formula for calculating the sample size was applied to arrive at the probability sample of the health workforce from public healthcare facilities to take part in the study.

Formula.

$$n = \frac{NC^2}{1 + (N - 1) e^2}$$

$$= \frac{437 (0.5)^2}{(0.5)^2 + (437 - 1)(0.05)^2} = 164$$

Based on the above calculations 164 respondents sampled from 14 (11 levels 4 and 3 level 5) public healthcare facilities were sampled to participate in the study: 150 respondents to semi-structured questionnaire and 14 Key informants. The 150 respondents were selected through simple random sampling while 14 key informants (8 Medical Superintendents of Health, 2 Procurement Officers, 2 Health Records, and Information Officers and 2 Medical Stores Officers) selected through purposive sampling from the chosen 14 public health facilities were picked to participate in the

study. Purposive sampling was employed to ensure the selection of respondents who were directly involved in “health information management and the oversight of essential medicine supply chains at the facility level.” This approach aimed to align the collected data with the study's objectives, ensuring that the information gathered was relevant and specific to the research focus. A total of 150 participants were chosen, with the distribution based on their roles and geographical location.

The distribution of participants was as follows: 24 medical officers, with 10 from Makueni, 4 from Kajiado, and 10 from Mombasa; 34 pharmacists, including 6 from Makueni, 8 from Kajiado, and 20 from Mombasa; and 33 clinical officers, consisting of 13 from Makueni, 6 from Kajiado, and 14 from Mombasa. Additionally, 16 health records and information officers were selected, with 6 from Makueni, 3 from Kajiado, and 7 from Mombasa. Furthermore, 20 procurement officers were included, with 8 from Makueni, 4 from Kajiado, and 8 from Mombasa. The sample also consisted of 10 nurses (4 from Makueni, 2 from Kajiado, and 4 from Mombasa), 8 pharmaceutical technologists (3 from Makueni, 2 from Kajiado, and 3 from Mombasa), and 5 medical stores officers (2 from Makueni, 1 from Kajiado, and 2 from Mombasa). All participants responded to a semi-structured questionnaire designed to gather detailed insights into their roles and experiences. Only 143 respondents completed the semi-structured questionnaires and 12 completed the interview. From the targeted 164, a total of 155 participants participated in the study.

Table 3. 3

List of Level 4 and 5 Public Healthcare Facilities in Mombasa, Makueni and Kajiado Counties

County	Facility Name	level
Mombasa	Likoni Sub County Hospital	Level 4
	Bomu Medical Hospital	Level 4
	Tudor sub-County Hospital	Level 4
	Coast General Teaching and referral Hospital	Level 5
Kajiado	Kajiado County Referral Hospital	Level 5
	Kitengela sub-county hospital	Level 4
	Ngong sub-County Hospital	Level 4
	Ongata Rongai sub-County Hospital	Level 4
Makueni	Makindu sub-County hospital	Level 4
	Kibwezi Sub County Hospital	Level 4
	Kambu Sub County Hospital	Level 4
	Sultan Hamud Sub County Hospital	Level 4
	Mtito Andei Sub County Hospital	Level 4
	Makueni County Referral Hospital	Level 5

Table 3.3 presents a list of level 4 and 5 Public Healthcare Facilities found in Mombasa, Makueni and Kajiado counties.

Instrumentation

A semi-structured questionnaire was developed for conducting semi-structured interviews. A semi-structured interview was instrumental in enabling more focus on the topic, probing, use of open-ended questions and allowing each participant an independent thought on the subject matter of the study. The questions were divided into five major parts to cover digitized information to the management of “essential medicine supply chain” at the public health facility level: (i) quality of digitized health

information, (ii) digitized health information processing strategy, (iii) ICT infrastructure (iv) workforce skills and (v) policy on digital health information. The instrument was subdivided into 5 parts to enable the study to gather relevant information covering all objectives and hypotheses for analysis to determine the extent of the relationship between digital health information and the management of “essential medicine supply chain” in public healthcare facilities in Kenya.

The semi-structured questionnaire created in the ArcGIS enterprise platform, survey 123, for data collection and analysis was administered to health workers to gather information on the use of digital health information for the management of “essential medicine supply chain” at levels 4 and 5 public healthcare facilities in Kajiado, Makueni, and Mombasa counties. Face-to-face key informant interview guide involving 8 Medical Superintendents of Health, 2 Procurement Officers, 2 Health Records and Information Officers, and 2 Medical Stores Officers from each of the sampled level 4 and 5 public healthcare facilities in the counties of Kajiado, Makueni, and Mombasa was conducted to provide a free exchange of ideas, gather more candid in-depth information and to offer opportunity for more questions and detailed responses on digital health information for management of “essential medicine supply chain”. The study also included an observation method for the researcher to gain more insight into the actual presence and use of ICT for information management and use within the facility, such as computers, electricity supply/connection, access to internet service, and electronic data collection and management platform.

3.7 Methods of Data Collection

A questionnaire form focusing on a set of quantitative indicators, including the reliability of digitized health information, timeliness, accuracy, completeness, accessibility, data analysis, data extraction, data collection, data compilation, data cleaning, computer availability, electricity connectivity, hardware and software maintenance, internet and intranet connectivity, skills/training, management support, supervision, enabling IT environment and policy support to information for the management of “essential medicine supply chain” was designed and administered to 164 respondents in 3 level 5 (County referral hospitals) and 11 level 4 (sub-county hospitals) public healthcare facilities in Mombasa, Makueni, and Kajiado counties. A Questionnaire designed in survey 123 on ArcGIS enterprise platform (web page and operational dashboard) was accessed by the interviewer on the chosen mobile phones. A mixed-mode electronic data collection approach, including a web app and analysis platform, was employed to fasten data collection, entry, and analysis. Data collection and processing took place between 1st August and 10th October 2023. The interviews were recorded, and notes were taken. The researcher was asked questions, filled in, and completed one form per respondent through ArcGIS survey 123 on the mobile phone. Completing the questionnaire in ArcGIS survey 123 took place both online and offline depending on the internet connectivity. Once the form had duly been filled it was uploaded when the connectivity to the internet was secure and marked as sent to the ArcGIS enterprise platform. The researcher was then not able to edit the sent forms although the forms could still be viewed until they were deleted from the phone. The duly filled-out questionnaire was transmitted to a secure central database for storage and analysis.

3.8 Methods of Data Management, Analysis, and Presentation

Quantitative analysis was applied to consider individual expressions not captured in quantitative data about the use of digital health information for the management of the “essential medicine supply chain” at the facility (Kanfe et al., 2020). Quantitative analysis made use of descriptive statistics and inferential statistical techniques; correlation analysis to assess the relationship between the independent and dependent variables and how strong that relationship may be; and regression analysis to find out which independent variables affected the use of digital health information in the management of “essential medicine supply chain” at the public healthcare facility.

Inferential statistics were used to analyze the research hypothesis. A p -value of ≤ 0.05 as a statistically significant consideration was applied to all statistical tests. Statistical Package for Social Sciences (SPSS, version 19.0) was used for multiple regression analysis to measure the influence of digital health information on the management of the “essential medicine supply chain” (dependent variable). It also helped to understand how the management of the “essential medicine supply chain” (dependent variable) at the health facility can be explained by the quality of digitized health information, health information process strategy, ICT infrastructure support and health workforce factors (independent variables) and policy framework on digital health information (mediating variable).

Research question analysis consisted of hypotheses testing, regression analysis and correlation analysis. Pearson coefficient was computed to examine the correlation between essential medicines chain management (dependent variable) and quality of digitized health information, health information process strategy, ICT infrastructure

support and health workforce factors (independent variables) and policy on digital health information (mediating variable).

A multiple linear regression analysis approach on the use of digital health information in public health facilities was used to learn the influence of the independent variable on the dependent variable (Leleu et al., 2014). Through multiple regression analysis, the researcher evaluated the model and the effect of independent variables on the dependent variable after performing correlation analyses. In this case, regression analysis was applied to broaden the insight into the relationships between variables.

“For testing hypothesis for correlation between variables, the null hypothesis is usually used to state that in the population there is no true relationship between two variables” (Damschroder, et al., 2009). The correlation coefficient was applied to assess the null hypothesis. The internal consistency reliability coefficients (Cronbach’s alpha) were measured at above 0.7 acceptance level (acceptable and good).

Pearson Correlation was used to evaluate if there was a significant relationship between the independent and dependent variables in the hypothesis.

$H_0: \rho = 0$ (" when the population correlation coefficient is 0; there is no significant relationship or association ")

$H_1: \rho \neq 0$ ("when the population correlation coefficient is not 0; significant relation or correlation could exist").

$H_1: \rho < 0$ ("when the population correlation coefficient is less than 0; a negative correlation could be the case").

The “moderated multiple regression model (MMR)” was applied to assess the mediating effect of policy on “digital health information on the independent variables and essential medicine supply chain management.”

Table 3. 4

Hypothesis Analysis

Variable	Null Hypothesis	Type of Analysis	Interpretation
Quality of digitized health data	H01	Pearson Correlation	P<0.05 reject null
	No significant influence	Linear Regression	P>0.05 do not reject null
Digitized health information processing strategy factor	H02	Pearson Correlation	P<0.05 reject null
	No significant influence	Linear Regression	P>0.05 do not reject null
ICT infrastructure support	H03	Pearson Correlation	P<0.05 reject null
	No significant influence	Linear Regression	P>0.05 do not reject null
Healthcare Workforce	H04	Pearson Correlation	P<0.05 reject null
	No significant influence	Linear Regression	P>0.05 do not reject null
Policy of digitalization	H05	Pearson Correlation	P<0.05 reject null
	No significant influence	Linear Regression	P>0.05 do not reject null
Moderating Policy framework on digital health Framework	H06	Pearson Correlation	P<0.05 reject null
	No significant influence	Linear Regression	P>0.05 do not reject null

Filled forms were uploaded to the ArcGIS enterprise platform. The ArcGIS enterprise platform was used to export the data in standard CSV (Comma-separated Values) which was then imported into SPSS for analysis. The collected data was edited, coded, and examined for errors and omissions before correction. Coding involves categorization. Through the Statistical Package for Social Science (SPSS) Software and NVivo software, data was further subjected to descriptive and qualitative analysis, and the results were displayed through graphs, charts, and narrative descriptions. Qualitative data was organized, coded, and analyzed as per emerging themes and

content. The recorded key informant interview (6 Medical Superintendents of Health, 2 Procurement Officers, 2 Health Records and Information Officers, and 2 Medical Stores Officers) was downloaded and transcribed verbatim and then subjected to verification for accuracy and authenticity. Content analysis was conducted through coding of the transcribed data which was then categorized into themes in line with the questions asked and indicators. Common themes were arranged into categories, subcategories, and themes.

Qualitative analysis supplied in-depth insight into the use of digital health information in managing “essential medicine supply chain”. Qualitative data from the interview was transcribed verbatim, processed, cleaned, and analyzed using qualitative NVivo software. This involved merging corresponding thematic categories, coding, sub-coding, and summarizing emerging trends and themes. The summarized data was appropriately expressed in context to enable triangulation to arrive at agreement and convergence. Qualitative data quantification was conducted by numbering the frequency of categories and themes and presenting them in percentages in terms of themes associated with given categories of respondents. Once qualitative data was transformed, the next step was to calculate simple correlation and stratify codes by health facility type.

The findings were organized by research questions and hypotheses using statistics to show how the questions and hypotheses were responded to. Qualitative findings were organized by themes and quotations to illustrate the themes shown in the study.

Quantitative findings were summarized and presented through tables, figures, charts, and graphs.

3.9 The Research Model

Multiple Regression Model

Multiple regression was used to investigate the relationship between the use of quality of digitized health information, digitized health information processing, ICT infrastructure support, and workforce skills (independent variables), and policy on digital health information (mediating variable) on the management of “essential medicine supply chain” (dependent variable) in public health facilities in Kenya. The aim was to use the independent variable to predict the value of the dependent variable by weighing the value of each predictor and its contribution to the prediction outcome (More *et al*, 2006).

$$Y=a+b_1X_1+b_2X_2+b_3X_3+b_4X_4$$

Y represent the dependent variable, and X_1 , X_2 , X_3 , and X_4 represent the 5 independent variables. By calculating the weights, a , b_1 , b_2 , b_3 , b_4 , regression analysis ensured maximum prediction of the dependent variable from the 4 independent variables (More *et al.*, 2006).

Table 3. 5

Digital HIS: Problems and Intervention

Digital Health category: Use of Digital health information				
Digital health information problem indicators		Performance Improvement Objective		
Indicator	Baseline value	Target	Period/year achievement	of
Percentage of quality digitized health data		90%		
Percentage of health data processing strategy		90%		
Percentage of health workforce skill		90%		
Percentage ICT resource support		90%		
Adherence to digitization policy		80%		
Priority problems and constraints affecting the use of digital health information in essential medicines supply chain management		Proposed Interventions		
Limited quality of digitized health information produced by health facilities due to: Untimely information Incomplete information Unreliable information		Development of a framework for the use of digital health in the management of “essential medicine supply chain” in Kenya’s Public healthcare facilities		
Limited digitized health data processing by health facilities due to Poor data collection Poor data extraction Poor data analysis Insufficient ICT infrastructure within the health facility due to. Inadequate computers Lack or insufficient connectivity electricity. Lack or insufficient connectivity to the internet. Inadequate skilled workforce due to Lack of training Lack or inadequate management support. Lack or inadequate supervision. Limited digitization policy support due to. Weak regulatory guidelines				

3.10 Pre-Test of Tools

A pretest study was conducted at Machakos level 5 hospital and Kathiani sub-County Hospital (level 4) in August 2023 to assess the correctness, validity, practicability, sensitivity, reliability, and consistency of the tools; to ensure that respondents understood the questions and the instructions. The choice of Machakos County level 5 hospital and Kathiani level 4 health hospital in Machakos County was informed by Mutua et al. (2022) study on the effect of devolution on healthcare systems performance in Machakos County level 5 hospital, which recommended a study on healthcare systems building blocks other than infrastructure and healthcare workforce in Machakos. Machakos level 5 presented similar characteristics (closest level 4 and 5 public health facilities to Makueni and Kajiado, similar characteristics of patients visiting public health facilities and similar public health facility category level 4 and 5) as the level 5 public health facilities in Mombasa, Makueni and Kajiado, and so did Kathiani level 4 to level 4 public health facilities in Mombasa, Makueni and Kajiado. Problems and limitations found were corrected to refine the questionnaire before study instruments were administered to respondents in Kajiado, Makueni, and Mombasa Counties. 30 respondents were sampled and participated in the pre-test. The pre-test study was conducted in August 2023 before the actual research, after receiving clearance from KeMU and research approval from the National Commission for Science, Technology, and Innovation (NACOSTI).

3.11 Ethical Consideration

Potential participants were issued with and asked to read the consent form having information about the research. Only those who consented and signed the consent form were included in the study. Potential participants were informed prior that participating

in the study was voluntary, and that they could withdraw at any time and stage of the study. Relevant information concerning the aim of the study and how long the study would take was provided to all participants. In seeking participants' informed consent, participants were made aware of the approval from County Health Departments and Medical Superintendents of Health from the respective public health facilities and that the information they shared was to be kept confidential. No personal details (names, phone numbers, email addresses, photos, and videos) of the respondents were collected. In adherence to data privacy protocol, raw data from the participating health facility was kept confidential. Study results were communicated through Kenya Methodist University devoid of falsification of data, manipulation of data analyses or misrepresentation of results. Kenya Methodist University Institutional Scientific Ethics and Review Committee granted ethical approval vide KeMU/ISERC/HSM/17/2023, National Commission for Science, Technology, and Innovation (NACOSTI) License no. NACOST/P/23/28760 and Coast General Teaching & Referral Hospital Ethics Review Committee Ref. ERC-CGH/MSc/Vol 1.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Introduction

This chapter outlines the data analysis procedure and interpretation. It further discusses the findings before providing a summary. The findings are presented in tables, charts, and verbatim. The analyzed data is presented under themes that reflect the research objectives.

4.2 Response Rate

Out of the expected 150 semi-structured questionnaires administered, 143 (16 HRIO, 30 Clinical Officers, 34 Pharmacists, 10 Nurses, 8 Pharmaceutical Technologists, 20 Medical Officers, 5 Medical Stores Officers, and 20 Procurement Officers) were duly filled in and returned. Out of the expected 14 key informants' interviews, 12 (6 Medical Superintendents of Health, 2 Procurement Officers, 2 Health Records and Information Officers, and 2 Medical Stores Officers) were completed. In total, 143 semi-structured questionnaires and 12 key informants' guides were completed out of the expected 164. The response rate is shown in Table 4.1.

Table 4. 1***Response Rate***

	Response	Frequency	Per cent
Semi-structured questionnaire	Returned	143	95.3%
	Unreturned	7	4.7%
	Total	150	100%
Key Informants	Returned	12	85.72%
	Unreturned	2	14.28%
	Total	14	100%

The recorded response is depicted in Table 4.1. This achievement aligns with the criteria set forth by Kothari (2004) and Mugenda and Mugenda (2003) who opine that a response rate that exceeds 50% is deemed sufficient for a study. This is further supported by Cooper and Schindler (2014) who contend that “a response rate exceeding 30% of the total sample size” provides ample data to generalize the characteristics of a study problem based on the perspectives of a select group of respondents within the target population. Given these perspectives, the 95.3% semi-structured response rate and 85.72% for key informants were deemed satisfactory for the study.

4.3 Reliability Test

Instrument reliability pertains to its capacity to yield consistent and stable measurements. Cooper and Schindler (2014) state that “reliability evaluates the stability, equivalence, and internal consistency of an instrument.” Njine et al. (2017) elaborates that “reliability can be viewed from two perspectives: reliability, signifying accuracy, and unreliability, indicating inaccuracy.”

Cronbach's alpha, a widely employed reliability coefficient, gauges internal consistency by assessing the interrelationship of all items on a test, both with each other and with the overall test—reflecting the internal coherence of the data. The “reliability coefficient is expressed as a value between 0.00 and 1.00,” with higher values indicating greater reliability.

In this study, the data collection instrument, the questionnaire, underwent testing on 18.3% of the sample population in Machakos Level 5 Hospital and Kathiani Level 4 Hospital to ensure its relevance and effectiveness. Reliability was evaluated using questionnaires completed by 30 randomly selected respondents, distinct from the final study sample to mitigate response bias. The questionnaire responses were entered into the Statistical Package for the Social Sciences (SPSS), and Cronbach's alpha coefficient was computed to assess reliability. The calculated Cronbach alpha aimed to gauge the questionnaire's reliability, with results presented in Table 4.2.

Table 4.2 displays the reliability outcomes, indicating that all statements exhibited reliability, as the Cronbach alpha exceeded 0.7—the specified reliability cutoff for the study. Consequently, “the internal consistency reliability of the measure was deemed excellent.” This suggests that the gathered data is reliable, as an alpha coefficient surpassing 0.7 implies a high internal consistency, allowing for the generalization of the study conclusions.

Table 4. 2

Reliability Coefficient

Variable	Cronbach's Alpha	Comment
Quality of digitized health information	0.853	Accepted
Digitized health information processing strategy	0.859	Accepted
ICT infrastructure support	0.871	Accepted
Workforce skills	0.791	Accepted
Policy framework	0.867	Accepted
“essential medicine supply chain” management	0.795	Accepted
Average Cronbach Alpha for all the variables	0.839	Accepted

The Cronbach Alpha value is always applied in the verification of reliability. The “average Cronbach alpha” for all the variables stood at 0.839, which was greater than the recommended threshold. From the results in all the variables, the value of Cronbach's Alpha surpassed the value of 0.7, implying the reliability of the data collection instrument.

4.4 Validity Test

The “Kaiser-Meyer-Olkin (KMO)” test was conducted to assess validity. Descriptive terms for “the KMO Measure of Sampling Adequacy” include: 'Marvelous' for values in the 0.90 range, “meritorious in the 0.80s, 'middling' in the 0.70s, 'mediocre' in the 0.60s, 'miserable' in the 0.50s, and 'unacceptable' below 0.50.” The “KMO Measure of Sampling Adequacy” for this variable set yielded a value of 0.771, categorized as 'middling'. As “the KMO Measure met the minimum criteria,” assessing the “anti-image correlation” matrix was unnecessary.

Another test, “Bartlett's test of sphericity” was used to examine the supposition that “the correlation matrix is an identity matrix,” implying that all variables are

uncorrelated. If the Sig value is below the alpha level, the null hypothesis of an identity matrix is rejected. In this analysis, the Sig. value resulted in “the rejection of the null hypothesis,” indicating correlations in the dataset suitable for factor analysis. This analysis satisfied the necessary conditions.

Table 4. 3

Measure of Sampling Adequacy Using Kaiser-Meyer-Olkin

Kaiser -Meyer-Olkin Measure of Sampling Adequacy		0.771
Bartlett's Test of Sphericity	Approx. Chi-Square	107.242
	Df	15
	Sig.	0.000

4.5 Demographic Traits

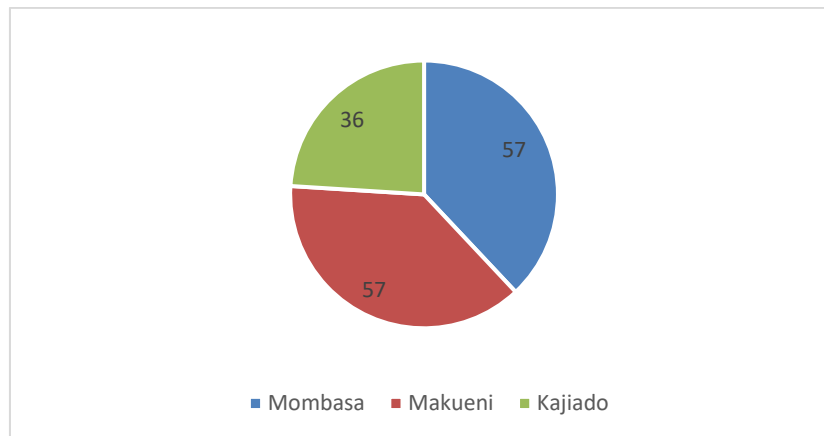
This section contains information that describes the counties, hospitals, and job descriptions of the participants.

4.5.1 Respondents Per County

According to the findings in Figure 4.1, most of the respondents were from Makueni (57) and Mombasa (57), while Kajiado County produced 36 respondents. Thus, the total number of respondents is 150.

Figure 4. 1

Respondent per County



4.5.2 Occupation

From Table 4.4, most of the respondents were pharmacists (23.78%), followed by clinical officers (20.93%); procurement officers (14.00%), medical officers (14.00%); Health Records and Information Officers (HRIOs) (11.19%), nurses (7.00%); pharmaceutical technologists (5.60%); and medical stores officers (3.50%).

Table 4. 4

Occupation

Category	Frequency	Percent
Clinical officer	30	20.93%
Health records and information officer	16	11.19%
Medical officers	20	14.00%
Medical stores officers	5	3.50%
Nurses	10	7.00%
Pharmaceutical technologists	8	5.60%
Pharmacists	34	23.78%
Procurement officers	20	14.00%
Total	143	100%

The fact that the pharmacists formed the largest percentage of the study population shows that the data collected reflected the true picture of the situation regarding the

presence/absence of “digital health information systems in support of essential medicine supply chain management.” Besides, a significant percentage of the HRIOs were deemed ideal because they are normally at the frontline of keeping patient records and disease trends and managing the health information systems.

4.6 “Influence of Quality of Digitized Health Information on Essential Medicine Supply Chain Management in Public Healthcare Facility in Kenya”

Firstly, the study sought to evaluate the influence of the quality of digitized health information (reliability, timeliness, and completeness) on the “management of “essential medicine supply chain” in public healthcare facilities in Kenya.”

4.6.1 Descriptive Statistics

Respondents were asked to indicate their degree of agreement on “the influence of quality of digitized health information on management of “essential medicine supply chain” in public healthcare facilities in Kenya.”

Table 4. 5

Quality of Digitized Health Information

Statements	Disagree	Neutral	Agree
This health facility has a functional digital HIS that supports the management of the essential medicine supply chain	99%	0%	1%
Information from your digital health information system s reliable for the management of the essential medicine supply chain	93%	0%	7%
Information from your digital health information system is timely for the management of the essential medicine supply chain	93%	0%	7%
Information from your digital health information system is accurate for the management of the essential medicine supply chain	89%	0.00%	11%
Information from your digital health information system is complete for the management of the essential medicine supply chain	96%	1%	3%
Information from your digital health information system has improved the management of the essential medicine supply chain	93%	1%	2%

Results in Table 4.5 show that 99% of respondents disagreed that “their health facility had a functional digital HIS that supports the management of the essential medicine supply chain.” In contrast, only 1% of the respondents agreed that “their facilities had a functional digital HIS that supports the management of essential medicine supply chain.” The results reveal that a significant number of healthcare facilities in Kenya continue to depend on paper-based methods for handling and managing the “essential medicine supply chain”. This situation mirrors findings by Kaupa and Naude (2021b) who observed that many hospitals in Malawi also do not have digital health information systems.

The findings were also substantiated by key informant interview findings, which showed that “most public healthcare facilities in Kenya do not have complete digital health systems,” instead rely upon a mixture of paper and electronic system-based processing. As a Medical Superintendent of Health (key informant) stated:

“Apart from KHIS/DHIS and the Digital health platform (DPH), which was introduced in 2022 and yet to be installed, the facility has no experience in using digital health information for managing the medical supply chain. We process medicine data for supply chain on paper.”

Findings from Table 4.5 also revealed that most healthcare facilities did not have “functional digital health information systems that support the management of essential medicine supply chain.” Most public healthcare facilities use a mixture of paper and electronic systems. To support this, another Medical Superintendent of Health (key informant) stated that:

“The electronic system used in the facility is MED Boss, a mixture of paper and electronic system. It is used at the store’s level for data storage but not as a supply chain tool. MED Boss is not an integrated system but only used in stores.”

Faridi and Malik (2020) highlight that using a combination of paper-based and digital systems can lead to significant inaccuracies and inconsistencies in managing the “essential medicine supply chain”. This mixed approach often results in challenges such as drug pilferage and loss, primarily due to the inability of these systems to generate accurate, reliable, and timely information. The integration of disparate systems complicates data management, leading to potential errors and inefficiencies in tracking and controlling the supply chain. The WHO (2008) suggests that the process of digitizing paper-based data is more straightforward when implemented from the beginning of data collection. This is because transferring data manually from one system to another poses considerable difficulties. The WHO (2021) further reports that more than 40% of healthcare facilities worldwide depend on a blend of paper and electronic systems, which undermines their ability to provide reliable evidence on data quality and processing. This mixed approach often fails to ensure data accuracy, reliability, completeness, and timeliness, impacting the effectiveness of data collection, extraction, and analysis processes.

As per Table 4.5, 93% of the respondents disagreed that “information from health facility digital health information systems was reliable for managing the essential medicine supply chain.” A minority 7% of the respondents agreed that “information

from digital health information systems was reliable for managing essential medicine supply chain.” This finding relates to reliance on a mixture of paper and electronic systems, which is prone to unreliable, incomplete, and delayed information for the management of “essential medicine supply chain” and service delivery. The findings echo Kuyo et al. (2018) who state that paper-based data collection and management of information are prone to errors and insufficiency in reporting. Meloan and Lacopino (2017) also corroborates that paper-based reporting in managing and controlling medicine information and stocks causes medicine stockout. These findings align with the observations of Ngusie et al. (2022) and Kanfe et al. (2022) who emphasize the crucial role of timely, reliable, and accurate information in delivering high-quality healthcare services. Both studies underscore that the effectiveness of healthcare delivery depends significantly on the availability of such information. Without timely and accurate data, healthcare providers face challenges in making informed decisions, which can adversely affect the overall quality of care. Therefore, ensuring that health information systems are reliable, and current is fundamental for enhancing service delivery and achieving optimal health outcomes. Meloan and Lacopino (2017) further strengthens the argument that paper-based processes or inadequate investment in ICT may cause challenges in managing the “essential medicine supply chain”, resulting in medicine stockout.

From the findings, effective management is facilitated by ensuring timely orders and minimizing errors, which are critical for maintaining a smooth supply chain. However, this level of efficiency can only be realized if public healthcare facilities shift from their current reliance on a combination of paper and electronic systems to a fully

integrated digital health information system. Transitioning to a unified digital system is essential for optimizing the management of the “essential medicine supply chain.” The current mixed approach, which involves both paper-based and electronic methods, often leads to inefficiencies and inaccuracies. By adopting a comprehensive digital health information system, facilities can enhance the accuracy and timeliness of their data, streamline order processing, and reduce errors. This shift is crucial for improving “the overall effectiveness of the medicine supply chain management and ensuring that public healthcare facilities can better meet the demands for essential medicines.”

When respondents were asked (see Table 4.5) to state to what level they felt that information from digital health “information systems was timely for managing the essential medicine supply chain”, 93% disagreed with the statement. Only 7% of the respondents felt that “information from the digital health information system was timely for managing the essential medicine supply chain.” Again, respondents’ response is attributed to using a mixture of paper and electronic information systems, which causes delays in managing the “essential medicine supply chain”. The findings align with the observations of Phalange (2017) who emphasizes that digitalization significantly enhances the effectiveness of information systems in providing clear, real-time data. This capability is crucial for the continuous monitoring of essential medicines, as it supports efficient inventory management and optimizes the overall supply chain at healthcare facilities. By leveraging digital tools, facilities can achieve greater transparency and improve their ability to manage medicine supplies effectively.

Moreover, Meloan and Lacopino (2017) highlights that having timely access to information about stock levels of essential medicines is vital for preventing stockouts. The ability to view real-time data on inventory facilitates prompt replenishment of medicines, thereby reducing the risk of shortages and ensuring that healthcare facilities maintain a steady supply of essential drugs. This proactive approach, enabled by digitalization, is key to managing the “essential medicine supply chain” effectively and mitigating potential disruptions in healthcare services.

From the findings in Table 4.5, 89% of respondents disagreed that “information from digital health information systems was accurate for managing essential medicine supply chain.” On the other hand, 11% of the respondents agreed that “information from their digital health information system was accurate for managing the essential medicine supply chain.” Low levels of accuracy of information for managing “essential medicine supply chain” was because of reliance on a mixture of paper and electronic systems. As Miljkovic et al. (2020) study reveals, paper-based systems can cause delays in data extraction, processing, and dissemination of essential medicine information. According to MoH (2021b), transition from paper to digitized health information can influence the “management of essential medicine supply chain in public healthcare facilities” in Kenya by ensuring the accuracy of information for managing and monitoring essential medicines supply chain.

Table 4.5 shows that most of the respondents (96 %) also disagreed that “information from digital health information systems was complete for managing the essential medicine supply chain.” On the other hand, only 3% of the respondents agreed that

“information from their digital health information system was complete for managing the essential medicine supply chain.” The incomplete management of “essential medicine supply chains” often stems from the use of both paper-based and electronic systems. According to Kharbanda et al. (2020), although digitizing health information offers significant advantages, many hospitals remain hesitant to fully embrace digital solutions for managing “essential medicine supply chains.” This study highlights that several obstacles impede the widespread adoption of “digital health information systems within public healthcare facilities in Kenya,” particularly concerning the efficient management of essential medicines.

Factors contributing to the slow adoption include inadequate infrastructure, resistance to change, and insufficient training for healthcare personnel. These barriers prevent facilities from fully leveraging the benefits of digital systems, resulting in incomplete and unreliable information that hampers effective supply chain management. Overcoming these challenges is crucial for improving the efficiency and accuracy of essential medicine management, ensuring timely availability, and reducing the risk of stockouts in healthcare settings. Level 1 to 5 public healthcare facilities have neither budget nor sufficient funds to purchase medicine or medical commodities from MEDS, KEMSA or any pharmaceutical companies. Such public health facilities are not mandated to collaborate directly on procurement agreements with pharmaceutical companies since that mandate remains with the County Government and the National Government. The decision on the number of medicines, medical products, or commodities to be supplied to public health facilities rests with the County Government and the National Government where necessary. Since public health

facilities do not have a budget or sufficient funds to purchase and install digital health information infrastructure, including installation of computers, internet, electricity, service, and maintenance of equipment, they are therefore not responsible for the slow adoption of “digital health information systems for managing essential medicine supply chain” as that is the mandate of the County and National Governments. It is also the same for healthcare personnel training in digital literacy and skills and the distribution of policies on digitalization, which is also mandated by the county and national governments. The other challenge is that most remote or rural public health facilities do not have sufficient supply or connectivity to electricity and internet, posing a challenge to installing digital health information systems for information sharing and managing “essential medicine supply chains.” Sometimes such public facilities are served with silos of fragmented project-based digital systems which cannot manage information for the medicine supply chain. Ngusie et al. (2022) highlight that incomplete information significantly hampers the effective utilization of data by health professionals, ultimately impacting service planning and delivery. They argue that the presence of incomplete, inaccurate, or inconsistent information undermines the reliability of non-digital systems. This lack of dependable data erodes the confidence of managers in using such information for strategic planning and health service delivery. Moreover, these studies emphasize that the challenges associated with incomplete information stem from outdated or inefficient information systems. Without comprehensive and reliable data, healthcare professionals struggle to make informed decisions, which adversely affects the overall quality of service. To address these issues, transitioning to robust digital information systems is crucial for enhancing

the accuracy and completeness of data, thereby improving the efficiency of healthcare management and service delivery.

Respondents were also asked to state if “information from digital health information systems had improved the management of the essential medicine supply chain.” From the findings in Table 4.5, most of the respondents (93%) disagreed with the statement because public health facilities have no digital health information systems and instead rely upon a mixture of paper and electronic systems for processing information to manage “essential medicine supply chain.” Only 2% of the respondents agreed that “information from digital health information systems had improved the management of essential medicine supply chain.” This study concurs with the MSH (2012) that incomplete and inaccurate data collection from fragmented systems causes delays and errors in processing information for quantification, forecasting, and managing the “essential medicine supply chain”.

However, few key informant respondents whose facilities had at least some digital health information systems, although not designed with tools to process supply chain information, reiterated the importance of digital health information systems.

As a Procurement Officer (key informant) postulated,

“It makes it easy to compile data and reports regarding the number of medicines available and medicines required. This informs the procurement of healthy commodities. Right now, am dealing with 50 patients who need medicines unavailable in the facility. I am unable to forecast and quantify the total medicines that are needed for at least three months. It is difficult to tell

and procure all the drugs needed from the records because the information is patched in different sections and not easily compiled into one report. Data is on medicine stock, and what is needed is not easily available on short notice, which could help us make informed decisions about the requisition and supply of drugs. Digitalization of information across sections would help in stock monitoring and sharing within the hospitals to minimize expiries and shortages. It would also minimize pilferages.”

Medical Stores Officer (key respondent) respondent stated that:

“Digital health information systems help reduce pilferage and medicine theft within the facility. It ensures the timely delivery of essential medicines and other commodities. When there are efficient digital health information systems in place in public health facilities, it is obvious that stocking essential medicines in public health facilities will be fast in responding to the demand and needs of patients.”

The study (Table 4.6) also sought to determine whether ““essential medicine supply chain” management depends on the quality of information produced by the digital health information system.”

Table 4. 6

Management of Essential Medicines Supply Chain

Question	Yes	No
Overall, do you agree that managing the essential medicine supply chain depends on the quality of information produced by digital health information?	97.60%	2.40%
Do you face any challenges working with the existing digital health information systems in managing your facility essential medicine supply chain?	68.20%	31.80%

From the findings, as shown in Table 4.6, 97.60% of the respondents agreed that “the management of the “essential medicine supply chain” was dependent on the quality of information produced by the digital health information system.” In comparison, only 2.40% disagreed with this. A high level of agreed responses was based on respondents' perceived understanding of the importance of digital health information. However, the system used in public health facilities was a mixture of paper and electronic systems. The findings underscore the critical role that the quality of information generated by digital health information systems plays in managing the “essential medicine supply chain”. Effective management is closely linked to the accuracy, reliability, and timeliness of the data provided by these systems. This observation aligns with Muinga et al. (2020) who highlight that manual systems are not only slower but also prone to a higher frequency of errors compared to digital solutions. Building on this perspective, Lugada et al. (2022) further emphasize that high-quality information is essential for enhancing both planning and management within healthcare supply chains. The study supports this view by demonstrating that the transition to digital systems can significantly improve the efficiency and effectiveness of supply chain management, leading to better-informed decisions and more reliable operations. Thus, adopting advanced digital health “information systems is crucial for optimizing the management of essential medicines and overall healthcare delivery.”

The study also sought to determine whether respondents faced any challenges managing the “essential medicine supply chain” in their facilities using existing health information systems

Table 4. 7***Specific information Challenges Faced***

Challenge	Frequency	Per cent
Reliability	139	97.2%
Completeness	140	97.9%
Accuracy	135	94.4%
Accessibility	130	90.9%
Timeliness	141	98.6%

Table 4.7, findings display the opinions of 143 respondents with regard to “challenges they faced working with the existing health information systems in managing the “essential medicine supply chain” in the facility,” 97.2% felt that the information was not reliable, 97.9% the information was not complete, 94.4% information was not accurate, 90.9 the information was not accessible and 98.6% the information was not timely. Most public healthcare facilities in Mombasa, Makueni and Kajiado relied upon a mixture of paper and electronic systems for information to manage the “essential medicine supply chain”. The finding agrees with Kuyo et al. (2018) that paper-based data processing is prone to errors, and mixing paper and some form of electronic system was found to expose information to similar errors, making the information unreliable. Findings also concur with MSH (2012) that incomplete and inaccurate data from fragmented systems cause delays and errors in decision-making in managing the “essential medicine supply chain”. As stated by Reiner (2015) the study reveals that the lack of integration of information systems, instead of relying on paper and some form of electronic system, caused challenges with data extraction and processing into reliable information for “the management of the essential medicine supply chain.”

As one Procurement Officer (key informant) stated:

“Compilation and processing of data on medicine, availability, and storage in this facility is done manually on paper. Gathering that information from different sections and records takes time. Ultimately, data produced is normally inaccurate and incomplete, so without proper verification, information that is put together and communicated to the County for purchase or medicines is incomplete, inaccurate, and delayed, leading to incorrect quantities and incorrect product selection.”

The response from the Procurement Officer confirms the challenges of reliability, completeness, accuracy, accessibility, and timeliness of information that is reported in Table 4.7. The findings align with the WHO (2021) assertion that the reliability of information from health facilities depends significantly on the consistency and completeness of the reports generated. Inadequate or inconsistent data can undermine the effectiveness of health management systems. This perspective is supported by Koumamba et al. (2021) who note that many African nations face substantial challenges in achieving high-quality health information due to issues such as unreliable, incomplete, inconsistent, and untimely data. As WHO (2021) points out, the presence of incomplete or incorrect information can severely hinder the ability to plan and manage the supply chain effectively. Such deficiencies in data quality can adversely impact service delivery and supply chain management, making it difficult to ensure that essential medicines are available when needed. The evidence underscores the need for more reliable and comprehensive reporting systems to improve health outcomes and operational efficiency in healthcare facilities.

4.7 Influence of Digitized Health Information Processing Strategy on “essential medicine supply chain” Management in Public Healthcare Facility in Kenya

Secondly, the study sought to assess the influence of digitized health information processing (data collection, data extraction, data analysis) strategy on the “management of “essential medicine supply chain”” in public healthcare facilities in Kenya.

4.7.1 Descriptive Statistics

The respondents were asked to indicate their level of agreement on how digitized health information processing strategy influences the “management of “essential medicine supply chain”” in healthcare facilities in Kenya. The results are presented in Table 4.8.

Table 4. 8

Digitized Health Information Processing Strategy

Statements	Disagree	Neutral	Agree
Extractions of digital health information system has improved information for the management of the essential medicine supply chain in this facility	93%	2%	5%
Analysis of data through digital health information system has improved information the management of the essential medicine supply chain in this facility	96%	1%	3%
Data collection through digital health information system has improved information for management of the essential medicine supply chain in this facility	97%	1%	2%
Better management of the essential medicine supply chain in this facility relies on information processed through a digital health information system	96%	1%	3%

From the findings, as shown in Table 4.8 above, 93% of the respondents disagreed that data “extraction through existing forms of digital health information systems had

improved information for the management of essential medicine supply chain in their facilities.” On the other hand, only 5% of the respondents agreed with this. The findings in Table 4.8 indicate that in most public hospitals across Kenya, data extraction through a mixture of paper and electronic systems has not improved information for the management of “essential medicine supply chain in facilities.” This is mainly because “most public healthcare facilities do not have a digital health system with tools for processing the medicine supply chain.” Instead, they rely upon a mixture of paper and electronic systems to manage the “essential medicine supply chain.” The existing forms of “electronic health information systems in public healthcare facilities” are used to prepare health records and store data and bills and not for processing information for managing the “essential medicine supply chain”.

A Medical Stores Officer (key informant) responded that:

“The information systems that we have do not digitally communicate directly within departments in the health facility, nor are they connected with KHIS. There is neither a KEMSA supply management system nor the logistics management information systems in the facility to process the medicine supply chain. Quantifying essential medicine and other commodities is thus done manually on paper and is a tedious activity to compile a record on medicines in the facility.”

This shows that such incomplete and unintegrated information systems and using paper could not ensure the production of quality information and end-to-end communication; hence, it is not easy to use them for data extraction towards supporting the management of “essential medicine supply chains” in public healthcare facilities in Kenya. The findings (table 4.8) are consistent with the MoH (2021a) which shows

that health facilities in Kenya have a problem with inadequate essential medicine data processing (extraction) and visualization of essential medicines at the facility to support the management of “essential medicine supply chain”. Reiner (2015) states that due to a lack of integration or interoperability of the health information systems, healthcare workers face the challenges of extracting and retrieving medical information from the information systems.

From the previous studies, MSH (2012) states that digitized information systems extract (process) data much faster than paper-based systems because of digital formula programming which automatically makes quantification or forecasting of medicines effective and ready to support the management of supply chain. MSH (2012) further notes that if the data formula and entry are correct, digital solutions will process correct estimates of the needed essential medicines. MSH (2012) further observes that manual extraction of the quantities of essential medicines in the facility takes a long time to type, rewrite tables, quantify, forecast, and print reports.

One HRIO (key informant) corroborated this by postulating that:

“Data extraction on medicine is done manually, not through the digital health systems. We do not have a digital health information system with tools for processing medicine supply chain activities in the facility. even KHIS is not available in this facility.”

From the findings in Table 4.8, 93% of the respondents stated that data extraction did not improve “information for managing the essential medicine supply chain.” Findings indicate that the extraction and processing of medical data in public healthcare facilities in Kajiado, Makueni, and Mombasa is done on paper. The Medical Stores Officer states that using the manual system to process data is difficult, a testimony

confirming 96% response that “management of the essential medicine supply chain” at the facility does not rely on information processed through existing digital health information systems. Kharbanda et al. (2020) state that the first stage of digitizing facility information systems should involve modernization and digitization of systems that are used to gather, share, and analyze vast amounts of data.

Data extraction informs how digitized health information processing strategy influences the “management of essential medicine supply chain” in public healthcare facilities in Kenya. Hospitals possess terabytes of data through digital health information systems, from patient records to disease trends. This data can only be meaningful if what is necessary is extracted and analyzed to help ensure efficient management of the “essential medicine supply chain”. However, this is not evident in the Kajiado, Makueni, and Mombasa public healthcare facilities. The current findings also align with Stobierski et al. (2022) who argues that when information processing (analysis) is flawed, decisions based on such flawed information risk producing incorrect information that affects planning and service delivery.

The results in Table 4.8 also reveal that 96 % of respondents disagreed that data analysis through existing forms of digital health information systems has improved information for managing “essential medicine supply chains” in their facilities. On the other hand, only 3% of the respondents agreed that data analysis through existing digital health information systems has improved information for managing “essential medicine supply chain” in their facilities. According to UNDP (2022), the capacity of health information systems in health facilities to analyze data on the management of essential medicine into information that can effectively be used to manage the supply

chain in many countries is inadequate. The implications of the findings in Table 4.18 and the response from HRIO could be what WHO (2021) observed: over 40% of health facilities globally cannot provide evidence of data quality and process analysis. The findings also corroborate the argument by Nkanata et al. (2018) that delays by information systems to analyze information timely affect meaningful evidence-based decision-making, planning of services and service delivery.

The results in Table 4.8 further exhibit that 97% of the respondents disagreed that data collection through existing forms of digital health information systems has improved information for the management of “essential medicine supply chain” in their facilities. In contrast, only 2% of the respondents agreed with this. The findings show that data collection towards “management of essential medicine supply chain in most public hospitals in Kenya” is not conducted through digital health information systems; instead, it is processed through a mixture of paper and electronic systems. A response from HRIO confirmed that data extraction is not done through a digital information system because such a system is not available in the facility. The Medical Stores Officer also reinforced a similar position that data on medicine was collected and quantified manually. These statements have implications regarding timeliness and quality of “information to support decision-making for managing essential medicine supply chain in the public healthcare facilities” in Kajiado, Mombasa, and Makueni counties. WHO (2021) observes that poor data collection negatively affects health policies, service delivery, public health, and “essential medicine supply chain” management. The findings in Table 4.8., are consistent with Rubio-Rivas et al. (2021) who argue that HIS systems in Latin America and Africa have poor data because data

collection is associated with the use of a mixture of paper and electronic systems which are not integrated or interoperable and lack of full digital HIS implementation strategies.

Respondents were asked to state if “better management of “essential medicine supply chain” in their facilities relied upon the existing digital health information systems.”

The findings in Table 4.8 also reveal that 96% of the respondents disagreed that “better management of “essential medicine supply chain” in their facilities relied on information processed through existing digital health information systems.” On the other hand, only 3% of the respondents agreed that “better management of the “essential medicine supply chain” relied upon the existing digital health information.”

The findings in Table 4.8 depict a lack of digital health information systems for the “management of essential medicine supply chain.” The responses reveal that most public hospitals in Kenya still rely mostly on paper-based systems with a few digitised segments for managing “essential medicine supply chain” in facilities. According to MoH (2020b), a successful supply chain is achieved through producing accurate medicine consumption data, quantification and forecast, procurement according to plan, and monitoring or availability of available stocks to mitigate against shortages.

With most public healthcare facilities still relying on paper-based systems to manage the “essential medicine supply chain”, most of the challenges existing in public healthcare facilities related to the medicines supply chain will persist. The current findings in Table 4.8 support the previous studies; for example, PAHO (2021) states that 55% of the Caribbean Region, to a larger extent, uses paper-based data collection method and as such data have limited use at the facility. PAHO (2021) further notes

that 44% of the Caribbean Region countries do not collect data but rely on international organizations' estimation.

In a few public healthcare facilities that have adopted some form of digital health information systems—though not specifically designed for medicine supply chain management—the interview findings reveal that digitized health information processing plays a significant role in influencing the management of “essential medicine supply chains.” The availability of digital data enables more efficient data management, allowing for better projections and informed decision-making in the digital era. The ability to access and process accurate data is crucial in ensuring that essential medicines are appropriately tracked, forecasted, and supplied, contributing to the overall efficiency of supply chain management.

Furthermore, the findings indicate that a digitized health information processing strategy enhances interdepartmental and inter-hospital communication, which is critical for managing the “essential medicine supply chain”. When various departments within healthcare facilities are interconnected through digital systems, it creates a more coordinated approach to managing stock levels, orders, and distribution. Improved communication across different levels of healthcare infrastructure fosters a more streamlined supply chain process, reducing the risk of stockouts and ensuring that essential medicines are delivered in a timely manner.

A digitized health information processing strategy also influences the “management of “essential medicine supply chain”” in Kenya's public healthcare facilities by

producing quality information on medicine consumption and stock. When information on medicine is correct, complete, and timely, it facilitates sound management of “essential medicine supply chain” processes in the facility.

As a Procurement Officer (key informant) stated:

“Currently there is no digital information system for the supply chain to process medicine data. It would be easy to produce reports through a proper information processing strategy, which is significant in making decisions regarding managing the “essential medicine supply chain”. This is not the case now because information on medicine and supply chain is managed through paper.”

Digitized health information processing strategy also enhances accountability in the “management of “essential medicine supply chain”” in public healthcare facilities in Kenya.

Response from another Procurement Officer (key informant) :

“If the systems were digitized, information processing would produce quality information, and there would be improved decision-making and an “essential medicine supply chain” process.”

Digitized health information processing strategy influences the “management of “essential medicine supply chain”” in public healthcare facilities in Kenya by reducing time for decision-making and management of “essential medicine supply chain” processes.

Another HRIO (key informant) confirmed that:

“Although both KHIS and FunSoft digital systems operate in the facility to support reporting and billing, these systems are not structured and organized

for medicine supply chain and logistical functions, let alone the management of “essential medicine supply chain” process. Information for procurement and supply of Medicine products and other commodities is recorded on paper and managed manually. This explains why we sometimes delay receiving the required number of medicines and medical products. Sometimes a follow-up must be made whenever an error is detected in the information provided to the county.”

Through a digitized health information processing strategy, healthcare facilities can forecast and quantify medicines needed, save on turnaround time, and generate reports through digital health information systems (DHIS). This enables fast-tracking decision-making and efficiently managing the “essential medicine supply chain”.

Table 4. 9

Digitized Health Information Processing Strategy

Statements	Yes	No
Is data collection on essential medicine in your facility done through the digital information system?	7.10%	92.9%
Is data extraction for managing the “essential medicine supply chain” in your facility done through a digital health information system?	5.90%	94.10%
Is data analysis for managing the “essential medicine supply chain” in your facility done through a digital health information system?	7.10%	92.90%

Respondents were also asked to state if “data collection on essential medicine in public healthcare facilities was done through the digital information system.” From the results in Table 4.9, most of the respondents (92.9%) disagreed that data collection on essential medicine in their facilities was done through the digital information system,

while only 7.10% of the respondents agreed to this. The results in Table 4.9 and the response from HRIO indicate that KHIS and FunSoft are not used in public healthcare facilities in Kajiado, Makueni, and Mombasa for collection, compilation, extraction, and communicating information for the management of the “essential medicine supply chain”. Instead, data on the medicine supply chain is processed through a mixture of paper and electronic systems not equipped with tools for processing the medicine supply chain. Findings corroborate those of Tull (2018) who found that most of the data in healthcare facilities in Ethiopia were derived from paper-based records.

The study, as shown in Table 4.9 above, also indicated that most of the respondents (94.10%) disagreed that data extraction for managing “essential medicine supply chain in facilities was done through digital health information systems.” Only 5.90% of the respondents agreed that data extraction for managing “essential medicine supply chain” in facilities was done through digital health information systems. Like in the above case, reliance on a mixture of paper and electronic systems made extracting data through the digital system difficult. The findings further show that most of the respondents (92.90%) disagreed that data analysis for managing “essential medicine supply chain in their facilities was done through digital health information systems,” with only 7.10% of the respondents agreeing to this. These findings confirm Meloan and Lacopino (2017) statement that most African countries depend on paper-based recording of medicine data to manage and control medicine stocks. The findings contrast those of Tortorella et al. (2021) who found that healthcare facilities in developed countries used healthcare digital application systems to collect and extract data.

As a Medical Stores Officer (key informant)

stated,

“Although currently essential medicines are available in the facility, we do experience shortage of some essential medicines caused by delays in either sending the request in time or when the order made is incorrect in numbers and product specifications. Tracking and monitoring medicines is done through a manual system, which has also caused us some challenges in ascertaining the correct stock and the needed quantity of medicines.”

A Medical Superintendent of Health (key informant) reacted that the availability of medicines in the facility was erratic.

“We do not have an information system that is connected across the different departments to collect and share information on medicine consumption and available stock of medicines. The information gathered in the facility on medicines is done manually on paper, and sometimes, it does not contain all the information. Because that information is sent to the county long after compiling, as such, we do not always have 100% of the medicines needed. We primarily depend on the county to purchase for us the commodities. We supplement the purchase of medicine by using funds generated from our facility, which depends on the amount we collect.”

A Procurement Officer (key informant) stated:

“Essential medicines are not enough in the facility, we frequently experience medicine stockouts because personnel responsible for compiling medicine

stock do not receive correct information in time, and sometimes it reaches them late when the figures have changed; the compilation is done manually sometimes with errors so what is ordered does not reflect the needed quantity.”

The statement from the key informant above reveals that most public healthcare facilities in Kajiado, Makueni, and Mombasa counties rely on a mixture of paper and electronic systems to collect medicine consumption data and process the information to manage “essential medicine supply chain” processes. Because of delays in submitting the purchase orders to the county, the medicines that are supplied to the facility do not always meet the needs of the time.

4.8 The Influence of ICT Infrastructure Support on “essential medicine supply chain” Management in Public Healthcare Facility in Kenya

Thirdly, the study sought to determine the influence of ICT infrastructure (computer, electricity connectivity, and internet) support on the “management of “essential medicine supply chain”” in public healthcare facilities in Kenya.

4.8.1 Descriptive Statistics

The respondents were requested to indicate “their level of agreement with the statements on the influence of ICT infrastructure support on the management of essential medicine supply chains in public healthcare facilities in Kenya.” Results are presented in Table 4.10.

Table 4. 10***Influence of ICT Infrastructure Support***

Statements	Disagree	Neutral	Agree
Your facility has enough functional computers to support digital information for managing the essential medicine supply chain	85%	4%	11%
Your facility has electricity connectivity to support the ICT application of digital health information for the management of the essential medicine supply chain	17%	1%	82%
Your health facility has reliable internet to support digital health information for the management of the essential medicine supply chain	85%	4%	11%
Better management of essential medicine supply chain in this facility relies on ICT infrastructure for management of digital health information system	8%	2%	90%

From the results in Table 4.10, most of the respondents (85%) disagreed that “facilities had enough functional computers to support digital information for managing essential medicine supply chain.” On the other hand, only 11% of the respondents agreed that “facilities had enough functional computers to support digital information for managing essential medicine supply chain”. The findings indicate that many public hospitals in Kenya do not have enough functional computers requisite to enhance “digital information systems for managing the essential medicine supply chain.” This is consistent with MoH’s Kenya Supply Chain Strategy (2020-2025), which highlights that although the use of ICT to manage “essential medicine supply chains” in public healthcare facilities is on the rise, several challenges hinder full utilization of these technologies. These challenges include inadequate ICT infrastructure, frequent breakdowns of the few available computers, poor internet connectivity, and insufficient digital skills among healthcare workers. These barriers slow down the

adoption of digital systems and reduce their effectiveness in managing the supply chain of essential medicines “across various levels of the healthcare system.” Additionally, Meloan and Lacopino (2017) echoes these concerns, stating that the inadequate use or complete lack of ICT in “processing essential medicine data contributes to frequent medicine stockouts in the healthcare sector.” Without proper digital systems to track, monitor, and manage the supply of medicines, healthcare facilities face difficulties in ensuring a steady and reliable supply of essential drugs. The absence of robust ICT tools not only disrupts real-time data processing but also impedes effective decision-making, ultimately compromising the timely availability of medicines and other critical health products in public hospitals.

Abdullah et al. (2017) emphasize the critical role that ICT infrastructure plays in managing the “essential medicine supply chain in public healthcare facilities in Kenya.” Their findings highlight that robust ICT support is essential for ensuring efficient tracking, distribution, and monitoring of essential medicines. Without this infrastructure, facilities face significant challenges in maintaining an organized and responsive supply chain. Effective ICT systems enable real-time data collection, streamline processes, and reduce the likelihood of errors, ensuring that medicines are available when needed and stockouts are minimized. However, the study also reveals that many public healthcare facilities in Kenya still operate without fully integrated digital health information systems. This lack of integration presents a major hurdle in the effective management of the “essential medicine supply chain”. In the absence of a cohesive digital system, healthcare facilities often rely on fragmented or outdated methods, such as paper-based records or mixed digital systems that are not well-

connected. These disjointed processes hinder accurate data tracking and lead to inefficiencies in the supply chain, ultimately compromising the ability to maintain adequate medicine supplies across the healthcare network. From one HRIO (a key informant):

“ICT infrastructure for digitizing health information system for management of “essential medicine supply chain” has not been installed in the facility. “Essential medicine supply chain” processing is still paper-based due to, among other reasons, the limited computers and internet connection in public healthcare facilities.”

A Procurement Officer (key informant) postulated:

“ICT infrastructure is essential in every sector in the current technological world. In our facility, a functional ICT with the capacity to process supply chain functions could play a key role in managing medicine supplies. Only the supply chain department has at least a functioning computer and although it is used for storage of data, it is neither interconnected nor is it used for procurement purposes .”

These findings concur with those of Oreni et al. (2021) who found that while ICT plays a key role in ensuring quality data collection, the available ICT systems in public healthcare facilities in Kenya were not integrated to share information.

The findings in Table 4.10 also found that most respondents (82%) agreed that their health facilities have electricity connectivity to support ICT applications. In contrast,

only 17% of the respondents disagreed that health facilities have electricity connectivity to support ICT applications. The findings from this study indicate that the majority of public hospitals in Kenya have reliable access to electricity, which is crucial for supporting various health systems, including digital information systems and ICT infrastructure. This stands in contrast to a study by Moner-Girona et al. (2021) which found that “only 28 percent of healthcare facilities in eight sub-Saharan African countries had consistent access to electricity.” The disparity suggests that while Kenya may have made strides in improving electricity connectivity in public hospitals, many other countries in the region continue to face significant challenges in ensuring a stable power supply. Reliable electricity is a fundamental requirement for operating digital health systems and ensuring the efficient management of the “essential medicine supply chain”. Signé (2021) underscores that frequent power outages in rural areas of “sub-Saharan Africa negatively impact the functioning of digital information systems, ICT infrastructure, and medical equipment.” These outages disrupt not only the management of the “essential medicine supply chain” but also overall healthcare service delivery. In areas where power reliability is a challenge, the use of digital systems becomes erratic, leading to gaps in data processing, delays in medicine distribution, and compromised patient care. Ensuring a stable electricity supply is therefore critical to maintaining operational efficiency in healthcare facilities and safeguarding the integrity of the “essential medicine supply chain”.

The study also sought to determine if health facilities have “reliable internet to support digital health information to manage essential medicine supply chain.” From the results in Table 4.10, most of the respondents (85%) disagreed that “health facilities

have reliable internet to support digital health information for the management of the essential medicine supply chain.” Only 11% of the respondents agreed with this. The study findings indicate that a majority of public healthcare facilities in Kenya lack reliable internet connectivity, “hindering the effective use of digital health information systems for managing essential medicine supply chains.” This challenge aligns with Aila and Kithuka (2021) who argue that unreliable internet access impedes the production, broadcast, and efficient utilization of health information, which is crucial for planning and delivering healthcare services. In the context of supply chain management, such limitations can lead to delays in processing orders, inefficient inventory management, and challenges in ensuring the timely distribution of essential medicines across facilities. Kuyo et al. (2020) further highlight the impact of unreliable internet on the effectiveness of digital health platforms like DHIS2, particularly in Uasin Gishu County. Their study found that 47.1% of the challenges were due to unstable internet connectivity, while 48.6% were linked to inadequate user skills, 36.7% to non-connected computers, and 34.3% to insufficient management support. These issues collectively hinder the use of digital systems to manage health information efficiently. Interviews with key informants, particularly HRIOs, also emphasized concerns regarding inconsistent internet connectivity, which limits their ability to manage “essential medicine supply chains” effectively and undermines overall healthcare service delivery.

As one HRIO stated:

“Internet interruptions in the facility are quite common, for example, we lost internet for 2 months as we were transitioning from one provider to another. This affected services that relied on information transfer through the internet.”

From the findings in Table 4.10, most of the respondents (90%) agreed that “better management of “essential medicine supply chain” in their facilities rely on ICT infrastructure for management of digital health information systems.” Only 8% of the respondents disagreed with this. The same findings reveal that most public healthcare facilities in Kenya appreciate the role of ICT infrastructure “for management of digital health information system on the management of ICT infrastructure for management of digital health information system.” While most hospitals do not have an integrated ICT infrastructure that can support “the management of “essential medicine supply chain,” health facility management acknowledges the role they played by an integrated ICT infrastructure in improving the management of the “essential medicine supply chain”. The findings support those of Ohia et al. (2023) who postulate that ICT infrastructure is essential in ensuring that digitized health information technology works towards supporting “essential medicine supply chain” management. End-to-end communication becomes efficient when a hospital facility is well-equipped in terms of computers and digital information systems. However, the lack of reliable internet jeopardizes the effort to complete ICT infrastructure and digital information systems to support the management of the “essential medicine supply chain”.

As shown in Table 4.11, the study also sought to determine “whether health facilities are connected to electricity from the Kenya Power grid to support a digital health information system for managing the supply chain.”

Table 4. 11***Health facility electricity and internet connectivity***

Questions	Yes	No
Is your health facility connected to electricity supply from the Kenya Power grid supply to support a digital health information system for the management of supply chain?	97.60%	2.40%
In your opinion does the connection to electricity in your facility support the use of a digital health information system for the management of the essential medicine supply chain	90.60%	9.40%
Does your health facility have a generator for supplying electricity during blackout from Kenya's Power supply to support a digital information system for the management of the supply chain?	96.50%	3.50%
Does the absence of electricity in your health facility affect the availability of digital health information for the management of supply chain?	3.50%	96.50%
Does your health facility have adequate internet connectivity to support the use of digital health information system transmission of information for the management of the supply chain?	22.40%	77.60%
Does lack of internet connectivity in your health facility affect the transmission of digital health information for effective management of supply chain?	88.20%	11.80%

From, the findings in Table 4.11, 97.60% of the respondents agreed that “their health facilities are connected to electricity supply from the Kenya Power grid supply to support digital health information system for the management of the supply chain.” Only 2.40% of the respondents disagreed with this. The same findings show that “public health facilities in Kenya have no challenges of connection to electricity supply from the Kenya Power grid supply to support digital health information system for management of the supply chain,” even though most of these facilities do not have an integrated ICT infrastructure and a digital information system with tools to support supply chain functions.

As shown in Table 4.11, findings also indicated that the connection to electricity in health facilities supported digital health information systems, as indicated by most respondents (90.60%). Only 9.40% of the respondents disagreed with this. The same findings indicate that in most public health facilities in Kenya, the electricity connection supports the use of digital health information systems. While most public hospitals do not currently have integrated ICT infrastructure and “digital health information systems that could support essential medicine supply chain management,” they have electricity connectivity, making it easier to connect an integrated ICT infrastructure and digital health information system once such systems are installed. The findings are in tandem with Ngusie et al. (2022) who found that electricity plays a key role in ensuring that healthcare facilities utilize digital healthcare information systems to support essential services.

From Table 4.11, most respondents (96.50%) reacted that their health facilities “have a Generator for supplying electricity during blackouts from Kenya's power supply to support the digital health information system for supply chain management.” Only 3.50% of the respondents disagreed with this. The findings reveal that most public health facilities in Kenya are well-prepared in case of any power outages. This is essential in ensuring that digital health information systems will enhance the management of “essential medicine supply chain” once installed. The findings concur with Michalski et al. (2015) who postulate that generators play a crucial role in supporting the essential drug supply chain in hospitals by ensuring the continuous operation of critical systems and equipment, especially during power outages. Many essential drugs, particularly vaccines and biologics, require strict temperature control

for efficacy and safety. Generators ensure that refrigeration units and cold storage facilities remain operational during power interruptions, preventing spoilage and ensuring drug integrity. Besides, hospital information systems and drug inventory management systems are crucial for tracking and managing the supply of essential drugs. Generators keep these systems running, allowing for real-time monitoring and management of drug stocks.

When respondents were asked to state, “whether the absence of electricity in health facilities affected the availability of digital health information for the management of the supply chain,” most of them, as shown in Table 4.11 (96.50%), responded that the “absence of electricity in their health facilities did not affect the availability of digital health information for the management of supply chain.” Only 3.50% of them responded that it did affect them. Most of them responded no, mainly because while most public health facilities in Kenya “are connected to electricity, electricity did not affect the management of the essential medicine supply chain.” After all, the medicine supply chain was processed manually through a mixture of paper and electronic systems. As Lugada et al. (2022) state, while electricity plays a key role in determining whether a healthcare facility can procure digital health information systems, most systems nowadays can be powered by solar energy, which is slowly replacing electricity as the main energy source.

The study also sought to find out if health facilities have “adequate internet connectivity to support the use of digital health information system transmission of information for the management of the supply chain.” From Table 4.11, most of the

respondents (77.60%) stated that “their health facilities did not have adequate internet connectivity to support the use of digital health information systems for the transmission of information for the management of the supply chain.” Only 22.40% of the respondents responded that they had adequate internet connectivity to support the use of digital health information systems for transmitting information for supply chain management. The findings reveal that most public health facilities in Kenya do not have adequate internet connectivity to support using digital health information systems to transmit information for supply chain management. Internet connectivity was only installed in a few departments and not all essential departments supporting the “essential medicine supply chain”.

As one HRIO stated, *“In our hospital, the Internet router is only available in the Administration, the Finance Department, and the Procurement. These other sections rely on unstable bandwidth connections.”*

The lack of reliable internet connectivity poses a significant threat to the functionality of digital health systems in public healthcare facilities, particularly in managing “essential medicine supply chain.” Without stable internet access, the processing and transmission of digital information required for inventory management, ordering, and tracking of essential medicines become difficult, leading to inefficiencies and potential stockouts. This challenge is critical in ensuring that essential medicines are readily available in public health facilities, and any disruption in digital health systems due to poor internet connectivity may severely hinder these operations. These findings are consistent with the observations of Kuyo et al. (2018) who identified unstable internet connectivity as a key factor limiting the adoption of the District Health Information

Software version 2 (DHIS 2) in healthcare facilities within Uasin Gishu County. Their study highlighted how inconsistent internet access within most facilities impeded the use of digital systems, reducing their overall effectiveness in processing health information. This further underscores the importance of improving internet infrastructure to support digital health systems and ensure seamless management of “essential medicine supply chains” across public healthcare institutions.

Relatedly, the study also sought to investigate if “the lack of internet connectivity in health facilities affects the transmission of digital health information for effective supply chain management.” From Table 4.11, most of the respondents (88.20%) responded yes while only 11.80% responded no. The findings highlight that the majority of public hospitals in Kenya acknowledge the critical role of internet connectivity in facilitating the transmission of digital health information for the effective management of “essential medicine supply chains.” Reliable internet access enables real-time data sharing, which is crucial for monitoring stock levels, processing orders, and ensuring timely deliveries of essential medicines. Without consistent internet connectivity, these systems face disruptions, which can lead to inefficiencies, delays, and even stockouts, ultimately affecting healthcare service delivery. This observation aligns with the research of Kyalo et al. (2018) who identified the internet as a key technical factor influencing the integration of HMIS in Kenyan health facilities. Their study demonstrated that inadequate internet connectivity can severely limit the functionality and effectiveness of HMIS, highlighting the importance of strengthening internet infrastructure in public healthcare institutions. Enhancing

connectivity would not only improve the management of “essential medicine supply chains” but also optimize the overall use of digital health systems in Kenyan hospitals.

4.9 Influence of Workforce Skills on “essential medicine supply chain” Management

Fourthly, the study sought to examine the influence of workforce skills (training, management support, and supervision) on the “management of “essential medicine supply chain”” in public healthcare facilities in Kenya.

4.9.1 Descriptive Statistics

The respondents were asked to state their degree of agreement with the statements on “the influence of workforce skills on the management of “essential medicine supply chains” in public healthcare facilities in Kenya.” Results are presented in Table 4.24

Table 4. 12***Influence of Workforce Skills***

Statement	Disagree	Neutral	Agree
Your health facility has an adequate number of trained staff on digital health information to support the management of the essential medicine supply chain	90%	3%	7%
Your health facility has adequate staff training in medical supplies and products supply chain management	82%	0%	18%
In your facility, there is a supervisor who supervises the dissemination of digital health information for the management of essential medicine supply chain within the facility	81%	4%	15%
Regular supervision of digital health information dissemination has improved efficiency in the management of the essential medicine supply chain in my facility	91%	3%	6%
Lack of regular supervision of digital health information dissemination affects the management of the essential medicine supply chain in this facility	18%	2%	80%
An inadequate number of trained personnel in digital health information affects the efficient management of the essential medicine supply chain in this facility	92%	2%	6%

Results in Table 4.12 exhibit that most of the respondents (90%) disagreed that health facilities had adequately trained staff on “digital health information to support the management of the essential medicine supply chain.” On the other hand, 7% of the respondents agreed that health facilities had adequately trained staff on “digital health information to support the management of the “essential medicine supply chain.” These findings reveal that half of the public healthcare facilities in Mombasa, Makueni, and Kajiado do not have enough trained staff on “digital health information to support the “essential medicine supply chain” management.” These findings are supported by previous studies by Tull (2018) in Ghana and Tanzania, where HISs

faced significant implementation challenges due to inadequate training of personnel, poor staff involvement, and increased workload. This means public healthcare facilities would encounter slow adoption of digital health information systems to manage “essential medicine supply chain” due to the inadequate number of staff with knowledge and skills in digital health information systems. The fact that 3% of the respondents remained neutral indicates that some public healthcare facility staff do not know anything about “digital health information to support the management of the “essential medicine supply chain.” Findings from the interviews reveal that there is inadequate use of “digital information in the management of essential medicine supply chain.” The lack of an adequate number of skilled workforces in digital health information affects the timely management of the “essential medicine supply chain.” The interviews acknowledge that inadequate numbers of trained staff on the use of digital health information systems are partly associated with an inadequate number of ICT infrastructure within the facility.

As one Medical Superintendent stated,

“We cannot comfortably and adequately train our staff on ICT and digital health information aspects because we do not have sufficient ICT facilities that staff can use. Additionally, we do not have the adequate number of digital information technology infrastructure that would require a considerable number of trained personnel in that field.”

Findings in Table 4.12 show that in public healthcare facilities with some form of digital health information systems, a lack of workforce skills has slowed down the efficient use of “digital information in managing essential medicine supply chain.”

As the Medical Superintendent of Health (key informant) stated:

“Inadequate number of staff with knowledge and skills on digital health information for the management of “essential medicine supply chain” has caused delays in data on medicine and service delivery. It has also caused inaccurate information and untimely procurement of essential medicines.”

Another Medical Superintendent of Health (key informant) averred that:

“When you are not skilled enough, it is easier to make mistakes because of burnout, also forget to enter some information. Besides, data collection through paper causes delays and errors. Without workforce skill, “essential medicine supply chain” management is subject to errors and delays.”

This was further beefed up by another Medical Superintendent of Health (key informant) who felt that:

“Lack of workforce skills in this facility has caused some of us to use manual ways of dealing with medicine and commodities data management and also it has led to poor supply chain management.”

According to the findings in Table 4.12, 82% of the respondents disagreed that health facilities have adequate staff trained in medical supplies and product supply chain management. On the other hand, 18% of the respondents agreed that health facilities have adequate staff trained in medical supplies and product supply chain management. The findings (table 4.12) show that most public healthcare facilities in Kajiado, Makueni, and Mombasa do not have adequate staff trained in the management of medical supplies and products supply chain management. These findings agree with Duncan et al. (2022) who note that the following indicators: education and training,

data and digital literacy, individual competence, and technology use, and the workforce skills factors, evaluate the degree to which hospital personnel is competent to use digital health technology to support planning and service delivery.

This study also sought to determine if public healthcare facilities have supervisors who monitor the dissemination of “digital health information for the management of “essential medicine supply chain”” within the facility. From the results in Table 4.12, most of the respondents (81%) agreed that healthcare facilities have supervisors who monitor the dissemination of “digital health information for management of essential medicine supply chain.” Conversely, only 15% of the respondents disagreed that healthcare facilities have supervisors who monitor the dissemination of “digital health information for management of essential medicine supply chain within the facilities.” This clearly indicates that most of the public hospitals in Mombasa, Makueni and Kajiado have supervisors to monitor the dissemination of digital health information, although not necessarily for “the management of the essential medicine supply chain.” Aila and Kithuka (2021) note that poor use of information at the facilities results from staff members' lack of technical knowledge and capacity to gather and combine data into useful information. MoH (2021a) observes that most staff that perform the medicine and medical products supply chain functions learn on the job and through attending courses sponsored by pharmaceutical supply chain management development programs. This implies that there is a need for healthcare facilities across the country to train supervisors on basic digital health information skills in support of “essential medicine supply chain” management.

Further, in Table 4.12, only 6% of respondents indicated that regular supervision of digital health information dissemination has improved efficiency in managing “essential medicine supply chain” in their facilities. Conversely, only 91% of the respondents disagreed that regular supervision of digital health information dissemination has improved efficiency “in managing “essential medicine supply chain” in their facilities.” These findings concur with Teklegiorgis et al. (2016) who found that 80 per cent of the facilities in Ethiopia did not use information because of low-quality supervision and feedback. From the previous findings, Lugada et al. (2022) observe that hospital stockouts are occasioned by ineffective supervision and oversight, inadequate supply chain system management skills, and poor inventory management. Relatedly, Laukka et al. (2020) also note that some healthcare leaders lack an understanding of health information technology and, therefore, lack an understanding of how to provide management support to subordinates.

This study further endeavored to determine if the lack of regular supervision of “digital health information dissemination” affects the management of “essential medicine supply chains” in healthcare facilities. From the findings in Table 4.12, 80% of the respondents agreed that the lack of regular supervision of DHI dissemination affects the management of ““essential medicine supply chain” in healthcare facilities,” while 18% disagreed with this. The findings suggest that although many healthcare facilities in Kenya lack integrated digital health information systems for managing the “essential medicine supply chain”, most staff members acknowledge the importance of regular supervision in ensuring the effective dissemination of digital health information. Regular oversight plays a vital role in streamlining processes, improving data

accuracy, and ensuring timely decision-making, which are critical for efficient supply chain management. The recognition of this need by healthcare personnel indicates a shared understanding of the value of monitoring digital systems to enhance overall performance, despite the current infrastructure limitations. These observations align with the conclusions drawn by Kaupa and Naude (2021a) who identified the lack of proper supervision and coordination as one of the key obstacles to effective supply chain management of essential medicines. Their research highlighted that without adequate oversight, inefficiencies such as delays, errors, and mismanagement of inventory can arise, ultimately affecting the availability of essential medicines. Strengthening supervision practices, even in environments with limited digital infrastructure, can help mitigate these challenges and improve the management of “essential medicine supply chains.”

This study also sought to determine if the inadequate number of trained personnel on digital health information affects efficient “management of “essential medicine supply chain” in healthcare facilities.” From the findings in Table 4.12, 92% of the respondents agreed that the inadequate number of trained personnel on digital health information affects the efficient “management of “essential medicine supply chain” in healthcare facilities,” while only 6% of the respondents disagreed with this. These findings reveal that an inadequate number of trained personnel on digital health information affects the efficient “management of “essential medicine supply chain” in public healthcare facilities in Kenya.” The study’s findings align with Muthuri et al. (2021), who noted that insufficient management support in Meru County, driven by a shortage of adequately trained personnel, contributed to delays in medical supply

deliveries, frequent shortages of essential medicines, and numerous patient complaints. The lack of skilled human resources not only undermined the efficiency of supply chain processes but also directly impacted patient care and satisfaction by creating gaps in the availability of necessary medicines. This points to the critical need for well-supported management structures and adequate staffing to improve the overall supply chain performance. Furthermore, the study highlights the broader implications of insufficient management support in healthcare facilities, particularly in the context of “essential medicine supply chain” management. Without the proper training and support, healthcare personnel are unable to manage inventory effectively, forecast demand accurately, or ensure timely distribution of medicines. This lack of capacity not only delays services but also erodes patient trust in the healthcare system. Strengthening management frameworks and investing in the training of healthcare workers is essential for ensuring a more efficient and responsive supply chain, ultimately improving patient outcomes.

To further investigate the influence of workforce skills on the “management of “essential medicine supply chain”” in public healthcare facilities in Kenya, respondents were asked to provide “Yes” or “No” answers and state whether they thought that health workforce skills influenced health facility success in managing “essential medicine supply chain” using information from digital health information systems. The findings are indicated below in Table 4.13.

Table 4. 13

Workforce skill influence on “essential medicine supply chain”

Statements	Yes	No
Do you think health workforce skills influence health facility success in essential medicine supply chain management using influence health facility success in essential medicine supply chain management using information from digital health information systems?	96.50%	3.50%
Has your facility's lack of workforce skills ever cause digital health information challenges in the management of essential medicine supply chain?	77.60%	22.40%
Do you think the lack of adequate access to digital health information to support the management of the essential medicine supply chain in your facility is attributed to lack of skills in using digital health information systems?	92.9%	7.1%
Have you ever received training in the use of digital health information systems?	64.70%	35.30%
Was the training received on digital data management relevant for managing essential medicine supply chain?	61.20%	38.80%
Has your facility experienced essential medicine stock out because of inadequate use of digital information in managing the essential chain?	61.20%	23.50%
In your option, do you think staff skills in digital information on essential medicine consumption is processed for the management of the essential medicine supply chain in your facility?	94.10%	5.90%

From the findings in Table 4.13, 96.50% of the respondents responded “Yes” while only 3.50% responded “No.” This clearly indicates that a skilled workforce in digital health information systems is crucial in making the management of “essential medicine supply chain” in public healthcare facilities successful. The findings are in tandem with Ibeneme et al. (2022) who emphasize the importance of digitally skilled workers in accomplishing the application of digital health systems in healthcare facilities.

This study also wanted to know if healthcare facilities' lack of workforce skills ever caused “digital health information challenges in managing essential medicine supply chain.” From the findings in Table 4.13, 77.60% of the respondents responded “Yes,”

while only 22.40% responded “No”. These findings reveal that the “lack of workforce skills in public healthcare facilities in Kenya causes digital health information challenges in the management of essential medicine supply chain.” The findings emphasize the crucial role that digital health workforce skills play in effectively managing the “essential medicine supply chain”. Skilled healthcare personnel with a deep understanding of digital systems are better equipped to handle the complexities of supply chain management, including tracking medicine stocks, forecasting demand, and ensuring timely deliveries. This capacity not only improves the overall efficiency of the supply chain but also reduces the likelihood of errors, stockouts, and delays in the distribution of essential medicines. Facilities that invest in enhancing the digital competencies of their staff are, therefore, more likely to achieve smoother operations and better healthcare outcomes. These insights align with Habib et al. (2022) who found that healthcare facilities with well-informed and digitally competent staff experienced fewer challenges in managing their medicine supply chain systems. The integration of digital systems into supply chain processes requires personnel who can navigate these technologies with ease, ensuring that data is accurately recorded, analyzed, and applied in decision-making. As the healthcare sector continues to embrace digitalization, the development of digital health skills among the workforce becomes increasingly vital to optimizing supply chain operations and ensuring the continuous availability of essential medicines. Strengthening digital literacy within the healthcare workforce is not only a strategic priority but a fundamental step toward building resilient and responsive health systems.

Respondents were also asked to state if they thought that the “lack of adequate access to digital health information to support the management of “essential medicine supply chain” in facilities contributed to a lack of skills in using digital health information systems.” From the findings in Table 4.13, 92.90% of the respondents answered ‘Yes’ while only 7.10% answered “No.” These findings indicate that a lack of skills in the use of digital health information systems is one of the major factors that caused a lack of adequate access to digital health information to support the management of “essential medicine supply chain” in public healthcare facilities in Kenya. Without adequate access to digital health information systems, most of the functions related to managing the “essential medicine supply chain” will not run smoothly. The findings agree with Goundrey-Smith (2019) who found that staff do not have the same level of skills and knowledge on ICT and digitalization due to a lack of ICT facilities within hospitals.

The study also sought to find out if respondents had ever received training in using digital health information. From the findings in Table 4.13, 64.70% of the respondents answered yes, while only 35.30% answered no. The findings, therefore, indicate that most of the healthcare staff in public healthcare facilities in Kenya have received training in using digital health information. While most public health hospitals have yet to install integrated digital health information systems, the high number of trained staff is good preparation for using the systems to support the management of the “essential medicine supply chain” once they are acquired. The findings concur with Faridi and Malik (2020) who found that in the 21st century, healthcare institutions have

prioritized regular staff training in emerging technologies, including digital health information systems.

Respondents were also asked to state if the training they received on digital data management was relevant for managing the “essential medicine supply chain”. From the findings in Table 4.13, 61.20% of the respondents answered yes, while only 31.80% answered no. The findings clearly indicate that the training the healthcare staff in public healthcare facilities in Kajiado, Makueni, and Mombasa received on digital data management was relevant for managing “essential medicine supply chain”. This is a good preparatory stage that will ensure that once these facilities have an integrated digital health information system, staff will be pulled to support operations. The findings concur with Duncan et al. (2022) who support the need for comprehensive training of healthcare staff in digital health information systems.

Respondents were also asked to state if their facilities experienced essential medicine stockout because of inadequate use of integrated digital information to manage the essential medicine chain. From the findings in Table 4.13, 76.50% of the respondents agreed that facilities experienced essential medicine stockout because of inadequate use of digital information in managing the essential medicine chain while only 23.50% disagreed with this. The findings clearly show that most public healthcare facilities in Kenya experience essential medicine stockout because of inadequate use of digital health information in the management of essential medicine chain. From the previous sections, inadequate use of digital information in the management of essential medicine chain can be attributed to using a mixture of paper and electronic systems in

public healthcare facilities in Kenya. From the previous findings, Bwana et al. (2014) found that medicine stockout in public hospitals majorly stemmed from a lack of proper systems to track the medicines.

Respondents were also asked to share their views on whether staff skills in digital health information influence how digital information on essential medicine consumption was processed to manage facilities' "essential medicine supply chain". From the findings in Table 4.13, 94.10% of the respondents stated yes, while only 5.90% stated no. The findings reveal that information processing for management of "essential medicine supply chain" in public healthcare facilities in Kajiado, Makeni, and Mombasa relied on staff skills in digital health information. The findings concur with Bhargava and Ollis (2022) who found that healthcare workers skilled in digital health information systems were likely to put their skills in ensuring an effective process in the medicine supply chain.

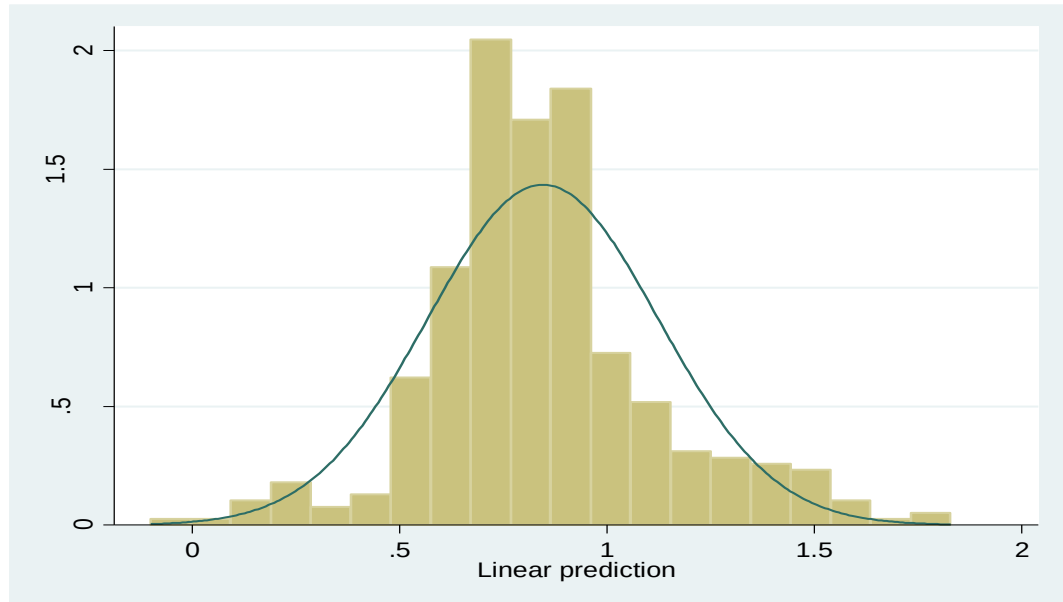
4.10 Diagnostic Tests

The test for normality was examined using the graphical method approach, as shown in Figure 4.2. The results in the figure indicate that the residuals are normally distributed.

4.10.1 Normality Test

Figure 4. 2

Normality Test



4.10.2 Multicollinearity

As per the findings by William et al. (2013) multicollinearity is defined as the existence of correlations among predictor variables. In cases with perfect correlations between predictor variables, multicollinearity can result in the inability to compute a unique least squares solution in regression analysis (Field, 2009). This issue leads to the inflation of standard errors and confidence intervals, causing instability in the estimates of coefficients for individual predictors (Belsley et al., 1980). The evaluation of multicollinearity in this study involved the use of variance inflation factors (VIF). According to Field (2009), VIF values exceeding 10 indicate the presence of multicollinearity.

Table 4. 14

Multicollinearity results using VIF.

Variable	VIF	1/VIF
Quality of digitized health information	3.66	0.27344
Digitized health information processing strategy	3.42	0.2926
ICT infrastructure support	3.24	0.30847
Workforce skills	2.27	0.43976
Policy framework	1.02	0.98226
Mean	2.72	

The results in Table 4.14 present variance inflation factors, which were established to be 2.72, which is less than 10. Thus, according to Field (2009), there is no Multicollinearity.

4.10.3 Heteroscedasticity test

The error process might exhibit Homoscedasticity within cross-sectional units, yet the variance could vary among units, a phenomenon referred to as group-wise Heteroscedasticity. The hettest command computes Breusch-Pagan to identify group-wise Heteroscedasticity in the residuals. The null hypothesis specifies that $\sigma^2_i = \sigma^2$ for $i = 1 \dots N_g$, where N_g is the number of cross-sectional units.

Table 4. 15***Heteroscedasticity Results***

Modified Wald test for group wise heteroscedasticity in fixed effect regression model	
H0: $\sigma^2_i = \sigma^2$ for all i	
chi2 (80) =	3907.02
Prob>chi2 =	0.0632

The results in Table 4.15 indicate that the null hypothesis of Homoscedastic error terms is not rejected as supported by a p-value of 0.0632.

4.10.4 Autocorrelation Test

Since serial correlation in models biases the standard errors and makes the results less efficient, the study adopted the Breusch-Godfrey test for autocorrelation, which classifies serial correlation as an idiosyncratic error term in a model.

Table 4. 16***Test of Autocorrelation***

Wooldridge test for autocorrelation in panel data H0: no first-order autocorrelation	
F(1, 79) =	0.226
Prob > F =	0.6360

From Table 4.16, the null hypothesis of no serial correlation is not rejected, given that the p-value is significant (p -value = 0.6360).

4.11 Hausman Test

The Hausman test was employed to ascertain the suitability of either the fixed or random effects model. This test primarily examined whether the unique errors (ui)

correlate with the regressors. The obtained p -value of 0.000 was less than the conventional threshold of 0.05, prompting the rejection of the null hypothesis asserting that the unique errors are not correlated with the regressors. Consequently, it is indicated that the fixed effects model is more suitable. The results in Table 4.17, below illustrate the results of the Hausman test.

Table 4. 17

Hausman Results

	Coefficients			
	(b) - (B) (b-B)	sqrt (diag (V b-V_B))		
	fixed	random	Dif	S.E.
Quality of digitized health information	1.11E-06	1.30E-06	-1.87E-07	.
Digital health information processing strategy	6.33E-05	6.07E-05	2.61E-06	5.37E-07
ICT infrastructure support	1.86E-06	1.61E-06	2.46E-07	.
Workforce skills	0.0173114	0.020178	0.0028667	0.0009469
Policy framework	0.8264485	0.298626	0.5278226	0.0636262
b = consistent under Ho and Ha; obtained from xtreg				
B = inconsistent under Ha, efficient under Ho; obtained from xtreg				
Test: Ho: difference in coefficients not systematic				
$\chi^2(2) = (b-B)[(V_b-V_B)^{-1}](b-B)$				
= 91.64				
Prob> χ^2 = 0.0000				
(V_b-V_B is not positive definite)				

4.12 Multiple Correlation Analysis

Multiple correlation analysis was conducted between the quality of digitized health information, digitized health information processing strategy, ICT infrastructure support, workforce skills (independent variables), and management of the “essential

medicine supply chain” (dependent variable). Results are presented in Table 4.18:
Multiple Correlation Matrix.

Table 4. 18

Multiple Pearson Correlation Matrix

		Essential medicine supply chain management	Quality of digitised health information	Digitised health information processing strategy	ICT Infrastructure support	Workforce skills
Essential medicine supply chain management	Pearson					
	Correlation	1	.196**	.118*	.729**	.624*
	Sig. (2-tailed)		0.001	0.000	0.003	0.001
	N	143	143	143	143	143
Quality of digitised health information	Pearson					
	Correlation	.196**	1	.731**	.572**	.452**
	Sig. (2-tailed)	0.001		0.000	0.003	0.001
	N	143	143	143	143	143
Digitised health information processing strategy	Pearson					
	Correlation	.118*	.731**	1	.418**	.314**
	Sig. (2-tailed)	0.000	0.000		0.003	0.001
	N	143	143	143	143	143
ICT Infrastructure support	Pearson					
	Correlation	.729**	.572**	.418**	1	1.000**
	Sig. (2-tailed)	0.003	0.003	0.003		0.001
	N	143	143	143	143	143
Workforce skills	Pearson					
	Correlation	.624**	.452**	.314**	1.000**	1
	Sig. (2-tailed)	0.001	0.001	0.001	0.001	
	N	143	143	143	143	143
** Correlation is significant at the 0.01 level (2 tailed)						
* Correlation is significant at the 0.05 level (2- tailed)						

The results also revealed that ICT infrastructure support and “essential medicine supply chain” management have a strong positive and significant relationship ($r=0.729$, $n=143$ $p=0.003$). ICT infrastructure support improves efficiency in “essential medicine supply chain” processes. This means that there will be reduced drug stockout as there will be real-time sharing of data feeds among the procurement

department, the health records, the administration, the store, and the pharmacy, among others.

In addition, the results revealed that workforce skills and management of the “essential medicine supply chain” have a strong positive and significant relationship ($r=0.624$, $n=143$, $p=0.001$). These findings depict that the more digital health skills the healthcare staff have, the more efficient the “essential medicine supply chain” process becomes. These findings agree with that of Duque-Urbe et al. (2019) who found a positive relationship between workforce skills and supply chain management.

4.13 Multiple Linear Regression

The findings depicted in Table 4.18 outline the “fitness of model use of the regression model” in elucidating the study phenomena. Quality of digitized health information, digitized health information processing strategy, ICT infrastructure support for health information, and workforce skills “were found to be satisfactory variables in explaining the management of essential medicine supply chain.” This is “supported by the coefficient of determination, also known as the R square of 26.8%.” This means that the quality of digitized health information, digitized health information processing strategy, ICT infrastructure support for health information, and workforce skills explain 26.8% “of the variations in the dependent variable, which is “essential medicine supply chain” management.” The findings are in tandem with Waithira et al. (2019) who found a correlation between digital health information and essential healthcare services. The findings also corroborate those of Signé (2021) who agree that digitized health information is key in accomplishing service delivery across healthcare facilities in Africa. The findings are also in tandem with Kariuki et al.

(2016) who found a positive correlation between ICT infrastructure and information reporting in healthcare facilities in Kenya.

Table 4. 19

Model Fitness

Model	R	R Square	Adjusted Square	R	Std. Error of the Estimates
1	.518 ^a	.268	.263		6.101

- a. Predictors: (Constant) Quality of digitized health information, digitized health information processing strategy, ICT infrastructure support for health information, workforce skills
- b. Dependent Variable: “essential medicine supply chain” management

The results on the statistical significance of the model are represented below.

Table 4. 20

Statistical Significance of the Model ANOVA^a

	Sum of Squares	Df	Mean Square	F	Sig.
Regression	16.712	1	253.000	15.906	0.000 ^b
Residual	37.299	143	13.263		
Total	41.478	144			

- a. Dependent Variable: “essential medicine supply chain” management
- b. Predictors: (Constant) Quality of digitized health information, digitized health information processing strategy, ICT infrastructure support for health information, workforce skills

Table 4.20 provides the results on the statistical significance of the model. The results “indicate that the overall model was statistically significant. Further, the results imply that the independent variables” (quality of digitized health information, digitized health information processing strategy, ICT infrastructure support for health information, and workforce skills) are good predictors of “essential medicine supply chain” management. This was “supported by an F statistic of 15.906 and the reported p -value (0.000), which was less than the conventional probability of 0.05 significance level.” The findings are in tandem with Waithira et al. (2019) who found a correlation between digital health information and essential healthcare services. The findings are also in tandem with Shiferaw et al. (2017) who found a positive relationship between health information systems utilization and better service delivery in Northwest Ethiopia. The findings further concur with Duque-Urbe et al. (2019) who found a positive relationship between technology and hospital medicine supply chain management. The findings further support those of Ohia et al (2023) who found a positive relationship between workforce digital health information skills and medicine supply chain management.

Multiple regression of coefficient results is presented in Table 4.21

Table 4. 21***Coefficients***

Model	Unstandardized		Standardized			95.0%	Confidence
	coefficients		coefficients			Interval for B	
	B	Std. Error	Beta	T	Sig.	Lower Bound	Upper Bound
1 Constant)	7.569	1.201	7.569	28.963	0.001	75.122	100.201
Quality of DHI	0.468	0.117	0.383	3.988	0.004	0.321	0.489
DHI processing strategy	0.406	0.048	0.322	8.428	0.000	0.311	0.412
ICT infrastructure support for HI	0.379	0.084	0.289	4.517	0.001	0.255	0.392
Workforce skills	0.434	0.079	0.342	5.481	0.0002	0.328	0.441

a. Dependent Variable: “essential medicine supply chain” management

The first column presents the predictor variables (constant, quality of DHI, DHI processing strategy, ICT infrastructure support for HI, and workforce skills). Variable “constant” (Y-intercept) signifies the regression line height at the point when it intercepts the Y-axis. The Y constant simply represents the predicted value of “essential medicine supply chain” management when the other variables are 0.

The multiple linear equation is presented below.

$$Y = 7.569 + 0.468X_1 + 0.406X_2 + 0.379X_3 + 0.434X_4$$

Where:

Y=“essential medicine supply chain” management

X₁= Quality of digitized health information

X2= Digital health information processing strategy

X3= ICT infrastructure support

X4=Workforce skills

Therefore,

“Essential medicine supply chain” management=7.569 + 0.468*Quality of digitized health information + 0.406*Digital health information processing strategy + 0.379*ICT infrastructure support +0.434*Workforce skills

From the equation, when the quality of digitized health information increases by 1, “essential medicine supply chain” management is expected to increase by .468, when digital health information processing strategy increases by 1, “essential medicine supply chain” management is expected to increase by .406. When ICT infrastructure support increases by 1, “essential medicine supply chain” management is expected to increase by .379; finally, when workforce skills increase by 1, “essential medicine supply chain” management is expected to increase by .434.

As depicted in Table 4.21, multiple linear regressions were applied in testing the hypotheses. Multiple regression of coefficients showed that the quality of digitized health information and “essential medicine supply chain” management “had a positive and significant relationship ($r=0.468$, $p=0.004$).” These results support those of Dwivedi et al. (2021) whose study reveals a positive relationship between the quality of digitized health information and medicine supply chain management. From the regression equation, when the quality of digitized health information changes by 1%, the “essential medicine supply chain” management changes by 0.468%, indicating a positive association between the independent and dependent variables.

Further, Table 4.21 displays the multiple regression of coefficients, which also revealed that digitized health information processing strategy and ““essential medicine supply chain” management” in public healthcare facilities in Kenya were related ($r=0.406$, $p=0.000$). From the regression equation, when the digitized health information processing strategy changes by 1%, the “management of “essential medicine supply chain”” in public healthcare facilities in Kenya increases by 0.406%, indicating a positive association between these two variables. The findings concur with Rumisha et al. (2020) who found that digitized data was positively associated with healthcare management in Tanzania.

Further, multiple regression of coefficients in Table 4.21 showed that ICT infrastructure support and “management of “essential medicine supply chain” in a public healthcare facility in Kenya were related ($r=0.379$, $p=0.001$).” Gemma (2019) also found out a positive relationship between ICT and the supply chain of medicine in Hospitals in Zambia. From the regression equation, when ICT infrastructure support changes by 1%, the ““essential medicine supply chain” management in a public healthcare facility in Kenya changes by 0.379%, showing there is a positive relation between the two variables.” These results are consistent with those of Tshibanda (2022) who found a positive relationship between information technology and the supply chain of pharmaceutical departments within public hospitals of Johannesburg. As the regression equation shows, “workforce skills and “management of “essential medicine supply chain” in public healthcare facilities in Kenya were related ($r=0.434$, $p=0.002$).” When workforce skills “changes by 1%, the management of “essential medicine supply chain” in public healthcare facilities in Kenya” changes by 0.434%,

depicting a positive relationship between the two variables. The findings concur with Hagel et al. (2020) who registered a positive relationship between staff skills in digital health information and drug supply chain management in healthcare facilities in Kenya.

4.13.1 Hypothesis Testing for Quality of Digitized Health Information

The hypothesis ‘Quality of digitized health information does not significantly influence “management of “essential medicine supply chain”” in a public healthcare facility in Kenya’ was assessed using multiple correlation analyses and multiple linear regression. The “acceptance/rejection criteria were that, if the *p-value* is greater than 0.05, the *Ho1* is not rejected, but if it is less than 0.05, the *Ho1* fails to be accepted.” The null hypothesis was that the quality of digitized health information does not significantly influence the “management of “essential medicine supply chain”” in public healthcare facilities in Kenya. The *p-value*, as shown in Table 4.21, was 0.004 $p < 0.05$. This leads to rejecting the null hypothesis; hence, there is a significant relationship between the quality of digitized health information and the management of “essential medicine supply chain” in public healthcare facilities in Kenya. These findings agree with Dwivedi et al. (2021) who observed that the quality of digitized information impacts medicine supply chain management.

4.13.2 Hypothesis Testing for Digitized Health Information Processing Strategy

Multiple correlation analysis and multiple linear regression were used to assess the hypothesis that there is no significant relationship between the digitized health information processing strategy factor and the management of “essential medicine

supply chain” in public healthcare facilities in Kenya. The “acceptance/rejection criteria were that, if the *p-value* is greater than 0.05, the *Ho2* is not rejected, but if it is less than 0.05, the *Ho2* fails to be accepted.” Results in Table 4.21 show that the *p-value* was $0.000 < 0.05$. This shows the rejection of the null hypothesis and the acceptance of the alternative hypothesis, depicting that there is a significant relationship between digitized health information processing strategy and ““essential medicine supply chain” management” in public healthcare facilities in Kenya. These findings also agree with that of Muinga et al. (2020) who found that information processing positively impacts medicine supply chain management.

4.13.3 Hypothesis Testing for ICT Infrastructure Support for Health Information

The hypothesis was assessed by using multiple correlation analysis and multiple linear regression. The “acceptance/rejection criteria were that, if the *p-value* is greater than 0.05, the *Ho3* is not rejected, but if it is less than 0.05, the *Ho3* fails to be accepted.” The null hypothesis was that there is no significant relationship between ICT infrastructure support for health information and the “management of “essential medicine supply chain”” in public healthcare facilities in Kenya. As depicted in Table 4.21, the *p-value* was $0.001 < 0.05$. This led to the rejection of the null hypothesis and the acceptance of the alternative hypothesis, exhibiting a significant relationship between ICT infrastructure support for health information and the “management of “essential medicine supply chain”” in public healthcare facilities in Kenya. These findings agree with that of Gemma (2019) who found a positive relationship between ICT and the medicine supply chain in Hospitals in Zambia.

4.13.4 Hypothesis Testing for Workforce Skills

The hypothesis was evaluated by using Multiple correlation analysis and multiple linear regression to evaluate the hypothesis that there is no significant relationship between workforce skills and “management of “essential medicine supply chain”” in public healthcare facilities in Kenya. The “acceptance/rejection criterion was that, if the *p-value* is greater than 0.05, the *H₀* is not rejected, but if it is less than 0.05, the *H₀* fails to be accepted.” As demonstrated in Table 4.21, the *p-value* was $0.002 < 0.05$. This led to the rejection of the null hypothesis and the acceptance of the alternative hypothesis; hence, there is a significant relationship between workforce skills and management of “essential medicine supply chain” in public healthcare facilities in Kenya. These findings agree with that of Duque-Urbe et al. (2021) who concluded that workforce skills affect medicine supply chain management.

Table 4. 22***Summary of Hypothesis***

Hypothesis	p-value	Results
H ₀₁ :Quality of digitized health information does not have a significant influence on the management of “essential medicine supply chain” in public healthcare facilities in Kenya	0.004 <0.05	Positive and Significant (Rejected H ₀₁)
H ₀₂ :There is no significant relationship between the digitized health information processing strategy factor and the management of “essential medicine supply chain” in public healthcare facilities in Kenya	0.000<0.05	Positive and Significant (Rejected H ₀₂)
H ₀₃ :There is no significant relationship between ICT infrastructure support for health information and management of “essential medicine supply chain” in public healthcare facilities in Kenya	0.001<0.05	Positive and Significant (Rejected H ₀₃)
H ₀₄ :There is no significant relationship between Workforce skills and management of the “essential medicine supply chain” in public healthcare facilities in Kenya	0.002<0.05	Positive and Significant (Rejected H ₀₄)

4.14 Moderating Effects of Policy on Digital Health Information on Independent Variables and “essential medicine supply chain” Management

The fifth objective of this study was to develop a digital health information framework for managing “essential medicine supply chain” in public healthcare facilities in Kenya. Therefore, there was a need to evaluate the mediating effect of policy on digital health information on the independent variables and the management of the “essential medicine supply chain”. The study adopted the moderated multiple regression model (MMR) to accomplish this. The model is as follows:

$$Y = \beta_0 + \beta_i X_i + \varepsilon, \text{ where } (i= 1, 2, 3, 4) \dots\dots\dots (i)$$

$$Y = \beta_0 + \beta_i X_i + \beta_z Z_j + \varepsilon, \text{ where } (j = 1, 2) \dots\dots\dots (ii)$$

$$Y = \beta_0 + \beta_i X_i + \beta_z Z_j + \beta_{iz} X_i Z_j + \varepsilon \dots\dots\dots (iii)$$

The first model depicts the “association between the study’s dependent and the independent variables.” The second model introduces the “mediating variable (Zj: policy on digital health information) into the multiple regression model.” The third model presents the “interaction terms (Xi*Zj) in the association between the independent and dependent variables.” Policy on digital health information (regulatory guidelines on HIS) mediated the relationship between the independent variables and the “essential medicine supply chain” management.

In the model $Y = \beta_0 + \beta_1 X_1 + \beta_z Z_1 + \beta_{iz} X_1 Z_1 + \varepsilon$,

Y = “essential medicine supply chain” management,

β_0 = the constant,

$\beta_1, \beta_2, \beta_3, \beta_4$ = slope coefficients depicting the association between the independent variable and the dependent variables.

X1= Quality of digitized health information

X2= Digitized health information processing strategy

X3= ICT infrastructure support for health information

X4= Workforce skills

X1Z1 = the interaction term, which is the product of policy framework and independent variables (Policy* X1, X2, X3, X4).

The results are presented in Table 4.24

Table 4. 23

Mediating effect of policy on digital health information on independent variables and “essential medicine supply chain” management: Model Validity

Model		Sum of Squares	Df	Mean Square	F	Sig.
1.	Regression	21.231	6	5.671	98.882	0.00 ^a
	Residual	10.121	240	0.52		
	Total	31.352	246			
2.	Regression	19.521	8	4.537	84.211	0.01 ^b
	Residual	10.372	238	0.52		
	Total	29.893	246			
3.	Regression	20.036	9	2.560	43..726	0.01 ^c
	Residual	9.936	237	0.51		
	Total	29.972	246			

- a. Dependent Variable: Y
- b. Predictors (Constant), “X4, X3, X1, X2”
- c. Predictors: (Constant), “X4, X3, X1, X2, Pol”
- d. Predictors: (Constant), “X4, X3, X1, X2, Pol, PolX4, PolX3, PolX2, PolX1”

From the findings in Table 4.24, the F statistics in model one, $F(6, 240) = 98.882$, $P < .005$, was valid, meaning a significant relationship exists between independent variables and the management of the “essential medicine supply chain”. Upon introducing the policy on digital health information, the F statistics, $F(8, 238) = 84.211$, $P < .005$, model two remained valid. This depicted a significant relationship among independent variables, policy on “digital health information and management of essential medicine supply chain.” When the interaction term (policy framework *independent variables) was added in model two, the new model three was valid (F

(9,237) = 43.726, $P < .005$) depicting a significant relationship among independent variables, policy on digital health information, the interaction term (policy*independent variables) on management of “essential medicine supply chain”.

Table 4. 24

Mediating Effect of Policy on Independent Variables and “Essential Medicine Supply Chain” Management: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Sig. F Change
1	.801	.628	.622	.20534	.001
2	.801	.632	.626	.20662	.001
3	.807	.651	.640	.20432	.001

- a. Predictors “(Constant), X4, X3, X1, X2”
- b. Predictors: “(Constant), X4, X3, X1, X2, Pol”
- c. Predictors: “(Constant), X4, X3, X1, X2,” Pol, PolX4, PolX3, PolX2, PolX1

The R square in model one, as depicted in Table 4.25, indicates that 63% of the total variations in the management of the “essential medicine supply chain” can be explained by independent variables. The adjusted R square depicts that independent variables explain 62.2% of the total variation in managing the “essential medicine supply chain” when the constant is omitted from the study. The value of ($r = .801$, $P = .001$) depicts a significant positive influence of independent variables on managing the “essential medicine supply chain”. The standard error of estimate (0.205) depicts that the predictor variable has deviated from the line of best fit.

The second model introduced a policy on digital health information into the relationship between independent variables and the management of the “essential medicine supply chain”. While there was no change in R square, the model remains significant. This means that just adopting the policy on digital health information and failing to interact with the independent variables will not influence the relationship between independent variables and the management of the “essential medicine supply chain”.

The third model depicts the relationships among independent variables, management of the “essential medicine supply chain”, the interaction term (policy*independent variables), and the management of the “essential medicine supply chain”. The findings show that with the inclusion of the interacting term, the R square significantly enhanced further by 1.4% ($P = .001$) from 63% to 64%, indicating that policy on digital health information is a significant mediator of the relationship between independent variables and the management of “essential medicine supply chain” when an interaction occurs.

From model one in Table 4.26, all variables were significant predictors of managing the “essential medicine supply chain”. Upon introducing the interaction term (policy*independent variables) as depicted in model three, all the variables remained significant predictors of managing the “essential medicine supply chain”. The current findings are in tandem with Tull (2018) who found that in Botswana, weak management support, weak policy, and regulatory framework hinder the progress of the national HIS.

From the interviews, it was found that the policy framework on digital information has the potential to influence healthcare personnel to use information from digital information when managing “essential medicine supply chain” in public healthcare facilities when digital information systems with supply chain management capacity are adopted and installed across public healthcare facilities in Kenya. Health Records and Information Officer (HRIO) stated:

“When the policy framework on the use of digital health information will be available in the health facility, and personnel is trained, and digital information systems for the supply chain are installed in the facility, we will be able to upload medicine data on digital information system and do our data analysis, planning and, medicine requisitions using the digital health information system otherwise to make sure that health facility continues providing service we will continue to prepare data through the books and papers that are available”.

Procurement Officer (key informant) stated.

“The Policy framework and regulations on digital health information are important for us to understand the procedure and application of digital health information and provide direction on what should be included and how to manage data and information in planning and managing the medicine supply chain using digital systems for procurement in the facility. However, we do not know when the Ministry of Health will make that available to us.”

These findings relate to the study by Iqbal et al. (2017) which summarized that a lack of written guidelines and policies about the management of medicines in hospitals leads to inadequate processes and management of the medicine supply chain and

benefits to patients. Iqbal et al. (2017) argued that the successful management of medical systems is based on policy and procedure (guidelines for policy implementation) adherence.

MoH (2021b) raises concerns that despite the availability of regulations on the use of information systems for monitoring “essential medicine supply chain”, utilization of quality and timely information to support supply chain management is still inadequate to mitigate against the perennial essential medicine stockout. Paper-based or a mixture of paper and electronic systems for processing information for the management of “essential medicine supply chain” affects the availability of accurate and reliable data or delays in essential medicines supply chain management (MoH,2021). The findings are supported by Kuwawenaruwa et al. (2020) who found that a lack of effective regulations resulted in regular medicine stockouts in Dodoma, Tanzania.

Studies by Khobi et al. (2020), Kuwawenaruwa et al. (2020), Lugada et al. (2022) and Manish et al. (2018) show that the application of quality digital information, processing, application of ICT and staff skills in the management of medicine supply chain is mediated by increased access and application of policies (set of rules and guidelines) on digital health information that influence healthcare personnel to adhere to those requirements. Key informant's statements suppose that the management of public healthcare facilities in Kajiado, Makueni, and Mombasa, together with their staff, underscores the importance and influence (mediating role) of policies framework on digital health information in linking the relationship between the quality of digitized health information, digitized health information processing, ICT infrastructure support and workforce skills (independent variable) and management

of “essential medicine supply chain” (dependent variable) in public healthcare facilities.

Table 4. 25

Mediating Effect of Policy on Independent Variables and “Essential Medicine Supply Chain” Management: Regression Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B.	Std Error	Beta		
1.	(Constant)	.439	.142		3.160	.000
	X1	.068	.052	.058	1.337	.129
	X2	.254	.041	.298	5.221	.000
	X3	.102	.032	.139	3.143	.000
	X4	.362	.039	.432	9.102	.000
2.	(Constant)	.683	.154		3.835	.000
	X1	.067	.055	.058	1.182	.001
	X2	.222	.049	.287	4.453	.000
	X3	.172	.029	.133	3.190	.001
	X4	.426	.037	.416	8.111	.002
	Pol	.004	.034	.011	.225	.001
3.	(Constant)	1.118	.389		2.456	.002
	X1	.072	.172	.038	.301	.000
	X2	.017	.138	.017	.110	.001
	X3	.082	.009	.118	.866	.266
	X4	.476	.101	.871	3.219	.000
	Pol	.192	.180	.421	1.011	.290
	PolX1	.002	.064	.021	.039	.210
	PolX2	.112	.051	1.081	1.817	.000
	PolX3	.002	.034	.022	.075	.001
	PolX4	.021	.040	.411	1.023	.214

a. Dependent Variable: Y

4.15 A Digital Health Information Framework for Management of “essential medicine supply chain” in Public Healthcare Facilities

Based on study findings concerning inadequate quality (untimeliness, incompleteness, unreliability) of digitized health information, inadequate digitized health data processing (poor data collection, poor data extraction, poor data analysis), insufficient ICT infrastructure (inadequate computers – hardware and software, insufficient internet connections), inadequate number of skilled health workforce (inadequate training, inadequate number, inadequate supervision) and inadequate application of digitalization policies and guidelines on management of essential medicines supply chain in level 4 and 5 public healthcare facilities in Mombasa, Kajiado and Makueni counties, a digital health information framework for management of “essential medicine supply chain” in public healthcare facilities in Kenya was developed by this study (figure 4.3) to guide public healthcare facilities in Kenya on strategies for implementation of digital health information in the management of “essential medicine supply chain” across the entire public healthcare facility to improve essential medicine stock availability in public healthcare facilities as a mitigation measure against essential medicine stockout and to improve healthcare service delivery.

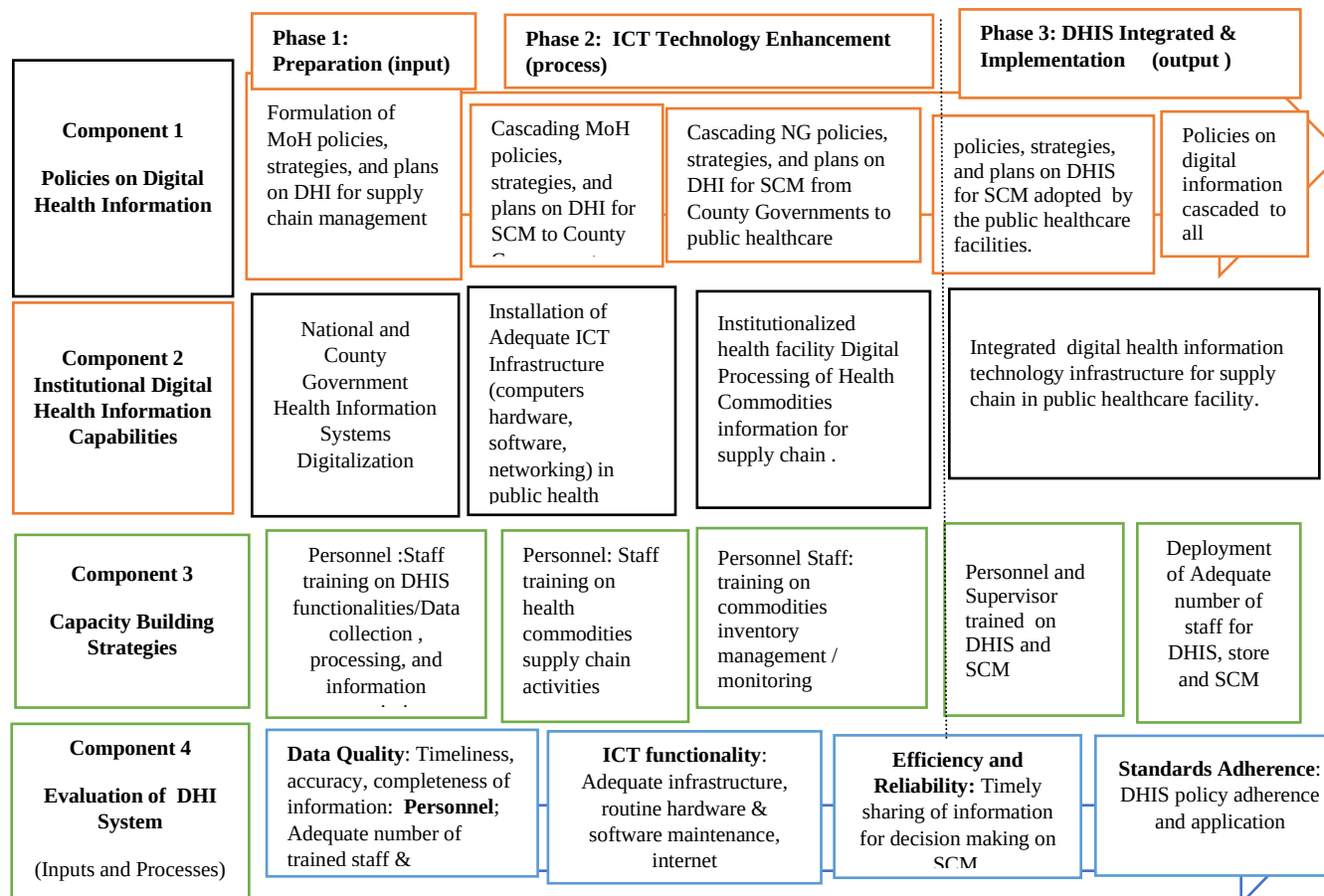
Digital technologies offer opportunities for improvement in data quality (completeness, accuracy, reliability, and timeliness) and improvement in quantification and forecasting in many areas of the medicine supply chain. Therefore, the transition from paper to digitization information for managing the medicine supply chain is crucial for mitigating essential medicines stockout and improving health service delivery in public healthcare facilities in Kenya (Meloan & Lacopino, 2017; Bwana et al., 2014). Timely, accurate and complete information on health facility

commodities is crucial for forecasting, resupplying quantities needed, and procurement (Tiye & Gudeta, 2018; WHO, 2021); UNDP, 2022) lobby for health facilities to strengthen the reliability of information to support evidence-based procurement and management of “essential medicine supply chain”.

The study concludes that policy framework on digital health information (mediating variable) influences the relationship between the quality of digital health information, digitized health information processing, ICT infrastructure support, workforce skills (independent variables), and management of “essential medicine supply chain” (dependent variable) in public healthcare in Kenya. This is because there is a significant relationship between the policy framework on digital health information (Mediating variable) and the management of the “essential medicine supply chain” in public healthcare facilities in the counties of Kajiado, Makueni, and Mombasa.

Figure 4. 3

A Digital Health Information Framework for Management of “Essential Medicine Supply Chain” in Public Healthcare Facilities



The developed digital health information framework for managing “essential medicine supply chain” in public healthcare facilities in Kenya” has four components to be achieved in three phases. The components are institutional digital health information capabilities, policies on digital health information, and capacity-building strategies and evaluation.

Evaluation

Integrating evaluation with system design and development from the onset is critical to guarantee proper health information system implementation. According to Odhiambo-Otieno (2005), the absence of evaluation criteria is a major shortcoming in the design and implementation of information systems. Evaluations are conducted for various reasons, including promotional, pragmatic, scholarly, and ethical reasons.

Promotional purpose: Evaluations encourage information systems in the health sector by reassuring healthcare providers that the systems are safe and benefit patients and institutions through improved cost-effectiveness. Pragmatic reason: Without evaluating their systems, developers can never know which techniques or methods more effective or why certain approaches are failed. Equally, other developers cannot learn from previous mistakes and may reinvent a square wheel (Odhiambo-Otieno, 2005).

Evaluation will be conducted at every implementation phase to assess the system’s efficacy and determine whether the outcomes are geared towards improving the management of the “essential medicine supply chain”. The following section describes how each component needs to be achieved in the three phases.

Phase One: Preparation

Under this phase, County Governments are expected to provide the necessary resources (skilled human resources, ICT infrastructure including computers and networking) to public healthcare facilities to create an enabling environment for the installation and integration of ICT and digital health information systems with supply chain capabilities to support timely management of supply chain within the entire facility. An observation is made through Ministry of Health, Kenya Supply Chain Strategy (2020-2025) that while the application of ICT to support the “management of “essential medicine supply chain” in public healthcare facilities” in Counties is increasing, full utilization of digitalization is slowed down by poor or inadequate ICT infrastructure, frequent system breaks down, lack of internet connection and inadequate digital skills to support management of “essential medicine supply chain” at all levels of the health system. To address these concerns, the following components will have to be accomplished to strengthen “digital health information infrastructure for management of “essential medicine supply chain” in the public healthcare facility to improve health service delivery.”

Component 1: Policies on Digital Health Information

To ensure the application of digital health information for the management of the “essential medicine supply chain” in public healthcare facilities, the circulation of policies, guidelines, and strategic plans for digital information for managing the medicine and commodities supply chain is important, as highlighted by Koumamba et al. (2021). This position is asserted in the Kenya National Pharmaceutical Policy, sessional paper 4 of 2012, whose goal is to ensure that Kenya achieves access to essential pharmaceutical services, health technologies, and quality essential medicines

(MoH, 2020a). Therefore, in phase one of policies on digital health information, the Ministry of Health (MoH) should take the initiative of circulating policies, guidelines, and strategic plans on digital health information (DHI) for supply chain management. Medical Superintendents of Health, Health Records and Information Officers, Pharmacists, Medical Stores Officers, and Procurement Officers should be oriented on the policies, guidelines, and standard operating procedures on using digital health information systems in the medicine supply chain. Copies of policies, guidelines, and standard operating procedures should be made available, and the Medical Superintendent of Health should ensure that they are operational within their respective public healthcare facilities to ensure timely management of the “essential medicine supply chain”.

Component 2: The Institutional Digital Health Information Capabilities

The health information systems used for reporting various health commodities in public healthcare facilities in Kenya are a mixture of paper and electronic systems. fragmented and released reports at varied rates according to MoH (2021a). Kuyo et al. (2018) have argued that a unified health reporting system can produce timely data for accurate planning for managing “essential medicine supply chain” and service delivery. Therefore, there is a need for National and County governments to transition to an integrated ICT infrastructure to support digital health information systems in public healthcare facilities. This will support efforts towards production, processing, and sharing of quality (complete, accurate, reliable, and timely) digitized “health information for managing “essential medicine supply chain” in public healthcare facilities,” minimize incidences of medicine stockouts, and improve health service delivery. This statement is supported by the argument posed by Teklegiorgis et al.

(2016) that accurate and timely information is critical for public health planning and management of the supply chain.

Component 3: Capacity Building Strategies

Ohia et al. (2021) note that healthcare personnel with the necessary information technology skills and expertise are more likely to be open to using new technologies like digital health information technology applications. Under the capacity building strategies, the Ministry of Health and County Governments should ensure that adequate staff are trained and equipped with skills in digital health information and supply chain and are deployed in public healthcare facilities. Regular Orientation, training in ICT and digital information technology and supervision should be provided to all personnel involved in medicine-related data collection, processing, quantification, forecasting, and information management.

Component 4: Evaluation

Evaluation at this phase requires the County Health Department, Ministry of Health, and Health Facility Management to assess the initial stage of digitalization of the information system in terms of the availability of policies, guidelines, and plans on digital health information, the support provided for digitalization of the information systems in public healthcare facilities, deployment of personnel with skills in ICT and supply chain management, supervisors and training of personnel in ICT and supply chain management to strengthen digitalization of information and supply chain management in public healthcare facilities in Kenya. The aim is to equip healthcare facility staff and information systems to generate and process quality (accurate, reliable, and timely) information for managing “essential medicine supply chain” in

public healthcare facilities to mitigate essential medicine stockout and improve health service delivery.

The following measure should be used for assessment in Phase I

Table 4. 26

Evaluation of Phase I

Usability	Is the policy on digital health information usable to public health facilities? Does the policy on digital health information fit within the workflow of public healthcare workers in public health facilities? What is the rate of errors associated with using the policy on digital health information for the management of “essential medicine supply chain” in public healthcare facilities? Does training on ICT affect staff workflow using digital information to manage “essential medicine supply chain” in public healthcare facilities? How does training on supply chain management affect staff workflow using digital information to manage “essential medicine supply chain” in public healthcare facilities? How does supervision affect the use of digital health information to manage “essential medicine supply chain” in public healthcare facilities?
Efficiency	Has the policy on digital health information changed the quality (timeliness, accuracy, completeness) of information for the management of “essential medicine supply chain” in public healthcare facilities? Has staff training on ICT changed the quality of information used to manage the “essential medicine supply chain” in public healthcare facilities?
Effectiveness	Has policy on digital health information contributed to a change in the time used to process digital health information for the management of “essential medicine supply chain” in public healthcare facilities? Has training in ICT changed health workers' application of policies and use of digital health information for the management of “essential medicine supply chain” in public healthcare facilities? Has training in supply chain management changed health workers' application of policies and use of digital health information to manage the “essential medicine supply chain” in public healthcare facilities?

Phase Two: Technology Enhancement

Component 1: Policy on digital health information

According to MSH (2012), fragmented systems and incomplete and inaccurate data cause delays in the process and take a long to verify data that is useful for quantification, forecasting, and management of the “essential medicine supply chain”. Thus, Information Communication and technology (ICT) infrastructure and the integration of the health information system in public healthcare facilities will play a significant role in anchoring the digitalization of information for the management of essential medicine. County Governments are encouraged to increase the effort to procure enough computers to be installed in key departments such as the Pharmacy, Store, Procurement, and Medical Superintendents of Health Offices, to mention a few. Such computers should be networked with the support of an internet connection to have the capacity to seamlessly share information on medicine availability, stock, and shortage by authorized individuals under strict adherence to personal data security and protection and confidentiality protocol. This phase involved integrating all the different digital systems information within public health facilities to communicate and share data and information seamlessly. This also means greater digital information systems use and transition from paper-based data collection, processing, and information sharing for the medicine supply chain.

Component 2: Institutional Digital Health Information Capabilities

In phase two, institutional digital health information capabilities involve acquiring and installing adequate functional ICT infrastructure, internet connection, hardware and software maintenance, and technical capabilities of the different information systems

to collect, process, and share information seamlessly. Besides, the digital processing of health commodities supply chain information must be institutionalized by applying an integrated end-to-end digital health information system within the public health facility. Institutionalizing computerized information technology systems in health facilities can potentially improve pharmacy inventory visibility and management (Ali, 2011). This point is supported by Tortorella et al. (2022) who state that an ICT-driven approach enables reliable real-time management of digital information systems to manage the medical supply chain.

Component 3: Capacity Building Strategies

Supportive supervision in most low- and middle-income countries is poor because of the small numbers of the workforce and inadequate skills, according to Avortri et al. (2019). According to MSH (2012), automation and application of innovative technologies alone, without closer supervision and personnel training, cannot guarantee better accuracy in information management. Tulu et al. (2021) advises that supportive supervision, feedback, and training promote the usage of health information. Thus, in phase two, capacity-building strategies involve training of pharmacists and pharmaceutical technologists, medical laboratory technologists, clinical officers, nurses, pharmacists, and pharmaceutical technologists, supplies officers and supply chain officers and HRIOs on digital health information and health commodities supply chain activities as well as training on commodities inventory management/monitoring. These cadres of staff should be targeted because at the National and county government level, medicine and medical products supply chain functions are undertaken by pharmacists and pharmaceutical technologists; at the

health facility level, supply chain management function is performed by medical laboratory technologists, clinical officers, nurses, pharmacists, and pharmaceutical technologists and procurement and procurement planning by supplies officers and supply chain officer (MoH, 2021a). MoH (2020a) stipulates that staff responsible for keeping essential medicine records should be adequately trained in the collection and processing of data.

Component 4: Evaluation

Evaluation in phase II should focus on generating information to assess the implementation, changes, and attributes of policy on digital health information, institutionalization of health facility digital and ICT infrastructure (computer hardware, software, and networking), and performance of healthcare workers regarding skills levels in ICT and supply chain management.

The following measure should be used for assessment in Phase II

Table 4. 27

Evaluation of Phase II

Usability	Are policies and guidelines on digital health information for managing the “essential medicine supply chain” cascaded and usable in a public healthcare facility? Does the policy and guideline on digital health information for managing “essential medicine supply chain” fit within the workflow of healthcare personnel in public healthcare facilities? Are ICT infrastructure (computer hardware, software, and networking) in public healthcare facilities usable by healthcare workers? What is the rate of errors when using the ICT infrastructure compared to before the installation of ICT infrastructure?
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	Can trained healthcare personnel adequately use ICT infrastructure to produce quality digital information?
Efficiency	Has policy and guidelines on digital health information changed the time used to produce digital health information and manage the “essential medicine supply chain” in public healthcare facilities? Has ICT infrastructure changed healthcare workers' performance regarding their time producing quality digital health information to manage “essential medicine supply chains” in public healthcare facilities? Has training of health workers in ICT changed the quality of information used to manage “essential medicine supply chain” in public healthcare facilities? Has training of health workers in supply chain management changed the quality of information used to manage the “essential medicine supply chain” in public healthcare facilities? Has supervision changed the quality of information generated for managing “essential medicine supply chain” in public healthcare facilities?
Effectiveness	Has policy on digital health information changed the time spent on ICT infrastructure to generate quality information used to manage “essential medicine supply chains” in public healthcare facilities? Has ICT infrastructure changed the generation of quality information used to manage the “essential medicine supply chain” in public healthcare facilities? Has ICT infrastructure changed healthcare workers' performance in producing quality information for managing “essential medicine supply chains” in public healthcare facilities? Has ICT training changed healthcare workers' performance in terms of producing quality information for managing “essential medicine supply chains” in public healthcare facilities? Has training in supply chain management changed healthcare workers' performance in producing quality information for managing the “essential medicine supply chain” in public healthcare facilities? Has supervision changed healthcare workers' performance in using ICT infrastructure and policy digital health information to produce quality information for the management of “essential medicine supply chains” in public healthcare facilities?

Phase Three: DHIS Integrated & Sustained Implementation

Component 1: Policies on Digital Health Information

As observed by Toroitich et al. (2022) health commodities management systems *and* policy guidelines outline the type of information system infrastructure, procedures for appropriate use, collection of accurate commodities consumption data, ways of data analysis, and dissemination of information for planning and service delivery. This segment should, therefore, involve the circulation and adoption of the policies, guidelines, and strategic plans on digital health information systems (DHIS) for supply chain management (SCM) by public healthcare facilities.

Rubio-Rivas et al. (2021) stressed the significance of management support for establishing and strengthening health information architecture and infrastructure to support efficient planning and service delivery. In this phase, both National and County governments should provide enough resources (financial, human resources, and material) for implementing a digital health information system to support the timely management of “essential medicine supply chain” in public healthcare facilities in Kenya.

Component 2: Institutional Digital Health Information Capabilities

At this stage, institutional digital health information capabilities should involve integrating the different digital health information systems and technology infrastructure within public healthcare facilities. Healthcare facility management should ensure inter-department ICT infrastructure connectivity capable of seamless communication and transfer of medicine-related data and information to manage “essential medicine supply chain” in the facility.

Component 3: Capacity Building Strategies

Olu et al. (2019) noted that African health workers' low adoption of digital health technology is an outcome of a lack of skilled digital health employees. Tulu et al. (2021) stated that the aim of training should, therefore, be to equip and improve health facility staff with skills to perform their tasks. In Kenya, MoH Kenya Supply chain strategy (2020-2025) observes that most staff that perform the medicine and medical products supply chain functions learn on the job and through attending courses sponsored by development programs on pharmaceutical supply chain management. Ministry of Health and County governments should deliberately make efforts to deploy an adequate number of skilled personnel trained in digital health information and supply chain management (SCM) and promote regular supervision. This approach is supported by Cory and Stevens (2020) who note that providing digital training to unskilled workforce in the health sector could improve digital skills in line with WHO's "Global Strategy on Digital Health 2020–2024" objectives.

Component 4: Evaluation

Evaluation at phase III focuses on assessing the output of implementing cascaded policy and guidelines on digital health information, integrated digital health information technology, deployed staff, and supervision.

The following measure should be used for assessment in Phase III

Table 4. 28***Evaluation of Phase III***

Usability	Does the cascaded policy and guidelines on digital health information fit within the workflow of healthcare workers in relation to the generation of digital health information for the management of “essential medicine supply chain” in public healthcare facilities? Does the health facility adequately train ICT personnel to operate a digital health information system and produce digital information for managing the “essential medicine supply chain” in public healthcare facilities? Does the health facility have adequately trained personnel in supply chain management to support the processing of digital information for the management of “essential medicine supply chain” in public healthcare facilities? Does the health facility have supervisors to monitor the processing of digital health information to manage the “essential medicine supply chain” in a public healthcare facility?
Efficiency	Has the cascaded policy and guidelines on digital health information hastened the use of ICT infrastructure to process quality digital information for managing “essential medicine supply chains” in public healthcare facilities? Has the integrated digital health information system for supply chain management changed healthcare workers' performance in terms of processing quality digital health information for the management of “essential medicine supply chains” in public healthcare facilities? Has the number of ICT-skilled healthcare workers changed performance in terms of the production of quality information for the management of “essential medicine supply chains” in public healthcare facilities?
Effectiveness	Has the cascaded policy and guideline on digital health information increased the use of ICT infrastructure to process quality digital health information and manage the “essential medicine supply chain” in public healthcare facilities? Has the application of ICT changed healthcare workers' adherence to policy and guidelines on digital health information in the application of digital health

information for managing “essential medicine supply chain” in public healthcare facilities?

Has training personnel in ICT and supply chain management changed healthcare workers' use of digital health information to manage the “essential medicine supply chain” in public healthcare facilities?

Evaluation

Monitoring and evaluation will be needed to measure the effectiveness of the digital health information system (DHIS) and its outcomes. While monitoring continuously assesses the system's efficacy (inputs and processes), evaluation will be conducted on a predetermined periodic basis to ascertain whether the hypothesized results (Outputs and Outcomes) are being achieved.

At the evaluation stage, information on digital health information applications on the management of “essential medicine supply chain” should be gathered and analyzed to determine its effect on ensuring that public healthcare facilities have an adequate supply of essential medicine, availability of enough medicine stocks, and reduced incidences of essential medical stockout in public healthcare facilities in Kenya. To evaluate the efficiency of digital health information on the management of essential medicine supply, some of the key considerations in terms of digital health information indicators could: 90% quality (timeliness, completeness, reliability) of digitized health information, 90% digital health data processing (data collection, data extraction, data analysis), 90% skilled workforce in the facility (number of personnel, supervision), 90% functional ICT infrastructure (computers- hardware and software, internet connection) and 80% adherence to digitalization policy in managing “essential medicine supply chain” in the public healthcare facility. The aim of evaluating the

application of digital health information on the management of “essential medicine supply chain” in public healthcare facilities should be to examine and improve the quality (complete, accurate, complete, and timely) of information for timely decision-making in the management of “essential medicine supply chain” to mitigate against essential medicines stockouts and to improve health service delivery in public healthcare facilities in Kenya.

Table 4. 29

Proposed Digital Health Information Framework Evaluation Guideline

Categories	Checklist	Quantitative Criteria	Qualitative Criteria
Management of the “essential medicine supply chain”	Correctness of information on medicine quantification and forecast information	The number of essential medicines quantified and forecasted	Information from pharmacists and medical stores
	Available stock of essential medicine in the facility	Number of available medicines in store	Information from pharmacists, medical stores & medical Superintendent of Health
Quality of Digitized Health Information	Accuracy of essential medicine consumption data and available stock information for the supply chain process	90% and above accurate digital information used for the management of “essential medicine supply chain”	Information from all departments
	Completeness of essential medicine consumption data and available stock information for the supply chain process	90% and above complete digital information used for the management of “essential medicine supply chain”	Information from all departments
	Reliability of essential medicine consumption data and available stock information for the supply chain process	90% and above reliability digital information used for management of “essential medicine supply chain”	Information from all departments

Digitized health Information processing	Timeliness of essential medicine consumption data and available stock information for the supply chain process	90% and above timely digital information used for management of “essential medicine supply chain”	Information from all departments
	Data collection through digital information system for supply chain	90% and above of digital data collected is used for the management of the “essential medicine supply chain”	Information from all departments
	Data extraction through digital information system for supply chain	90 % and above digital data extracted and used for the management of “essential medicine supply chain”	Information from all departments
	Data analysis through digital information system for supply chain	90% and above digital data analysis used for management of “essential medicine supply chain”	Information from all departments
	Essential medicine digital information transmission through digital information system for supply chain	90% and above digital information transmitted for management of “essential medicine supply chain”	Information from all departments
	Processing of essential medicine information through digital information system	90% and above of digital information is processed through the digital information system	Information from all departments
	dissemination of information on essential medicines for the supply chain	90% and above digital information disseminated for management of “essential medicine supply chain” within the facility	Information from all departments
	Exchange of essential medicines information for the supply chain	90% and above digital data exchanged for management of “essential medicine supply chain”	Information from all departments
	data and information processing and accessibility of essential medicine information within the facility for the supply chain	90% and above digital data and information processed and accessed for management of “essential medicine supply chain”	Information from all departments

ICT Infrastructure Support	Availability of functional hardware and software with the facility and country	90% and above functional hardware and software installed for management of “essential medicine supply chain”	Information from all departments
	Inter-department internet connection	90% and above internet connection and speed for processing information	Information from all departments
	Contractual agreement for maintenance and support	90% and above hardware and software maintenance	Information from all departments
	Inter department's connection of ICT and digital information systems	90% and above interconnection and communication between digital systems for processing information for the management of “essential medicine supply chain”	Information from all departments
	Budgetary allocations	Number of functional ICT and digital information systems	Information from the Medical Superintendent of Health
Workforce skills	Availability of healthcare workers with ICT skills	90% staff proficiency in the use of ICT	Information from the Medical Superintendent of Health
	Availability of healthcare workers with supply chain management skills	90% staff proficiency in supply chain management	Information from the Medical Superintendent of Health
	Facility Digital information application plans and guidelines	Copies of digital information application plans and guidelines for management of “essential medicine supply chain”	Information from the Medical Superintendent of Health
	Availability of a supervisor	Number of checklists, records of routine supervision	Information from the Medical Superintendent of Health
	Budgetary allocations	% of funds allocated for staff capacity building in ICT and Digital literacy	Information from the Medical Superintendent of Health

Policy and guidelines on digital health information	Availability of copies of the policy in the facility	Number of personnel who understand the digital information policy for management of the medicines supply chain	Information from the Medical Superintendent of Health
	Availability of copies of guidelines in the facility	Number of personnel who understand the digital information guidelines for the management of the medicines supply chain	Information from the Medical Superintendent of Health
	Availability of copies of guidelines in the facility	90% and above correct digital health information for the management of the “essential medicine supply chain”	Information from the Medical Superintendent of Health

The above evaluation criteria are categorized into 6 categories: management of “essential medicine supply chain” (quantification, forecasting), quality of digitized health information (accuracy, completeness, reliability), digitized health information processing (data collection, data extraction, and analysis), ICT infrastructure support (computer hardware and software, maintenance and internet connectivity), workforce skill (training, management support and supervision) and policy on digital health information (policy and guidelines). The study revealed the need for improving the quality of digitized health information, digitized health information processing, ICT infrastructure support, workforce skills capacity building, and exposing healthcare personnel to the policy on digital information for managing the medicine supply chain in public healthcare facilities in Kenya.

The results of this study are reflected in the digital health information framework for the management of “essential medicine supply chain” evaluation criteria. The criteria are thus relevant to the management of public healthcare facilities for evaluation of the

use of digital health information for the management of “essential medicine supply chain” and future research.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

This chapter highlights the conclusions and recommendations of this study.

5.2 Conclusions of the Study

The study revealed the existence of positive and significant relationships between the quality of digitized health information, digitized health information processing, ICT infrastructure support, and workforce skills with the management of essential medicines supply chain in public healthcare facilities in Kenya. The mediating role of policy on digital health information on independent variables and management of essential medicines supply chain is also recognized. The study also revealed that with the transition from paper or a mix of paper and electronic systems to digital health information systems for generating and processing health information, the quality (accuracy, completeness, and timeliness) of information can be improved for managing “essential medicine supply chain”. The study shows that opportunities for improvement of the quality of information for the management of “essential medicine supply chain” in public healthcare facilities are therefore dependent on the transition to digital health information technology, including installation of adequate functional ICT infrastructure support, training, and deployment of the adequate number of staff with skills in ICT and supply chain management, supervisors and circulation of copies of digital health information policies and guidelines to public healthcare facilities.

First, there is a need for public healthcare facilities in the counties of Kajiado, Makueni, and Mombasa to transition from a mixture of paper and electronic systems

to an integrated ICT infrastructure and digital health information with tools for processing (data collection, extraction, and analysis) information for management of “essential medicine supply chain” to reduce data errors, incompleteness, inaccuracies and delays in decision-making and management of “essential medicine supply chain”. As noted from the study, inaccurate and delayed information can lead to wrong medicine orders in the supply chain process, shortage of essential medicine, and delays in service delivery.

From the third objective, which was to determine the influence of ICT infrastructure support for the management of essential medicine supply in public healthcare facilities in Kenya, the study concludes that ICT infrastructure support for health information influences the management of “essential medicine supply chain” (dependent variable) in public healthcare facilities in Kenya. This was deduced from the fact that there is a significant relationship between ICT infrastructure support for health information and management of “essential medicine supply chain” (dependent variable) in public healthcare facilities in Kajiado, Makueni, and Mombasa counties.

The fourth objective, which was to examine the influence of workforce skills on the management of “essential medicine supply chain” in public healthcare facilities in Kenya, the study underscores the need for enhanced training of healthcare workers responsible for medical stores, pharmacies, procurement, and health records in digital health information and supply chain management to improve quality information for decision-making and management of “essential medicine supply chain” in public healthcare facilities in Kenya.

There is a need for a digital health information framework that could guide the Ministry of Health, County governments, and public healthcare facilities to strengthen the application of policy on digital health information, installation of integrated ICT infrastructure and digital information systems, capacity building of healthcare personnel with skills in ICT and supply chain management and supervision to strengthen processing of digital health information for management of medicine supply chain in public healthcare facilities in Kenya, to mitigate essential medicine stockouts and to improve healthcare service delivery. To address challenges observed about the effect of poor quality of information, inadequate ICT infrastructure support, inadequate number of healthcare workers with skills in ICT and supply chain management, and absence of copies of digital health information policies and guidelines for the management of medicine supply chain in public healthcare facilities in Kenya, a comprehensive digital health information framework for management of “essential medicine supply chain” in public healthcare facilities in Kenya was developed. The framework is composed of four components (policies on digital health information, institutional digital health information capabilities, and evaluation of digital health information systems) and three Phases (preparation {input}, ICT technology enhancement {process}, and digital health information systems integrated and implementation {output}) plays a significant role in strengthening adoption and application of digital health information systems and digital health information for decision-making and timely management of “essential medicine supply chain” in public healthcare facilities. The digital health information framework for the management of “essential medicine supply chain” in public healthcare facilities in Kenya does not only strengthen the use of digital health information and digital health

information technology innovation within public healthcare facilities, but it also enriches empirical research on digital health information technology in supply chain perspective and performance in the healthcare sector.

5.3 Recommendations of the Study

5.3.1. The Ministry of Health and County governments should purchase and install functional integrated ICT infrastructure, digital health information system, and internet connection to facilitate quality (complete, accurate, reliable, and timely) medical consumption data collection and processing of digital health information for decision-making and management of “essential medicine supply chain” in public healthcare facilities to mitigate essential medicine shortage and to improve healthcare service delivery.

5.3.2. Second, to mitigate essential medicines shortages, there is a need for public healthcare facilities to switch from a mixture of paper and electronic system processing of essential medicines data to an integrated functional ICT infrastructure and digital health information system. This will improve the quality (completeness, correctness, and reliability) of information and the timely dissemination of quality information for decision-making in the management of “essential medicine supply chain” in public healthcare facilities.

5.3.3. The Ministry of Health and County governments should support installations of functional ICT infrastructure and digital health information systems in each public health facility to ensure that all data and information for the management of essential medicine is processed through digital health information systems to improve

information quality and timely availability of information for decision-making in the management of “essential medicine supply chain”.

5.3.4. Third, the Ministry of Health and County governments need to promote the use of quality digital health information for managing “essential medicine supply chain” in public healthcare facilities through the installation of adequate functional integrated ICT infrastructure support (computer hardware, software, maintenance, and internet connection) and digital health information system with tools for processing medicine data to mitigate essential medicine stockouts and improve health service delivery.

5.3.5. Trained and skilled healthcare workers who are facilitated with functional ICT infrastructure support and digital health information systems have the potential to improve the quality of information required for decision-making and management of the “essential medicine supply chain”, improving service delivery in public healthcare facilities in Kenya.

5.3.6. The developed digital health information framework for the management of “essential medicine supply chain” in public healthcare facilities be adopted and applied to guide healthcare personnel in public healthcare facilities on the use of digital information for managing “essential medicine supply chain” to mitigate against essential medicine stockouts and improve service delivery in public healthcare facilities.

Since this digital health framework has not been piloted, it is recommended that the Ministry of Health pilot it in one level 4 public healthcare facility and one level 5 public healthcare facility in at least 3 counties categorized as peri-urban, urban, and rural counties. Because of the complexity in terms of scope and budget to finance the

implementation of the framework, pilot implementation could be undertaken, taking each component and the respective phases depending on available resources and time.

5.3.7. Suggested areas for further studies.

This study is limited in scope in terms of the sample size, categories of health facilities, and number of counties involved in the study, which may limit the generalization of the findings. Therefore, future studies could explore filling this gap by first undertaking research examining differences between private and public healthcare facilities about applying digital health information systems to managing commodities supply chain. The second consideration is research that could expand the scope of the current study to cover more sample size, more health facilities, and more counties out of the 47 counties of Kenya for generalization and a broader understanding of the complexity of using digital health information technology for supply chain management. Another area for further research could focus on capturing healthcare workers' perspectives on how digital health information impacts their workflow.

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APPENDICES

Appendix I: Informed Consent

Kenya Methodist University

P. O Box 45240-00100

Nairobi, Kenya

SUBJECT: INFORMED CONSENT

Dear Respondent,

My name is Robert Mugubi. I am a PhD student from Kenya Methodist University. I am conducting a study titled "Towards a Digital Health Information Framework for Management of “essential medicine supply chain” in Public Healthcare Facilities in Kenya."

Procedure to be followed.

Participation in this study will require that I ask you some questions and access all the hospital's departments to address information systems and medicines and supplies pillars of the health system. I will record the information from you in a questionnaire. You have the right to refuse participation in this study. You will neither be penalised nor victimised for not joining the study. Your decision to decline participation will not be used against you, and neither will it affect you at your place of employment. You may ask questions about the study at any time during this interview. You may refuse to respond to any questions. You may also stop taking part in this study at any time without any consequences.

Benefits

Your participation in this study will help us strengthen the health systems in Kenya and other low-income countries in Africa. As a result, countries, communities, and individuals will benefit from improved quality of healthcare services. This research is critical to strengthening the health systems as it will generate new knowledge in this area that will inform decision makers to make research-based decisions.

Rewards

Participation in this study is voluntary, and there are no rewards.

Confidentiality

The interviews will be conducted in a secluded setting within the hospital. Your name will not be recorded on the questionnaire. Questionnaires will be kept in a safe place at the University.

Contact Information

If you have any questions, you may contact the following supervisors:

Prof. George W. Odhiambo-Otieno - 0720 716 770 of Rongo University or Dr Caroline Kawila - 0721 612 745 of Department of Health Systems Management of Kenya Methodist University, Nairobi Campus.

Investigator's Statement

I, Robert Mugubi, 0722806184 the undersigned, have explained to the volunteer in a language s/he understands the procedures to be followed in the study and the risks and the benefits involved.

Name of
Interviewer.....Date.....

Interviewer Signature.....

Participant's Statement

The above statement about my participation in the study is clear to me. I have been given a chance to ask questions and my questions have been answered to my satisfaction. I understand that my participation in this study is entirely voluntary. I understand also that my records will be kept private and that I can leave the study at any time. I understand that there are no consequences to me should I stop participating at any time during the interview.

Name of Participant.....
Date.....

Signature.....

Appendix II: Main Questionnaire

TOWARDS A DIGITAL HEALTH INFORMATION FRAMEWORK FOR MANAGEMENT OF “ESSENTIAL MEDICINE SUPPLY CHAIN” IN PUBLIC HEALTH FACILITIES IN KENYA.

This questionnaire is designed for a study on **a digital health information framework for managing the “essential medicine supply chain” in public healthcare facilities in Kenya. The information will be collected through a face-to-face interview, using both paper and electronic questionnaires.** The interview will be conducted in English.

You have been chosen to take part in this study which is undertaken at the Kenya Methodist University in partial fulfillment of my PhD in Health Systems Management. Your participation is voluntary and highly appreciated. Your opinion and views will be especially important in the understanding of the status of the digital health solution for the management of medical supplies in public healthcare facilities in Kenya. To assess the management of medical supplies and products in Kenya's public hospitals through the application of digital health information technologies. Should you agree to participate, the interview may take between 30 and 45 minutes and you may also opt out should you feel so.

A: Basic Demographics

1. Name of the County (choose one only):

- ☐ Kajiado ☐ Makueni ☐ Mombasa

2. What is the name of this hospital (choose the hospital you work in - linked to the related county):

☐ Kajiado County Referral hospital ☐ Kitengela Sub County hospital ☐ Mutuyambua hospital

☐ Kibwezi Sub County Hospital ☐ Kisau Sub County Hospital ☐ Mtito Andei Sub County Hospital

☐ Makueni County Referral Hospital ☐ Likoni Sub County Hospital ☐ Bomu Medical Hospital

☐ Coast General Teaching and Referral Hospital

3. In what capacity are you working in this health facility? (Choose only one response related to your role):

- ☐ Health Records and Information Officer (HRIO) ☐ Head of Facility/ In charge/ Director ☐ Medical Stores Officers ☐ Medical Officer ☐ Clinical Officer ☐ Pharmacist ☐ Pharmaceutical technologist ☐ Drug inspector ☐ Nurse ☐ Supplies Officer ☐ Procurement officer

4. How long have you worked in this facility?

- ☐ Less than 3 months ☐ between 3 months and 1 year ☐ between 1 and 5 years ☐ More than 5 years

Section B. Quality of digitized health information for management of “essential medicine supply chain”.

INSTRUCTIONS: For Questions #5 to #9 below, please tick the descriptive scale based on your own experiences and feelings

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
5. This health facility has a functional digital health information system (HIS) that support in the management of essential medicine supply chain.					
6. Information from your digital health information system is dependable for essential medicine supply chain management.					
7. Information from your digital health information system is prompt for essential medicine supply chain management.					
8. Information from your digital health information system is complete for essential medicine supply chain management.					
9. Better management of essential medicine supply chain management in this facility relies on quality of digital health information produced.					

10. Overall, “do you agree that the management of “essential medicine supply chain” is dependent on the quality of information produced by the digital health information?”

- ☐ Yes
☐ No

11. If, # 10 is YES, how does “the quality of digital health information influence effective management of essential medicine supply chain in your facility?”

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12. If, #10 is NO, what could be the reason quality “of digital health information does not influence effective management of essential medicine supply chain” in your facility?

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13. Do you “face any challenges working the existing digital health information systems in managing “essential medicine supply chain” in your facility?”

☐ Yes

☐ No

14. If # 13 is YES, “which challenges do you face working with existing digital health information system in managing “essential medicine supply chain”?”

- ☐ Reliability,
- ☐ Timelines,
- ☐ Completeness
- ☐ Others specify.

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15. In your opinion what would be your recommendation(s) to solve information quality challenges to improve the management of essential medicine supply within your facility?

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Section C: Digitized health information processing strategy for management of “essential medicine supply chain”.

16. Is data collection on essential medicine in your facility done through the digital information system?

☐ Yes

☐ No

17. If, # 16 is NO, could you explain the reason digital “information system is not used for essential medicine data collection for supply chain management in your facility.”

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18. Is data extraction for managing essential medicine supply chain in your facility” done through digital health information system?”

☐ Yes

☐ No

19. If, # 18 is NO, could you explain the reason data extraction for managing “essential medicine supply chain in facility is not done through digital health information system”

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20. Is data analysis for managing “essential medicine supply chain” in your facility done through digital health information system?

☐ Yes

☐ No

21. If, # 20 is NO, could you explain the reason data analysis for managing “essential medicine supply chain” in your facility is not done through digital health information system

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INSTRUCTIONS: For Questions #22 to #25 below, please tick the descriptive scale based on your own experiences and feelings

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
22. Extraction of data through digital health information system has improved information for management of “essential medicine supply chain” in this facility					
23. Analysis of data through digital health information system has improved information the management of “essential medicine supply chain” in this facility.					
24. Data collection through digital health information system has improved information for management of “essential medicine supply chain” in this facility					
25. Better management of “essential medicine supply chain” depends in this facility relies on information processed through digital health information system					

26. Under each activity below briefly describe how processing of information (mention whether digital or paper) influence management of “essential medicine supply chain” in your facility.

- a) Data Collection.....
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- b) Data Extraction.....
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- c) Data Analysis.....

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Section D: “ICT Infrastructure support factor for the management of essential medicine supply chain”

INSTRUCTIONS: For Questions # 27 to #30 below, please tick the descriptive scale based on your own experiences and feelings

	Strongly disagree	Disagree	Neutral	Agree	Strongl y agree
27. Your facility has enough functional computers to support digital information for managing of essential medicine supply chain in your facility					
28. Your health facility has electricity connectivity to support ICT application of digital health information for management of essential medicine supply chain					
29. Your health facility has reliable internet to support digital health information for management of essential medicine supply chain					
30. Better management of essential medicine supply chain depends in this facility relies on ICT infrastructure for management of digital health information system					

31. Is “your health facility connected to electricity supply from the Kenya Power grid supply to support digital health information system for management of supply chain?”

- ☐ Yes
- ☐ No

32. If # 31 is YES, “in your opinion does the connection to electricity in your facility support the use of digital health information system for management of “essential medicine supply chain”?”

☐ Yes

☐ No

33. Does “your health facility have a backup Generator for supplying electricity in case of black out from Kenya power supply to support digital health information system for management of supply chain?”

☐ Yes

☐ No

34. Does “your health facility have a Generator for supplying electricity during black out from Kenya power supply to support digital health information system for management of supply chain?”

☐ Yes

☐ No

35. If, # 34 is NO, “does the absence of electricity in your health facility affect availability of digital health information for management of supply chain?”

☐ Yes

☐ No

36. Does “your health facility have adequate internet connectivity to support use of digital health information system transmission of information for management of supply chain?”

☐ Yes

☐ No

37. Does “lack of internet connectivity in your health facility affect the transmission of digital health information for effective management of supply chain?”

☐ Yes

☐ No

38. If # 37 is NO, could you explain the reason how lack of adequate internet connectivity affects “digital health information system for management of supply chain”

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39. Do computers in our “health facility have internet connectivity to support digital health information system” for management of supply chain among the units in the facility?

☐ Yes

☐ No

40. If # 39 is NO, could you explain the influence of lack of computer internet connectivity on “digital health information system for support of management of supply chain in your facility.”

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Section E: Workforce skills factor for management of “digital health information system for management of essential medicine supply chain

INSTRUCTIONS: For Questions # 41 to #47 below, please tick the descriptive scale based on your own experiences and feelings

	Strongly disagree	Disagree	Neutral	Agree	Strongl y agree
41. Your health facility has an adequate number of trained on digital health information to support management of essential medicine supply chain					
42. Your health facility has adequate staff trained on medical supplies and products supply chain management					
43. In your facility there is a supervisor who supervises the dissemination of digital health information for management of essential medicine chain within the facility					
44. Regular supervision of digital health information dissemination has improved efficiency in management of essential medicine supply chain in my facility					
45. Lack of regular supervision of digital health information dissemination affect management of essential medicine supply chain in this facility					
46. inadequate number of trained personnel on digital health information affect efficient management of essential medicine supply chain in this facility					
47. Better management of essential medicine supply chain in health facility relies on workforce skill in use of digital health information system					

48. Do you think that health facility success in “essential medicine supply chain” management if influence by health workforce skills in use of information from digital health information system?

☐ Yes

☐ No

49. If # 48 is YES, could you briefly explain how health workforce skills in use of information from “digital health information system influence better management of “essential medicine supply chain” in your facility”

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50. If # 48 is NO, could you explain how lack of workforce skills in use of information from “digital health information system affect better management of “essential medicine supply chain””

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51. Do you have skills in using “digital health information system for managing “essential medicine supply chain”?”

☐ Yes

☐ No

52. If # 51 is YES, could you briefly explain how has that skill helped you to use digital information to improve “essential medicine supply chain” in this facility?

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53. Has lack of workforce skills in your facility ever caused “digital health information challenges to the management of “essential medicine supply chain” in your facility?”

☐ Yes

☐ No

54. Do you think that lack of adequate “digital health information to support management of “essential medicine supply chain” in your facility is contributed by lack of skills in use of digital health information system?”

☐ Yes

☐ No

55. If # 54 is NO, could you briefly how lack of inadequate “digital health information to support management of “essential medicine supply chain” in your facility is not contributes by lack of skills in digital health information system”

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56. Could you explain how lack of workforce skills in your facility has caused “digital health information challenges to the management of “essential medicine supply chain” in your facility?”

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57. Have you ever received training in the use of digital health information?

- ☐ Yes
- ☐ No

58. If # 57 is YES, Was the training received on digital data management relevant in information for managing “essential medicine supply chain”?

- ☐ Yes
- ☐ No

59. In your opinion do you think staff members in your facility are trained on how to use “digital health information systems for management of “essential medicine supply chain”?”

- ☐ Yes
- ☐ No

60. If # 59 is YES, does staff training have influence on the use of “digital health information for the management of “essential medicine supply chain” in your facility?”

- ☐ Yes
- ☐ No

61. If # 60 is NO, what could be the reason staff training does not influence the use of “digital health information for management of “essential medicine supply chain” in your facility?”

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62. Has your facility experienced essential medicine stockout because of inadequate use of “digital information in essential medicine chain management?”

- ☐ Yes
- ☐ No

63. If # 62 is YES, could you explain the reason behind inadequate use of “digital information in essential medicine chain management resulting in essential medicine stockout?”

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64. In your opinion do you this staff skills in the use of digital health information have influence on how digital information on essential medicine consumption is processed and availed for “management of essential medicine supply chain in your facility?”

- ☐ Yes
- ☐ No

Section F: Policy framework on “digital information for management of essential medicine supply chain”

INSTRUCTIONS: For Questions # 65 to #72 below, please tick the descriptive scale based on your own experiences and feelings

	Strongly disagree	Disagree	Neutral	Agree	Strongly agree
65. A regulatory framework on digital health information system in this facility guides the use of digital information for management of essential medicine supply chain					
66. Guidelines (set of rules) on digital health information system in this facility guide the use of digital information for management of essential medicine supply chain					
67. Regulatory framework on ehealth influence the use of digital health information in management of essential medicine supply chain in this facility.					
68. Regulatory framework on ehealth is not used in this facility on use of digital information for management of essential medicine supply chain					
69. The management of this health facility apply guidelines on the use of digital information to conduct essential medicine supply chain management.					
70. ehealth policies influence the use of digital information in distribution for management of essential medicine supply chain in this facility.					
71. ehealth policies influence the use of digital health information for quantification in management of essential medicine supply chain in this facility					
72. Better management of essential medicine supply chain in this health facility are influenced by clear ehealth policies on use of digital					

INSTRUCTIONS: For Questions # 73 to # 75 below, please tick the descriptive scale based on your own experiences and feelings.

	Strongly disagree	Disagree	Neutral	Agree	Strongl y agree
73. Existing regulatory mechanisms (a set of rules) on digital health information system in my facility create an enabling digital information technology environment for management of					

essential medicine inventory in
supply chain for this facility

74. The guidelines on digital
health information system
provide support for real time use
of digital essential medicine
consumption information for
products selection in supply
chain management

75. Regulatory framework on
digital health information for
management of essential
medicines supports real time
distribution of essential
medicines in this facility

Section G: Management of “essential medicine supply chain”.

INSTRUCTIONS: For Questions # 76 to # 86 below on quantification, please tick
the descriptive scale based on your own experiences and feelings.

Quantification	Strongly disagree	Disagre e	Neutr al	Agre e	Strongl y agree
76. Digital information system is used in collection of essential medicine consumption data for use in management of “essential medicine supply chain” in these facilities.					
77. Essential medicine information used in management of supply chain in this facility is reliable (done through digital information system).					
78. Essential medicine information used for management of supply chain in this facility is timely processed through digital information system.					
79. Essential medicine information used for quantification of medicine consumption in supply chain in this					

facility is Accurately processed through digital information system).

80. Essential medicine information used for management of supply chain in this facility is complete (done through digital information system).

81. Essential medicine information used for management of supply chain in this facility is accessible (done through digital information system).

82. Digital health information supports timely quantification of essential medicine for management of supply chain in my facility.

83. Digital health information supports timely essential medicine (product) selection for management of “essential medicine supply chain”

84. Digital health information support timely procurement of essential medicines in this facility

85. Digital health information support timely distribution of essential medicines within this facility

86. Digital health information support the timely management of essential medicine inventory

Appendix III: Key Informant Interview Guide

TOWARDS A DIGITAL HEALTH INFORMATION FRAMEWORK FOR MANAGEMENT OF “ESSENTIAL MEDICINE SUPPLY CHAIN” IN PUBLIC HEALTHCARE FACILITIES IN KENYA.

Dear Respondent,

You have been chosen to take part in this study which is undertaken at the Kenya Methodist University in partial fulfilment of my PhD in Health Systems Management. Your participation is voluntary and is highly appreciated. Your opinion and views will be important in the understanding of the status of the digital health information for management of medicine and medical products supply chain in public healthcare facilities at levels 4 and 5 in Kenya. To assess management of medical supplies and products in Kenya's public healthcare facilities through application of digital health information technologies. This interview may take between 30 and 45 minutes and you may also opt out should you feel so.

A. KII information	
A1	Facility Name:
A2	County Name:
A3	Sub County Name:
A4	Date of the KII:
A5	Start time:
A6	Interviewer name:
B. Basic information	
	Interviewer: <i>“I am going to ask questions about yourself, your ideas and opinions on access of digital health information for the management of “essential medicine supply chain” in your facility”</i> When we say digital health information technology or information, we are referring to the use of ICT or electronic application and information system connected to it.
B1	What is your position in this facility? 1) Chief Medical Officer 2) Nursing in charge 3) Pharmacist 4) Health Records and Information Officer 5) Others; specify

B1	How long years have you been working in this position?
C. General perspectives about Digital health information system; When we say digital health information technology or information, we are referring to the use of ICT or electronic application and information system connected to it.	
C1	What are some of the positive impacts of using “digital health information technology in your facility?”
C2	What are some of the barriers you have experienced using “health information for management of “essential medicine supply chain” in your facility” [prob: data quality, processing, ICT infrastructure and workforce skills)
C3	Are similar barriers experienced when using “digital health information system in managing “essential medicine supply chain” in your facility” [prob: data quality, processing, ICT infrastructure and workforce skills)
C4	How has Kenya National eHealth policy 2016-2030, Kenya Health Policy 2012-2030, National Information communication and technology Policy supported the use of “digital health information technology in your facility?”
C5	Has “digital health information system been integrated to support essential medicine inventory and supply chain management in your facility?” Can you tell me about your facility experience using “digital health information for “essential medicine supply chain” management?”
D. Availability of essential medicines and stockouts	
D1	Describe the situation in terms of availability of medicines in this facility? Are essential medicines available? Are there times when essential medicines are out of stock?
D2	Describe how “digital health information is used in management of “essential medicine supply chain” in your facility.” [prob on the use of digital health information system on quantification, product selection, procurement, distribution, and inventory management
D3	How important is workforce skill in “digital health information system for management of essential medicine supply chains” in your facility?” is workforce skills prioritised in mitigating against essential medicine stockout? [prob, if not what could be the reason.]
D4	How important is ICT infrastructure for digitalization of health information system inessential medicine supply chains in your facility? Is “digital health information system prioritised for mitigation against essential medicine stockout?”

	In your opinion do you this the use of “digital health information has improved “essential medicine supply chain” management and mitigated against essential medicine stockout?” If not, what would be your recommendation
E. Policies	
E1	Are healthcare providers in this facility familiar with Kenya National eHealth policy 2016-2030, Kenya Health Policy 2012-2030, National Information communication and technology Policy and how they influence the use of digital health information for service delivery in Kenya? Have you ever received a copy of any of these policies?
E2	In your opinion, is any of these policies used for guiding the implementation of “digital health information system in this facility? Could you explain how these policies influence the use of digital health information in managing essential medicine inventory? How does the policy influence the use digital health information in “essential medicine supply chain” management in your facility?” Please explain in detail
	If not, why not?
	If not, what should be done to improve the situation?
E3	In your opinion, do you think policies on eHealth or digitalization influence or inhibit the use of “digital health information for management of “essential medicine supply chain” at the facility level?” If not, please explain in detail
	<i>Please prob</i>
E4	Are healthcare providers in this facility familiar with the Health products and technologies supply chain strategy 2020-2025? Could you explain how this strategy influences the used of “digital health information for management of “essential medicine supply chain” in your facility”
	If not, what do you think could be the reason, and what would be your recommendation to improve the situation?
	Has the facility developed a strategic plan for used of “digital health information for management of “essential medicine supply chain”?” If so, could you elaborate who the strategy is implemented to mitigate against essential medicine stockout.
E5	Could you explain the regulations that guide, promote, or inhibit the use of “digital health information for management of “essential medicine supply chain” in your facility? How have the regulations affected the use of digital health information to achieve successful “essential medicine supply chain” management at facility level?”
F. End of the interview	
F1	Do you have any questions you want to ask me?

F2	Thank you for your participation.
F3	End time of the interview:
G. Observations by the interviewer	
G1	Other observations or notes from the interviewer:

Appendix IV: List of Public Health Facilities Levels 4 and 5.

	County	Facility Name	level
	Mombasa		
1		Bomu Medical Hospital	
2		Tudor Sub County Hospital	Level 4
3		Likoni District Hospital	Level 4
4		Port Reitz Sub County Hospital	Level 4
4		Coast General Teaching and referral Hospital	Level 5
	Kajiado		
1		Kajiado County Referral Hospital	Level 4
2		Kitengela sub-county hospital	Level 4
3		Loitokitok Sub County Hospital	Level 4
4		Ngong Sub-County Hospital	Level 4
5		Ongata Rongai Sub County Hospital	Level 4
	Makueni		
1		Kambu Sub County Hospital	Level 4
2		Sultan Hamud Sub County Hospital	Level 4
3		Kilungu Sub County Hospital	Level 4
4		Mbooni Sub County Hospital	Level 4
5		Mukuyuni Health Centre	Level 4
6		Mutyambua hospital	Level 4
7		Kibwezi Sub County Hospital	Level 4
8		Kisau Sub County Hospital	Level 4
9		Tawa Sub County Hospital	Level 4
10		Matiliku Sub County Hospital	Level 4
11		Makindu Sub County Hospital	Level 4
12		Mtito Andei Sub County Hospital	Level 4
13		Makueni County Referral Hospital	Level 5

Appendix V: Sampled list of Level 4 and 5 facilities

	County	Facility Name	level	Random Numbers
Mombasa				
1		Tudor Sub County Hospital	Level 4	0.316478467
2		Likoni District Hospital	Level 4	0.041407923
3		Port Reitz Sub County Hospital	Level 4	0.006190861
4		Bomu Medical Hospital	Level 4	0.308018285
5		Coast General Teaching and referral Hospital	Level 5	0.143086575
Kajiado				
1		Kajiado County Referral Hospital	Level 4	0.501240795
2		Kitengela sub-county hospital	Level 4	0.051381527
3		Loitokitok Sub County Hospital	Level 4	0.203140956
4		Ngong Sub-County Hospital	Level 4	0.535501591
5		Ongata Rongai Sub County Hospital	Level 4	0.262698195
Makueni				
1		Kambu Sub County Hospital	Level 4	0.476242405
2		Sultan Hamud Sub County Hospital	Level 4	0.227005111
3		Kilungu Sub County Hospital	Level 4	0.107664519
4		Mbooni Sub County Hospital	Level 4	0.486331997
5		Mukuyuni Health Centre	Level 4	0.037083269
6		Mutyambua hospital	Level 4	0.570242633
7		Kibwezi Sub County Hospital	Level 4	0.310244319
8		Kisau Sub County Hospital	Level 4	0.060540407
9		Tawa Sub County Hospital	Level 4	0.045015856
10		Matiliku Sub County Hospital	Level 4	0.543970936
11		Makindu Sub County Hospital	Level 4	0.077365189

12	Mtito Hospital	Andei	Sub	County	Level 4	0.032250645
13	Makueni Hospital	County	Referral		Level 5	0.510546736

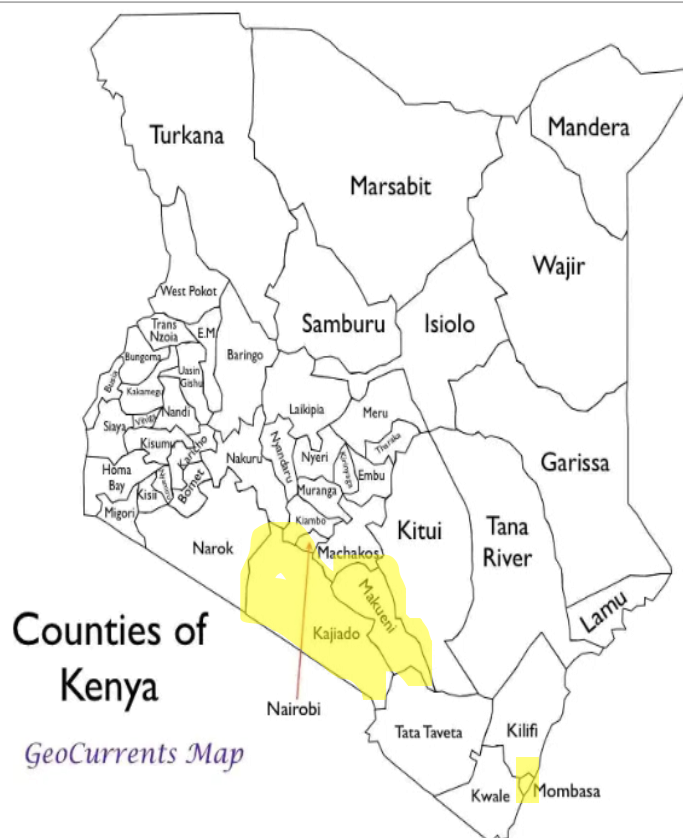
Appendix VI: Distribution of Human Resource

Cadre	Makueni	Kajiado	Mombasa	Total
Consultants	14	0	55	69
Medical Officers	65	16	115	196
Dentist	8	7	24	39
Dental Technologist	7	2	4	13
Ophthalmologists	0	1	0	1
Dentist	8	7	19	34
Gynecologist	0	2	0	2
Physician	0	1	0	1
Pediatrician	0	2	0	2
Surgeon	0	2	0	2
Dental Technologists	7	2	0	9
Public Health Officer	10	4	64	78
Pharmacist	14	14	42	70
Pharm Technologist	19	2	21	42
Lab Technologist	68	13	102	183
Orthopedic technologist	3	0	4	7
Clinical Officer (specialist)	41	11	60	112
Clinical Officer (general)	125	37	108	270
Nursing staff (KRCHN)	238	86	663	987
Nursing Staff (KECHN)	42	80	206	328
Nutritionist	19	6	13	38
Radiographer	16	4	15	35
Physiotherapist	16	9	27	52
Plaster Technicians	9	6	3	18
Occupational therapist	13	4	21	38
Health records & Information Officer	21	3	8	32

Medical Engineering Technologist	6	4	9	19
Medical Engineering Technician	6	0	2	8
Mortuary Attendant	1	1	7	9
Drivers	24	10	21	55
Accountants	13	3	9	25
Administrator	13	6	16	35
Laboratory Technician	43	3	10	56
Community Oral Health Officer	4	0	7	11
Secretarial staff/clerks	12	0	15	27
Attendants/Nurse Aid	398	0	2	400
Cooks	2	0	1	3
Security	72	0	2	74
Registered health Promotion Officer	4	0	1	5
Supply Chain Management Assistant	0	2	0	2
Total	1361	350	1676	3387

Source: Mombasa County Annual Work Plan ,2020-2021; Kajiado County Health Sector Strategic & Investment Plan (KHSSIP and Mombasa County Health Quality Management Policy 2022 – 2027.

Appendix VII: Map of Counties in Kenya



Appendix VIII: NACOSTI APPROVAL

 REPUBLIC OF KENYA	 NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION
Ref No: 412500	Date of Issue: 16/August/2023
RESEARCH LICENSE	
	
This is to Certify that Mr. Robert Mugubi Nalebeson Nalebe of Kenya Methodist University, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Kajiado, Machakos, Makueni, Mombasa on the topic: TOWARDS A DIGITAL HEALTH INFORMATION FRAMEWORK FOR ESSENTIAL MEDICINE SUPPLY CHAIN MANAGEMENT IN PUBLIC HEALTHCARE FACILITIES IN KENYA for the period ending : 16/August/2024.	
License No: NACOSTI/P/23/28760	
412500	
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	

Appendix IX: KeMU Letter to NACOSTI



KENYA METHODIST UNIVERSITY

P. O. Box 267 Meru - 60200, Kenya

Fax: 254-64-30162

Tel: 254-064-30301/31229/30367/31171

Email: deanrd@kernu.ac.ke

DIRECTORATE OF POSTGRADUATE STUDIES

August 10, 2023

Commission Secretary,
National Commission for Science, Technology and
Innovations, P.O. Box 30623-00100 NAIROBI.

Dear Sir/Madam,

RE: ROBERT MUGUBI NALEBE - (REG. NO. HSM-4-0623-1/2018)

This is to confirm that the above-named person is a bona fide student at Kenya Methodist University. in the School of Medicine and Health Sciences, Department of Health System Management undertaking a Doctoral Degree in Health System Management. He is conducting research on; "Towards a Digital Health Information Framework for "essential medicine supply chain" Management in Public Healthcare Facilities in Kenya".

We confirm that his research proposal has been presented and approved by the University.

In this regard, we are requesting your office to issue a research license to enable him to collect data.

Any assistance accorded to him will be appreciated.

Yours sincerely.

Dr. John M.

Muchiri (PhD)

Dean,

Postgraduate

Studies cc: Dean

SMHS

Appendix X: Authorization from the County Government of Kajiado

COUNTY GOVERNMENT OF KAJIADO



DEPARTMENT OF MEDICAL SERVICES & PUBLIC HEALTH
OFFICE OF THE COUNTY DIRECTOR PUBLIC HEALTH & SANITATION
P. O. BOX 31, KAJIADO

REF: CGK/PUBLIC HEALTH/01/VOL.111/075

18TH AUGUST 2023

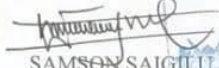
ROBERT MUGUBI NALEBE
KENYA METHODIST UNIVERSITY

RE: RESEARCH AUTHORIZATION

Reference is made on communication from the Dean of students Kenya Methodist University to NACOSTI dated 10th August, 2023 and the Research License from National Commission for Science, Technology and innovation reference No.NACOSTI/P/23/28760 for the period ending , 16th August 2024.

The Department has no objection in you carrying out research on ' Towards a digital Health Information framework for essential medicine supply chain management in Public Health Care facilities in Kajiado County'. You are however required to share findings of your research with this office.

Thank you.


SAMSON SAIGILI

COUNTY DIRECTOR PUBLIC HEALTH
Signature.....
P. O. Box 31 - 01100, KAJIADO

Cc:

CHIEF OFFICER FOR MEDICAL SERVICES

CHIEF OFFICER FOR PUBLIC HEALTH & SANITATION SERVICES

THE COUNTY DIRECTOR MEDICAL SERVICES

THE RESPECTIVE MEDICAL SUPERITENDENTS & FACILITY INCHARGES.

Appendix XI: Authorization from the Government of Makueni County

REPUBLIC OF KENYA



GOVERNMENT OF MAKUENI COUNTY



OFFICE OF DIRECTOR HEALTH SERVICES

PO BOX 89-90300 MAKUENI

Email: county.health@makueni.go.ke, contact@makueni.go.ke, Website: www.makueni.go.ke

REF: GMC/DOH/COH/RES.I (36)

22nd August, 2023

Robert Mugubi Nalebeson
Kenya Methodist University
P.O. Box 267.
Meru.
Email: bobnalebeson@yahoo.com

RE: AUTHORIZATION TO CONDUCT RESEARCH

Reference is made to your letter dated 26th July 2023 requesting for authority to carry out research on 'Towards a Digital Health Information Framework for Essential Medicine Supply Chain Management in Public Healthcare Facilities in Kenya'. We are also in receipt of the research project, introductory letter and research licence number NACOSTI/P/23/28760 dated 16th August 2023.

The Department of Health Services Makueni County is hereby glad and ready to support the research project, therefore authorizes you to conduct the research in the County. You are directed to:-

1. Present your research proposal to the Research and Knowledge Management Coordinator.
2. Ensure all ethical considerations pertaining handling of sensitive health data are practiced during data collection.
3. Collaborate with County Pharmacist and Health Records & Information Coordinator for dissemination of study findings.
4. Submit the final study report to the undersigned office.

Yours,

Dr. Harvey Mulei

Ag. Director Health Planning and Administration
Makueni County



Copy to:

- CECM – Health Services
- CO – Health Services
- Director(s) – Health Services
- County Health Records & Information Management Coordinator
- County Research and Knowledge Management Coordinator
- Med. Supts. – MCRH, Makindu Sch, Kambu Sch, Sultan Hamud Sch, Mtito Andei Sch and Kibwezi Sch.

Appendix XII: Authorization from Coast General Teaching & Referral Hospital



COUNTY GOVERNMENT OF MOMBASA
DEPARTMENT OF HEALTH SERVICES
COAST GENERAL TEACHING & REFERRAL HOSPITAL

Phone : 2314202/5, 2222148, 2225845
Mobile No : 0722207868
Fax : 2220161, Mombasa
Email : ceocgtrh@yahoo.com
When replying please quote :

P O Box 90231 – 80100
Mzizima Street
MOMBASA

Ref. ERC-CGH/MSc/VOL.I

Date: 29th September, 2023

Robert Mugubi Nalebeson Nalebe

**RE: TOWARDS A DIGITAL HEALTH INFORMATION FRAMEWORK FOR
ESSENTIAL MEDICINE SUPPLY CHAIN MANAGEMENT IN PUBLIC HEALTHCARE
FACILITIES IN KENYA**

This is to inform you that the Ethics Review Committee reviewed the proposal you submitted for review in a meeting held on 29th September, 2023.

The study is granted approval for implementation effective from the date of this letter. Please note that authorization to conduct this study will automatically expire on the 29th September, 2024. If you plan to continue with data collection and analysis beyond this date, please submit an application for continuing approval to the ethical Review Committee-Coast General Hospital in appropriate time.

Any unanticipated changes/problem resulting from the implementation of this protocol should be brought to the attention of the ERC-CGH. You are also required to submit any changes to this protocol to the ERC- CGH.

The ERC-CGH looks forward to receiving a summary of the research findings upon completion of the study to be part of the data base to be consulted when processing related researches to minimize duplication.

DR. WANJIRU-KORIR M.N.
SECRETARY ERC-CGH

