

# **The role of digital innovations in the supply chain of essential medicines and vaccines in Ghana**

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**The role of digital innovations in the supply chain of essential medicines and vaccines in Ghana.**

A thesis submitted in partial fulfilment of the requirement for the degree of Master of Science in International Health

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## **Abstract**

**Background and objective:** Availability of essential medicines and vaccines is a critical public health challenge faced most especially in low resource settings like Ghana. Leveraging on the use of digital tools that automate processes and provide visibility has become more important to address supply chain bottlenecks such as shortages, stock-outs, wastage, and medicine quality. This study sought to identify new innovations in health supply chain across SSA and highlight the role they play in improving supply chain efficiency and resilience.

**Method:** A literature review was conducted using the logistics cycle framework as a conceptual model.

**Results:** Twenty (20) distinct digital innovations were found to have been initiated within the last five years in SSA. Mapping the digital innovations to the logistics cycle revealed that a majority of these (52%) were e-LMIS platforms with none being used in product selection. The findings showed that these digital innovations had a significant effect on quantification, procurement, inventory management and distribution at the last mile. However, structural limitations such as access to constant electricity and internet, trained staff and financial resources undermined its impact and long term implementation.

**Conclusion:** To maximize the impact of digital innovations, the structural gaps must be addressed. Digital tools that require little internet, use alternate sources of power and are available on mobile phones can be explored. Adequate training and motivation of users, financial commitment by local stakeholders as well as consistent monitoring and evaluation is needed to facilitate nationwide implementation and sustainability.

**supply chain, digital innovations, essential medicines, vaccines, logistics management information system**

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## **List of Abbreviations**

3PL - Third Party Logistics

AI - Artificial Intelligence

CDC -Centre for Disease Control

CHIM - Centre for Health Information Management

CHO - Community Health Officer

CHW - Community Health Worker

CHPS - Community based Health Planning and Services

CTS - Commodity Tracking System

DHA - District Health Administration

DHD - District Health Director

DHIMS II - Health Information System

DI - Digital Innovation

DRF - Drug Revolving Fund

EML - Essential Medicines List

EPI - Expanded Programme on Immunisation

e-POD - Electronic Proof of Delivery

GEHIP - Ghana Essential Health Interventions Program

GF - Global Fund

GHILMIS - Ghana Health Integrated Logistics Management Information System

GHO - Global Health Observatory

GHS - Ghana Health Service

GHSC-PSM - Global Health Supply Chain - Procurement and Supply Chain

GHWO - Ghana Health Workforce Observatory

GoG - Government of Ghana

GSM - Global System, for Mobile Communication

GSS - Ghana Statistical Service

HIS - Imperial Health Sciences

ICT - Information and Communication Technology

IoT - Internet of Things

IT - Information Technology

LAN - Local Area Network

LMIC - Low and Middle Income Country

mHealth - Mobile Health

MAUL - Medical Access Uganda Limited

MoH - Ministry of Health

NCD - Non Communicable Disease

NHIA - National Health Insurance Authority

NHIS - National Health Insurance Scheme

NQTF - National Quantification Task Force

OTC - Over the Counter

PHC - Primary Health Care

RHD - Regional Health Director

RMS - Regional Medical Stores

SC - Supply Chain

SDG - Sustainable Development Goal

SDP - Service Delivery Point

SSA - Sub-Saharan Africa

STG - Standard Treatment Guidelines

TCMS - Temporary Central Medical Stores

TB - Tuberculosis

UHC - Universal Health Coverage

UNCDF-United Nations Capital Development Fund

UNFPA - United Nations Population Fund

UNICEF - United Nations International Children's Emergency Fund

USAID - United States Agency for International Development

WFP - World Food Program

WHO - World Health Organization

## **Glossary**

Digital Innovations - “Solutions given via digital technologies such as mobile phones, websites, or text messaging) have been proven as an option with immense potential to provide effective, cost-effective, safe, and scalable interventions to enhance health and healthcare” (1).

Inventory Management - In this context, inventory management of health commodities refers to “all activities related to acquisition, controlling, storage and coordination of medicines and other health products in such a way that they are available to save lives”(2).

Logistics - “Logistics activities can be considered as the operational component of supply chain management, including quantification, procurement, inventory management, transportation and fleet management, and data collection and reporting”(3).

Logistics Management Information System - “A logistics management information system (LMIS) is an organized system for collecting, processing, reporting and using health product data gathered across all levels of the health system” (4).

Quantification - “Quantification is the process of estimating the quantity and cost of the products required for a specific health program (or service), and, to ensure an uninterrupted supply for the program, determining when the products should be procured and distributed”(3).

Procurement - “The process of buying goods and services that enable an organisation to operate its supply chain, in a profitable and ethical manner” (5).

Supply Chain Management- “Supply chain management encompasses the planning and management of all activities involved in sourcing and procurement and all logistics management activities. Importantly, it also includes coordination and collaboration with channel partners, which can be suppliers, intermediaries, third party service providers, and customers. Supply chain management includes the logistics activities plus the coordination and collaboration of staff, levels, and functions”(3).

In this study the terms logistics and supply chain are used interchangeably

## **Dedication**

I am thankful first to God, for His grace which allowed me to stay the course of this program. I am also grateful to the KIT Royal Tropical Institute Scholarship fund for giving me this opportunity to train as an International Health professional. The knowledge and skills I have received here will impact thousands of lives in Ghana and beyond.

My sincere gratitude goes to my family and friends back home, for being my strongest support system and encouraging me all the way to the end.

I dedicate this thesis to my mother whose prayers pushed me to pursue a second degree, to my father who believed in me unconditionally and to my fiancée who spared no words in telling me how proud he was of me every day.

They say it takes a village to raise a person and I cannot thank my thesis and academic supervisors enough for the time and support they have given me to be the best version of myself.

To the friends I made during this journey, especially my MIH/NTC class, the memories we shared will never be forgotten. It has been an amazing year learning and growing and I am excited to see what the next chapter holds.

## Introduction

The development of disease prevention and treatment protocols has a long history, dating back to the 18th century. Over time, these protocols have evolved to adapt to the complexities of various diseases, leading to the creation of essential medicines and vaccines. The availability and accessibility of these health products are crucial in advancing a patient's journey along the continuum of care. As a pharmacist, I am deeply committed to improving healthcare outcomes and ensuring the well-being of individuals in society. Through my work as a pharmacist in Northern Ghana visiting health facilities and speaking to health professionals working in remote communities, I have come to recognize the critical importance of access to medicines and vaccines and the transformative potential of digital innovations in revolutionizing healthcare delivery.

Access to affordable and quality medicines is a fundamental human right, yet millions of people worldwide lack access to essential medications. In Ghana, this problem is particularly acute, as the country faces challenges related to healthcare infrastructure, funding, and distribution systems. By researching access to medicine, I aspire to contribute to the identification and implementation of innovative strategies that can bridge the gap between those in need and the life-saving medications they require.

Moreover, lack of access to medicine often results in poor health outcomes, preventable deaths, and increased healthcare costs. By focusing on research in this area, I am driven by a deep desire to empower individuals and communities to lead healthier lives. Digital innovations, such as telemedicine and mobile health applications, have the potential to transcend geographical barriers, enhance patient education, and facilitate timely access to medical advice, treatment, and commodities. By investigating the impact of these digital tools, I hope to provide evidence-based insights that can guide policymakers and stakeholders in Ghana towards implementing sustainable solutions that optimize health outcomes.

Digital innovations have the power to revolutionize healthcare systems, making them more efficient and equitable. In Ghana, where resources are often limited, leveraging digital technologies can help streamline healthcare delivery, reduce inefficiencies, and ensure that no one is left behind. Researching the intersection of access to medicine and digital innovations especially in the public sector will enable me to explore how tele-pharmacy, e-prescriptions, and e-commerce platforms can improve medication accessibility, especially in remote areas where physical pharmacies are scarce.

An effective pharmaceutical supply chain is crucial for ensuring a steady and reliable flow of medications to healthcare facilities and communities. Unfortunately, inadequate infrastructure, poor logistics management, and counterfeit drugs pose significant challenges in Ghana. By investigating the role of digital innovations in optimizing pharmaceutical supply chains, I aim to identify practical solutions that can enhance inventory management, reduce waste, and combat the circulation of counterfeit drugs. Ultimately, this research can contribute to a more robust and secure supply chain, leading to increased availability and affordability of essential medications and vaccines.

This study is divided into seven chapters. Chapter one covers relevant background information on Ghana and its health system, Chapter two describes the problem statement, justification, and research objectives, Chapter three describes the methodology and analytical framework, Chapter four looks at the health supply chain in Ghana, chapter five highlights

the digital innovations in the supply chain management of health commodities in sub-Saharan Africa, Chapter 6 covers the impact of supply chain innovations that have been implemented in Ghana and finally Chapter 7 encompasses the discussion, recommendations and conclusion of the study.

# CHAPTER ONE: BACKGROUND AND COUNTRY PROFILE

## 1.1 General Overview

Ghana is a country in West Africa, on the Gulf of Guinea. It is bordered on the west by Côte d'Ivoire, on the north by Burkina Faso, on the east by Togo, and on the south by the Atlantic Ocean (Figure 1). Ghana has a land size of around 238,540 square kilometres (92,101 square miles), ranking it as the 82nd biggest country in the world (6). Ghana has an estimated population of roughly 30.8 million people, which is unevenly dispersed, with the southern coastal areas, including Greater Accra and Ashanti, being the most densely populated (7). The male to female is 50.7: 49.3 with more than half ranging between 0 - 40 years. The country is divided into sixteen administrative regions, an increase from ten in 2018.



Figure 1 A map of Ghana showing her sixteen (16) administrative regions (8).

In recent years, Ghana has seen increasing urbanization. According to the World Bank (2021), urban areas host around 57% of the population, while rural settlements house the remaining 43% (9). Ghana's average family size varies by area and ethnic group. However, according to the Ghana Statistical Service (GSS) (2021), the country's average household size is predicted to be approximately 3.6 people (7). Although Ghana's labour force participation rate is estimated to be 65.3% among females and 72.4% among males as of 2022, it is worth emphasizing that the informal sector plays an important part in the country's economy, providing jobs for many Ghanaians. Literacy rates vary by sex and locality. For the population 15 years and older, literacy rate in English only is higher for males (84.5%) than females (76.2%) (10).

## 1.2 Ghana's Health System

A few decades ago the prevalent health issues in Ghana were observed to be primarily infectious, maternal, perinatal and nutritional in nature (11). Over the years however this has shifted to encompass chronic diseases that require long term management leading to a double burden of disease (12). In 2019, the top five causes of death in the population according to the Global Health Observatory (GHO) (see Figure 2) included stroke and ischaemic heart diseases (13) which was not the case twenty years ago. The shift in disease profile necessitates that the health system is well equipped and robust to keep up with changes in order to optimise health outcomes.

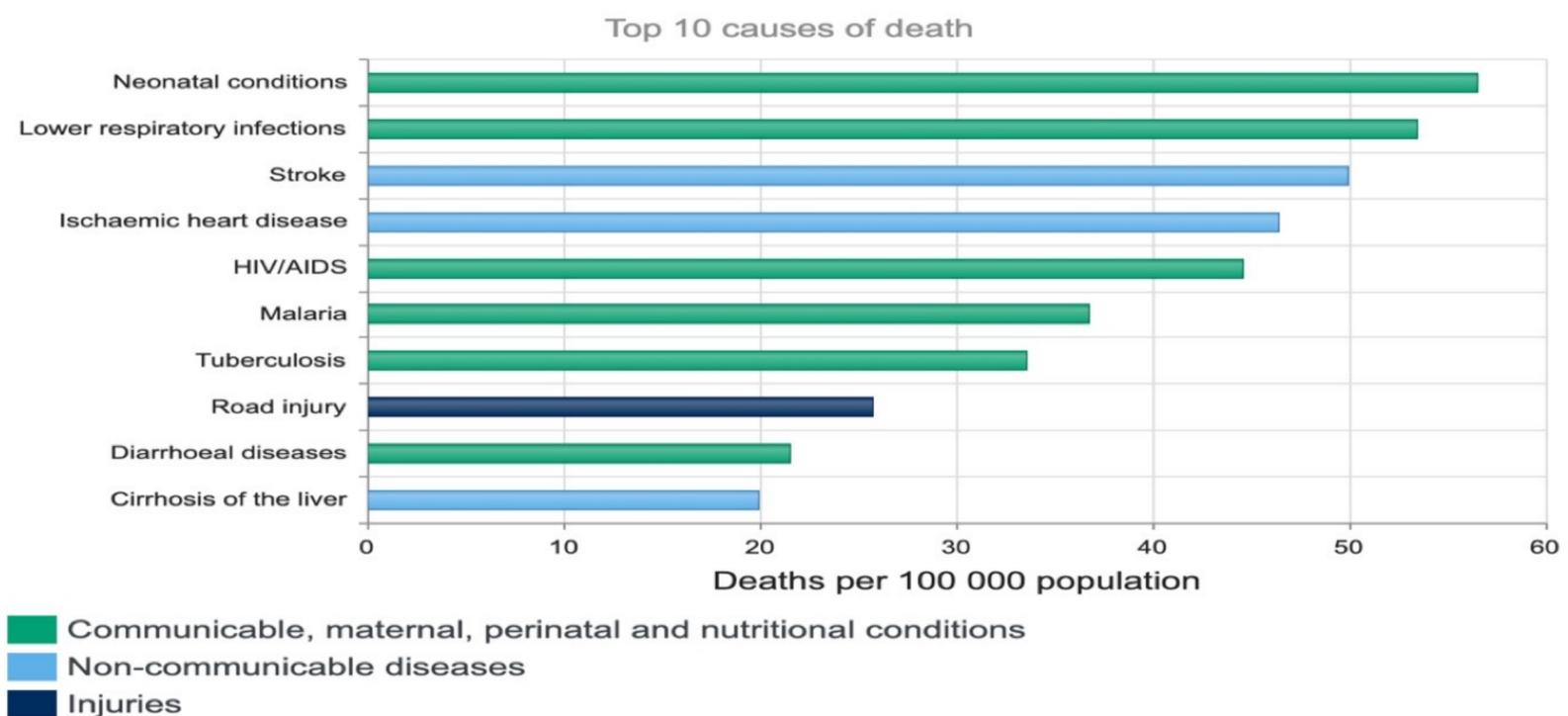


Figure 1 Graph of top 10 causes of death in Ghana, 2019 (13).

Although the figure above paints the picture for the country as a whole, disease trends tend to differ across age, sex, region, and socioeconomic situation. Malaria for instance which is known to be a childhood disease affecting severely children under the age of five, has seen an almost 70% decline in mortality rate over the past ten years, from 184 to 51 in a 100,000 as at 2019 (13). Although these numbers look promising, the majority of cases recorded are higher in rural communities with a prevalence of approximately three times that of urban communities (14) with mortality occurring in the first year of life.

Non communicable Diseases (NCDs) such as stroke and cancer disorders afflict individuals in their reproductive years. However, there are significant demographic differences in Ghanaian and African environments. Musculoskeletal illnesses and neuro-degenerative disorders for example, affect the aged disproportionately (15). Cancer, diabetes, and hypertension all affect younger populations when compared to the worldwide average age of onset (16). In terms of risk and morbidity, several illnesses are gendered. For example, whereas males have a larger incidence of diabetes, women have a higher prevalence of obesity, which is a key risk factor for diabetes (17). Under the next few subheadings, the state of Ghana's health system will be described using the World Health Organisation's (WHO's) health system building blocks model (Figure 3) which speaks to the interwoven functions of the six building blocks with empowered patients and communities as recipients of healthcare.



Figure 3 WHO health system building blocks (18).

### 1.2.1 Service Delivery

Positive progress towards the health-related Sustainable Development Goals (SDGs), which include reducing child mortality, maternal mortality, and the burden of HIV/AIDS, tuberculosis (TB), and malaria by 2030 requires improvement of healthcare services (19). Ghana's health system has been based on the basic healthcare model for many years, with a network of health posts and dispensaries at the most basic level, linked to health centres, polyclinics, and hospitals. Primary health care (PHC) in Ghana has been structured as a three-tiered system at the district level: Levels A, B, and C. These three tiers function in tandem to deliver acceptable quality primary health care services, backed up by a referral system (20).

As illustrated in (Figure 4), the district hospital and the district health administration (DHA) constitutes the apex (Level C). This level of management collaborates with the local government and decentralized agencies to plan, supervise, monitor, and coordinate health care delivery in the district. The district hospital provides the first level of comprehensive health care, which is administered by all health worker groups. The sub-district (Level B)

develops, monitors, and oversees the delivery of community-based services within the sub-district. This level is also in charge of directly supervising the activities of community health officers (CHOs). At the community level (level A) and the heart of the PHC programme is the Community-based Health Planning and Services (CHPS) which is national strategy which harnesses community engagement and participation in order to improve health service delivery (20).

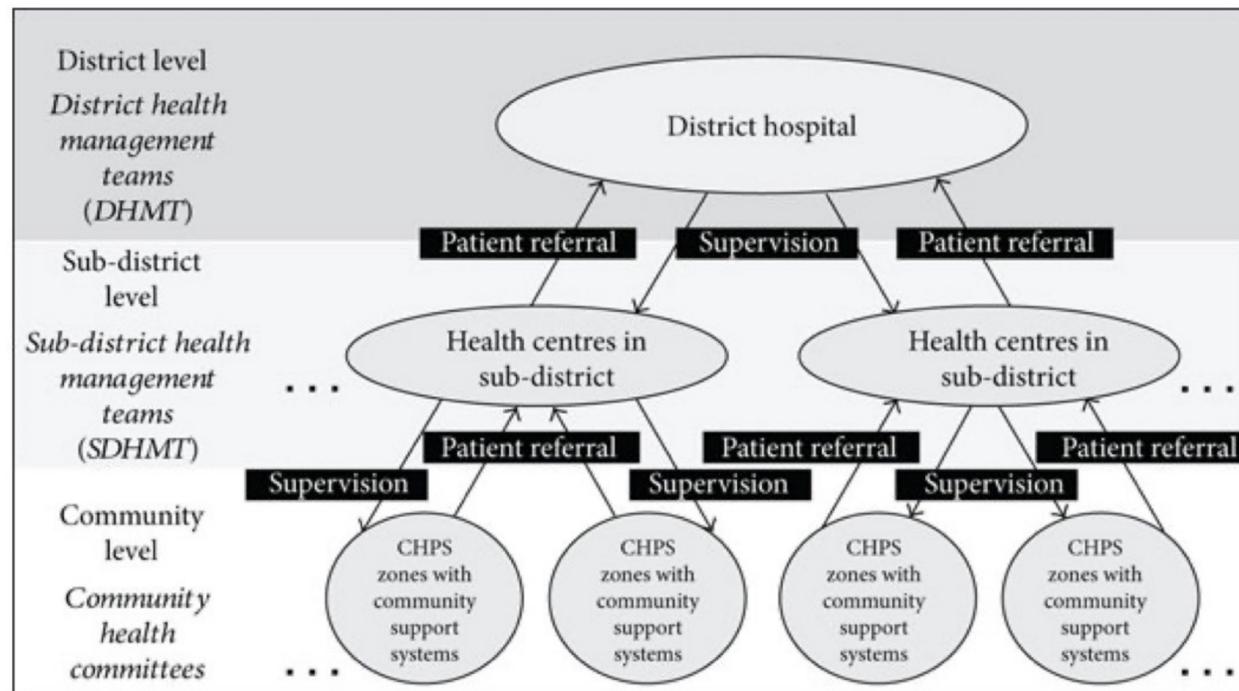


Figure 4 Structure of health service delivery in Ghana (21).

In 2010, the Ghana Health Service (GHS) launched the Ghana Essential Health Interventions Program (GEHIP) which was piloted in four districts in the Upper East Region (22). The aim of this initiative was to accelerate the adoption of the CHPS initiative and expand the scope of services provided. The success of this pilot led to the birth of the CHPS+ program in 2016 which combined the strengths of the existing CHPS initiative with the GEHIP strategies to strengthen the health system (23). As at July 2020, functional CHPS zones have been increased to six thousand, one hundred and sixty six (6,166), providing both clinical and public health services across the country (24).

### 1.2.2 Human Resources

As a country, Ghana's health workforce is well below global thresholds based on the following criteria: a) a density of essential healthcare professionals below the global median (i.e., 49 per 10 000 population); and b) a universal health coverage service coverage index below 55 (25). In the latest report by the Ghana Health Workforce Observatory (GHWO), the distribution of health workers varies substantially across and within regions. The majority of health professionals are located in the southern part of the country. The Greater Accra region is home to many highly qualified professionals, such as physicians and specialist professionals. Less than 15% of doctors work at district hospitals, compared to more than 45% in the four teaching hospitals across the country. The possibility of improving service delivery in the rural regions where more than 65% of the population lives is further diminished by the fact that the majority of qualified health workers are drawn to the southern region of the country where social amenities and living conditions are better. Most of the

highly qualified medical personnel work for the government. However, 10% of Ghana's health personnel is employed by the private sector, mostly in urban communities (26).

### **1.2.3 Health Information**

Ghana's health information system is a comprehensive framework for gathering, managing, analysing, and disseminating health-related data and information throughout the country. Health information data flow typically follows the health system's structure. Facilities and CHPSs report to subdistricts, which gather data. Both combined data and individual reports from facilities are transferred from the sub-districts to the district level, where they are collated once more. Some data is delivered directly to the national level from the districts, while others are routed through the regions. The Centre for Health Information Management (CHIM) is in charge of data collecting and management within the GHS at the national level. Ghana presently employs the District Health Information Management System (DHIMS II) as a fundamental component of its national health information system, although it confronts significant challenges which include fragmentation, lack of human resources, duplicate reporting and poor maintenance of information technology (IT) infrastructure (27).

### **1.2.4 Medicines and Technologies**

Access to medical commodities encompasses availability, affordability, accessibility, and acceptability. Although there is not enough data on access to pharmaceuticals in the country, the data shows that medicine procurement and delivery in the public sector has been quite problematic. These two activities have been designated to the Regional Medical stores of each region. Unfortunately, medicines are not bought in sufficient numbers; they are inadequately distributed, run out of stock, or expire as a result of poor inventory management processes (15). The rising burden of chronic conditions has increased healthcare expenditure, particularly related to medicines for individuals, and the National Health Insurance Authority (NHIA) (28). In Ghana, research has pointed to the issue of dual use of orthodox and traditional medicines, emphasising the need to conduct a comprehensive cost analysis for traditional medicines. (29). A significant proportion of the Ghanaian population relies on herbal treatments as their initial recourse or as a supplementary treatment alongside pharmaceutical drugs for various ailments, including infections, reproductive and sexual health issues, as well as chronic disorders (30).

### **1.2.5 Health Financing and Governance**

Ghana's National Health Insurance Scheme (NHIS) which was introduced in 2003, marked a transition from a system reliant on user fees. This national-level, universal health insurance program was implemented with the aim of enhancing healthcare accessibility and attaining universal health coverage (31). NHIS implements a policy that exempts individuals from paying out-of-pocket premiums, with the aim of guaranteeing healthcare accessibility for those who are poor and susceptible to health risks. The categories that are exempt from certain obligations or requirements encompass individuals who are under the age of 18, those who are 70 years of age or more, individuals who receive pensions, individuals who are classified as poor, and individuals who are pregnant(32). The financing of the NHIS is achieved by a hybrid structure that encompasses many sources, including revenue mobilization, pay roll deductions, government funding, and payment of premiums by individuals who meet a predefined criterion. The policy requires the implementation of a pre-

established benefits package that encompasses about 95% of the illness burden in Ghana (33) which includes various healthcare services such as in-patient hospital care, out-patient treatment as well as emergency services. NHIS beneficiaries have the opportunity to avail healthcare services all approved levels of health service delivery. The present enrolment rate in the program is expected to be barely one third of the population, mostly owing to financial obstacles (34). Even so, the current extent of coverage is insufficient in meeting the national objective of providing healthcare access to the whole population within five years of adopting the NHIS, as well as the global aim of attaining Universal Health Coverage (UHC). The system's efficacy is also undermined by persistent problems related to insufficient financial resources and limitations in liquidity, which have had a negative influence on the reliability and trustworthiness of the public health supply chain (34).

# CHAPTER TWO: PROBLEM STATEMENT, JUSTIFICATION AND RESEARCH OBJECTIVES

## 2.1 Problem statement and justification

The World Health Organisation (WHO) defines access to medicines as the percentage of the population that can readily obtain a minimum list of twenty essential medicines within a one-hour walking distance from their homes (35). These medications should be continuously available and affordable at health facilities or medicines outlets. Unfortunately, despite progress made by countries throughout the world, access to medicines remains a major public health concern. In fact, over two billion people globally lack access to basic essential medicines, with the majority residing in low and middle-income countries (LMICs) (36). This global health problem leads to critical gaps in healthcare delivery.

Globally, the availability of medicines is not always constant across and within countries. The World Health Statistics reports on the proportion of health facilities with a core set of relevant essential medicines available and affordable on a sustainable basis between 2012 and 2019 to be between 7.7% and 69.2% with Ghana having a score of 12.5% (37). Studies conducted in various countries across sub-Saharan Africa (SSA) over the last 5 years have also shown varying levels of availability (38–44). Similarly, concerning statistics emerge in the context of vaccines. In SSA countries, an alarming 38% reported annual stockouts of vaccines, with 43% of those stockouts affecting the diphtheria, pertussis, and tetanus (DPT) vaccine, and 31% impacting the BCG vaccine (45). A deep dive into the root causes showed that in 80% of cases, internal national factors were the most dominant. More precisely, government financing delays accounted for 39% of stockouts, procurement delays accounted for 23%, while 18% could be attributed to inadequate inventory management process in country (45).

A study conducted in eleven selected LMICs revealed that 20% to 60% of health spending was allocated to medicines (46). Additionally, up to 90% of the populace in low-income countries like Ghana, pay out-of-pocket for their medications (47). The double financial burden on both governments and patients therefore continues to grow with respect to increasing burden of disease. In Ghana, the government has the singular mandate aimed at ensuring a sufficient supply of medications necessary for the treatment of disorders affecting the majority of the country's population. To do this, the country produced a nationwide list of essential medicines that inform all health service providers' decisions regarding the selection and availability of the most essential medications at all levels of the healthcare system at all times at a reasonable cost (48).

Efforts at providing medicines that are available and affordable has however been a hurdle. A study done in Ghana showed that less than 50% of the health facilities sampled had stock of the recommended first line medicines to treat malaria (49). Along similar lines, a study which looked at availability of twenty essential childhood cancer medications and eight non cancer medications in Ghana, reported a mean availability of 27 and 38% respectively (43). A study in the Ashanti Region also reports figures between 26.4 to 52%, (50) which were well below WHO recommended targets of 80%.

In the area of vaccines, rural communities are disproportionately affected in terms of vaccination access due to low storage capacity and the difficulties of travelling by road to

receive vaccines at the district cold room. When childhood vaccination schedules are not adhered to, it not only endangers life of the child but also increases healthcare costs of the state when the child falls ill. Research done in Northern Ghana in 2017 and 2018 indicated that the annual cost accrued attributable to pneumococcal conjugate vaccine (PCV) and meningitis patients was \$5,230,035 (51). Despite the fact that progress towards improving vaccination coverage has been positive in Ghana (52), key supply chain performance indicators, such as stockouts, waste, and cold chain storage capacity, still need to be improved.

The Ministry of Health (MoH) and GHS health commodities supply chain is multi-tiered, with the Central Medical Stores (CMS) and National Expanded Program on Immunisation (EPI) serving as key storage and delivery hubs. Regional Health Directors (RHDs) oversee regional supply distribution which provide critical pharmaceuticals and vaccines to District Health Directors (DHDs) who in turn supervise use in healthcare institutions.

Notwithstanding this framework, the public health supply chain encounters obstacles, including inadequate infrastructure, particularly in hard to reach communities, leading to insufficient storage, delivery difficulties, and little to no cold chain facilities (53). The absence of accessible medicine gives rise to a series of adverse consequences, leading to various forms of distress and hardship. From the absence of relief for a child's severe earache, maternal fatalities resulting from excessive bleeding during childbirth, to preventable or treatable illnesses resulting in fatalities.

To achieve Universal Health Coverage (UHC) and reduce morbidity and mortality associated with preventable and treatable diseases, digital innovations have emerged as potential solutions to address these challenges by revolutionizing supply chain management to ensure that medicines are available and affordable in a way that complements other parts of the health ecosystem. In 2019, the government Ghana (GoG), led by the current vice president emphasised the governments' commitment to digitize multiple processes in the country including the private and public pharmaceutical supply chain (54).

Digital innovations (DIs; i.e., solutions given via digital technologies such as mobile phones, websites, or text messaging) have been proven as an option with immense potential to provide or enhance interventions in healthcare in a manner that is both efficient and cost saving (1). However, there is a paucity of data on the role and impact of the DIs implemented with respect to supply chain of health commodities in Ghana so far. This paper seeks to take a critical look at how digital innovations are being used to improve supply chain of medicines and vaccines. This is important to do because it allows policy makers and health system managers to take meaningful decisions as to whether these interventions need modifications or may need to be scrapped entirely. This will also allow recommendations to be made to the MoH and GHS on best practices that promote equitable and sustainable supply of health commodities.

## **2.2 Research Questions (RQ)**

RQ1: What digital innovations are being deployed in health commodity supply chain management in the last 5 years?

RQ2: How do these digital innovations have on supply chain efficiency?

## **2.3 General Objective**

To highlight the role of digital innovations on access to essential medicines and vaccines in Ghana in order to propose recommendations to the MoH and GHS on improving public health supply chain.

### **2.3.1 Objectives**

- a. To describe Ghana's public health commodity supply chain system.
- b. To identify digital innovations that have been deployed in the supply chain of essential medicines and vaccines in Sub Saharan Africa.
- c. To discuss the impact of current digital innovations in improving supply chain of essential medicines and vaccines in Ghana.
- d. To provide recommendations on opportunities for implementing similar digital innovations in Ghana's context to improve supply chain of health commodities.

## CHAPTER THREE: METHODOLOGY

To answer the objectives of this research, a literature review was conducted systematically, utilizing peer reviewed articles, grey literature from the website of relevant organisations as well as books.

### 3.1 Search strategy and inclusion criteria

To conduct a comprehensive literature review on the role of digital innovations in the supply chain of essential medicines and vaccines, a systematic search strategy was conducted between March and July 2022. Peer review literature was found using reference libraries such as PubMed, Vrije Universiteit (VU) library, Google Scholar. Grey literature in the form of national reports, factsheets and policy documents were obtained from websites of organizations such as the WHO, MOH, GHS, United States Agency for International Development (USAID) deliver and GAVI. Screening of titles and abstracts of all studies retrieved was done to ensure that they met the inclusion criteria which will be described below.

Table 1: Search Table and Keywords

	Type of study	Sources	
	Published peer reviewed papers	Google Scholar, PubMed, VU Library	
	Reports and grey literature	Websites of USAID, GHSC-PSM, MOH and other relevant stakeholders	
<b>AND</b>			
	Category	Search terms	Context
<b>OR</b>	Serving customers, Quantification, Forecasting, Procurement, Inventory Management, Storage, Distribution, Quality Monitoring, Transportation	e-health, m-health, digital health solutions, digital innovations, emerging technology, health supply chain, public health supply chain, health commodity supply chain, innovative tools, pharmaceutical supply chain, health products logistics, digitization, mobile applications, internet applications, electronic supply chain systems, vaccine supply chain, immunization supply chain, donor funded commodities, essential medicines list, supply chain innovations, digital agenda, supply chain efficiency, smart supply chain	Ghana, Sub Saharan Africa, Low- & Middle-Income countries

The search for peer reviewed journals was structured by identifying key concepts, including digital innovation, supply chain, essential medicines, and vaccines. For each concept, I

compiled a list of synonyms and related terms. These terms included “health logistics, access to medicine, access to vaccines, health supply chain, distribution, digital interventions among others. (Refer to Table 1). The search terms were combined using Boolean operators (AND, OR) to ensure a comprehensive retrieval of relevant articles. The "AND" operator was used to link terms within the same concept, while the "OR" operator was employed to include synonyms and related terms within each concept.

For grey literature I searched the websites of supply chain related stakeholders and digital health repositories. I also used the search terms compiled to find policy documents and reports. Throughout the literature review process, the search terms were iteratively adjusted and refined based on the initial search results. The reference lists of relevant articles were also examined to identify additional sources to retrieve as many relevant articles related to the research topic.

### **3.2 Scope of study and Inclusion/exclusion criteria**

A digital innovation is defined by the WHO as “ a discrete functionality of digital technology that is applied to achieve health objectives and is implemented within digital health applications and Information and Communications Technology (ICT) systems, including communication channels such as text messages” (55).

For the purpose of this study digital innovations will encompass

- Mobile Health (mHealth) initiatives
- Software databases
- Innovative solutions that rely on technology in one way or another

In order to narrow down the literature to be reviewed, abstracts of peer review documents were read to determine whether they met one of these 3 inclusion/exclusion criteria a) literature must have been published in the last 5 years b) literature must be in English c) DIs discussed must be apply to the supply chain of medicines and vaccines

### **3.3 Conceptual Framework**

The framework that was used in to understand the role of digital innovations in supply chain was the Logistics Cycle framework as depicted in (Figure 5) (3). The Logistics Cycle Framework, developed over the years by logisticians, is a comprehensive model used to analyse and improve the efficiency of supply chain systems. This framework provides a structured approach to understanding and managing the different stages of the supply chain, from procurement to distribution, with the ultimate goal of ensuring the availability of essential commodities, such as medicines and vaccines, to the end-users

The Logistics Cycle Framework enables the analysis of supply chain efficiency by assessing the performance of each stage in the logistics cycle and identifying areas of improvement. It allows for the measurement of key performance indicators at various stages, such as lead time, order fulfilment, and inventory turnover. By comparing actual performance against predefined benchmarks or targets, inefficiencies and gaps in the supply chain can be identified and addressed.

Additionally, the framework facilitates the identification of critical control points and potential interventions for enhancing efficiency. By systematically analysing each phase, the

framework enables evidence-based decision-making and the implementation of targeted interventions to enhance overall supply chain efficiency.

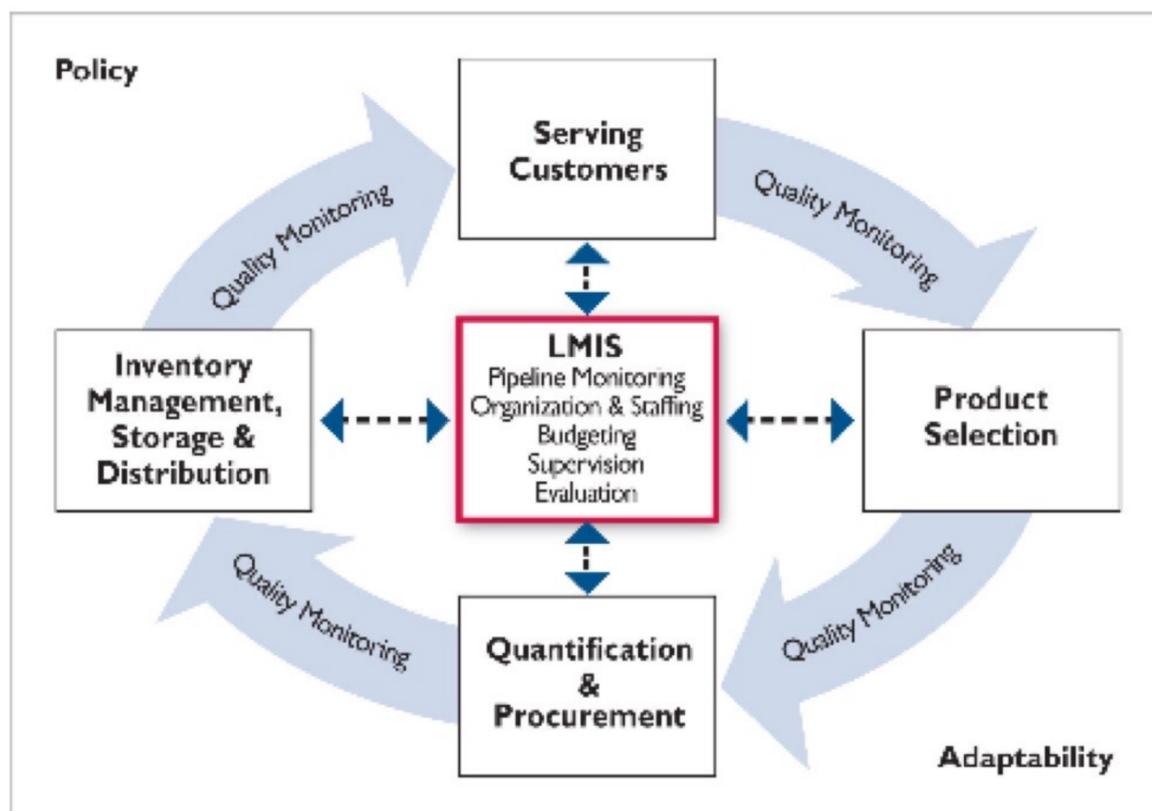


Figure 5 The Logistics Cycle Framework (3)

## **CHAPTER FOUR: GHANA'S HEALTH COMMODITY SUPPLY CHAIN**

This section presents an overview of the existing supply chain structure in Ghana and aims to offer a comprehensive understanding of the many participants involved in this intricate system. The selected conceptual framework serves as a guiding tool for this analysis.

### **4.1 Serving Customers**

The trend of rational prescription and use of medicines in Ghana has improved drastically. In 2017, the MoH reported that although there was no dedicated system or authority for monitoring rational medicine use, about 43.3% of prescriptions included one or more antibiotic. Also, prescriptions containing one or more injection have reduced from 50% to 13.3% (56). The results of another survey also pointed out that out of all prescriptions from the public sector, 87.5% were issued following guidelines in the Essential Medicines List (EML) (57). Medication advertisement and promotion policies are regulated to ensure that medicine advertisement and promotion meet high professional standards and comply with the appropriate laws. Whereas public education on topics around lifestyle modifications that prevent disease and promote health, as well as first aid, and appropriate alternative complementary therapy is allowed on all available media options, advertising and promotion of prescription-only medicines is prohibited (58).

### **4.2 Product selection**

National drug selection is critical because it influences the availability, affordability, accessibility and procurement of life saving medicines (59). To ensure the alignment of protocols and the incorporation of current public health trends and evidence pertaining to the selection and utilisation of medications in disease management, periodic evidence-based evaluation of existing national Standard Treatment Guidelines (STG) and EML is necessary. The most recent edition of these guidelines in Ghana were released in October 2017 (60). The 2017 recommendations incorporated an additional 64 conditions, introduced 153 more treatments, and omitted 56 medications from the 2010 EML. The care categories of Level 'A' and 'M' were modified to correspond with Ghana's basic healthcare and community mobilization activities. (61).

### **4.3 Quantification and Procurement**

The management of procurement for essential medicines is overseen by the Procurement and Supplies Directorate. The information that informs procurement decisions is derived from the annual estimation and forecasting exercise conducted by the National Quantification Task Force (NQTF). The methodology relies on the utilisation of data provided by both Regional Medical Stores (RMSs) and health facilities. Once a decision has been reached, the procurement process adheres to the standards outlined in the Public Procurement Act (62). The process involves quantification by NQTF, cost estimation and selection of procurement method, tendering, contract signing and finally supply planning and monitoring.

A number of bilateral and multinational bodies acquire program items sponsored by external contributors and this follows similar steps as described above. The Global Fund (GF),

USAID, the United Nations International Children's Emergency Fund (UNICEF), the United Nations Population Fund (UNFPA), and the World Food Programme (WFP) are among these. In addition to the procurement role, UNICEF has its own storage, distribution, and reporting system. (62). The allocation of procurement tasks is divided across the system. The procurement of some pharmaceuticals, such as antiretroviral medications, antimalarials, oxytocin, snake antivenom and anti-rabies vaccines is predominantly conducted through centralised channels. At present, the responsibility of acquiring essential health commodities and medical consumables lies with the RMSs, although programme commodities are still acquired through donations or centralised procurement by the Ministry of Health (MoH). (34).

#### **4.4 Inventory management, Storage and Distribution**

This particular phase of the supply chain cycle is also observed across several hierarchical levels. At the national level, two primary central-level warehouses exist. The Imperial Health Sciences (IHS) is a privately-owned pharmaceutical-grade warehouse which serves as a storage facility for supplies provided by the Global Fund and the USAID. The Temporary Medical Stores (TCMS) is responsible for the storage and management of supplies acquired from many donor organisations, as well as the MoH and the GHS. Both warehouses collectively provide services to a total of 14 institutions. These institutions consist of ten RMSs, which act as distribution centres for medical supplies around the nation, and four teaching hospitals that directly cater to patients' healthcare needs. The distribution of commodities from the IHS warehouse to RMSs is facilitated by third-party logistics (3PL) providers that have been hired by the GF and USAID via the Global Health Supply Chain Programme - Procurement and Supply Management (GHSC-PSM). The frequency of these delivery is set at six times per year, however there have been occasional delays in adhering to the established timetable (34). The health supplies are transported straight from the RMSs to the Service Delivery Points (SDPs). In recent years, there has been an improvement in the efficiency of last-mile distribution. This involves the regular delivery of goods on a monthly or biweekly basis. The majority of RMSs retain records of delivery for outbound items as a means of reconciling the quantity of things delivered. The process of tracking outbound shipments is now conducted by manual means, which introduces the potential for errors. As a result, the rates of on-time delivery have been seen to vary between 59% and 88% (34). At the sub-district level, DHAs assume a significant responsibility in overseeing multiple supply chain functions for smaller healthcare facilities, particularly in rural and underserved communities.

#### **4.5 Core of the logistics system**

According to Reign et al (63) pharmaceutical supply chains are only as good as their organisational structure, leadership and human resource. From reports by the MoH in the 2021 - 2025 Health Commodity Chain Master Plan (64), I summarize key findings related to the current state of organisation, staffing, supervision, information management, quality, and budgeting of the health supply chain.

##### **4.5.1 Organisation, staffing and supervision**

At the national, district, and health facility levels, the Supply Chain (SC) workforce comprises logisticians, pharmacists, warehouse staff, and SC managers. In the broader

framework of Ghana's public health system, characterised by insufficient and uneven human resources, it is especially SC functions that are understaffed and, in many cases, incorrectly staffed. Vacancies in SC posts abound across the system (for example, 24% of SC positions at district hospitals and 44% of SC positions at GHS headquarters are unfilled (64). Capacity-building activities in SC are largely focused on the regional level. In the previous year, about 23% of CHPS and clinics, and 26% of Health Centres and polyclinics, got no SC capacity development help. Mechanisms such as supporting supervision are in place, with 80% of institutions reporting on supportive supervision on a regular basis throughout the system (64).

#### **4.5.2 Budgeting**

The allocation and administration of finances in logistics have a significant influence on several parts of the logistics cycle. These include the procurement capacity for products, the availability of storage space, the management of vehicles, and the number of staff involved in logistical operations. Budgets are developed yearly and revised regularly at the MoH level; SC expenses are openly noted; and the government contributes to these expenditures. Most facilities at all levels indicate that the majority or all of their SC expenses were paid by government and/or facility income and cost recovery in 2019. Nevertheless, a number of hospitals documented inadequate budgets in the preceding year pertaining to the procurement of healthcare supplies. Health insurance is accepted at virtually all SDPs; nevertheless, SDPs regularly complain that insurance reimbursements are insufficient to cover the price of health commodities and are "rarely or never" received on time, particularly for specific medications. Facilities subsidize operations such as salary and employee incentives with internally produced cash meant for Drug Revolving Fund (DRF) (64).

#### **4.5.3 Quality of Medicines in the Supply Chain**

The quality of medicines on the market, both internationally sourced and locally manufactured is regulated by the Ghana Food and Drugs Authority (FDA). International imports alone account for 70% of medicines on the Ghanaian market with majority from India and China (65). In light of this, port inspections were increased by 36% to prevent entry of substandard medication into the country. Further information in a report published by the FDA in the past year, reported on an increase in post market surveillance of medicines that were already in country. In 2022, the number of non-compliant products recorded during surveillance operations was 90,093, a 329.6% increase over the previous year (66). For most people resident in Ghana, the private sector which spans from licensed pharmacies to chemical shops and self-made drug peddlers at bus stops, serves as the most convenient way of purchasing medicines. This may be attributed to the inconsistent medicine availability in public health facilities (67), resulting in high out of pocket fees(68). Since the private sector accounts for a large proportion of medicine consumption, the FDA has also increased efforts to partner with international organisations (e.g., Centre for Disease Control (CDC)/ Taskforce for Global Health) with the aim of securing funding to aid in strengthening regulatory systems in 2023(66).

## **CHAPTER FIVE: RESULTS**

### **5.1 Digital Innovations in Sub Saharan Africa**

An extensive search of the literature produced a total of 20 digital innovations (details in Table 2) used in managing supply chain of medicines and vaccines across Sub Saharan Africa (SSA) within a five year period (2017 - 2022) and will be discussed using the conceptual framework. In the health supply chain, the overall mandate is to ensure that the right products, in the right quality and the right quantity are available in the right amount and at time, at the right cost to the patients (3). However, human delays and bureaucratic systems make this a hard goal to achieve at all times. Digital innovations have been implemented in some countries which address varied bottlenecks of the system and improve access to health products

#### **5.1.1 Serving customers**

One of the most complex and challenging problems facing Federal Ministry of Health in Ethiopia is securing the integrity and safety of its pharmaceutical commodities supply chain. These problems include counterfeit, fake and illegal drugs, thefts, and diversion as well as timey product recall. The Electronic Regulatory Information System (eRIS) launched in 2017 has enabled the Ethiopian Food and Drugs Administration (EFDA) to track medicines from licensing to quality assurance, ensuring an unbroken chain of information. It is designed in 3 tiers, to cover the importation, licencing and registration of medicines and health products. This would be achieved through a three phase implementation roadmap proposed by the (EFDA). Additionally, the EFDA has also launched the use of unique barcodes that allows the tracking of products throughout the supply chain while providing end to end visibility(69). In Nigeria, the track and trace software was used a little differently. During the peak of the COVID 19 pandemic, it became extremely important to vouch for the potency of vaccines as they moved down the supply chain. Using the Internet of things (IoT) remote sensors with a Bluetooth GPS component was developed into a portable device which sent SMS alerts when temperature limits were breached (70). These DIs ensure that medicines and vaccines reaching the end user are safe and of good quality.

#### **5.1.2 Product Selection**

The literature provided no DIs that directly affected this stage of the logistics cycle.

#### **5.1.3 Quantification and Procurement**

Over the years, countries funded by international non-governmental bodies such as USAID utilized tools such as PipeLine for supply planning and Quantimed for forecasting of health commodities (71). In 2020, a new digital tool funded by USAID and under the coordination of GHSC-PSM was launched.

## The QAT Solution

Functionality	PipeLine	Quantimed	QAT
Ability to work offline	✓	✓	✓
Available in multiple languages	✓	✓	English, French, Spanish, Portuguese; with ability to add languages
Integration with external systems	✗	Can import into PipeLine	✓ See QAT Data Flow Ecosystem
Cloud-based	✗	✗	✓
Role-based access for data security	✗	✗	✓
Standardized master data	✗	✗	Can individually customize at the program-level
Forecasting & Supply Planning in one tool	✗	✗	Seamless integration between modules
Data analytics and visualization	Basic	Basic	Enhanced and user friendly
<b>Supply Planning</b>			
Supply planning logic	Basic	✗	Enhanced with ability to add batch & expiry data, avoid negative stock, & auto-calculate MAX parameter
“What if” scenario planning	✗	✗	✓
In-tool Supply Plan Review	✗	✗	✓
<b>Forecasting</b>			
Consumption Forecasts	✗	Basic	Multiple data adjustment methods & advanced extrapolation techniques
Demographic, Morbidity, & Services Forecasts	✗	Basic	Flexibility to design own forecast with advanced modeling/transitions or use QAT's standard templates
Ability to compare forecast methods	✗	✗	✓

Figure 6 Comparison of the new QAT tool to its predecessors (72).

The Quantification Analytics Tool (QAT) improves upon pre-existing tools, namely PipeLine and Quantimed and is designed to facilitate country-led forecasting and supply planning. This new tool offers an improved user interface and enhanced usability, along with advanced analytical capabilities and automated data exchange. As a result, program managers can efficiently create multiple forecasts for the purpose of comparison and selection. Additionally, they can improve the efficiency of purchasing and shipping schedules for commodities, effectively monitor the inventory level of supplies, and exchange data with external platforms and important partners as highlighted in Figure 6 (72,73).

Another DI being used in supply chain is the Ghana Electronic Procurement System (GHANEPS) rolled out in 2020 to improve procurement processes and ensure safe access to medicines via the internet. The implementation of a comparable platform in Rwanda has been associated with heightened efficiency, decreased transactional expenses, less corruption, and improved oversight and supervision of the public procurement process. (74). The Public Procurement Authority (PPA) is tasked with the responsibility of standardising the public procurement process in Ghana at a national level. Its primary objective is to promote the effective, transparent, equitable, and cost-effective use of financial resources. The mission of the PPA, however, encompasses all public agencies, rather than being specific to the MoH, and the practises employed are not necessarily customised to the distinct nature of health commodity procurement. (75).

### 5.1.4 Inventory Management, Storage and Distribution

Various means of distribution may be observed within the nodes of the supply chain. These modes include the use of government-owned trucks, engagement with 3PL partners, and

instances where downstream facilities personally visit warehouses to retrieve items. Although more options may mean distribution limitations are addressed, an overreliance on improvised distribution methods also brings chaos into the system, resulting in heightened administrative responsibilities and reduced predictability. The delay in getting health commodities to SDPs whether due to bad roads or absence of logistics by lower level facilities to travel was a real problem for the SC in Ghana(76). The GoG signed a contract with Artificial Intelligence (AI) enhanced medical drone delivery company, Zipline (77) in order to outsource the delivery of emergency commodities that could not be delayed. In addition to providing a solution for distribution, Zipline provided additional services of an inventory management software and a state of the art warehouse. Products received from the RMS were tracked using barcodes, ensuring accountability and traceability. However, this traceability was not a reflection of the whole system and allowed only the tracking of a small percentage of public health commodities (78).

Chemonics in 2018, designed a transport management tool known as TransIT. The TransIT system utilises a cloud-based architecture, allowing users to access transportation information at any time and from any location. This approach effectively reduces the expenses associated with infrastructure, system setup, and ongoing maintenance. The technology consolidates comprehensive data throughout the whole process, starting from distribution planning and continuing until the final delivery to the receiver. This data encompasses performance metrics, location information, and cost analysis, allowing for efficient and timely operations inside the in-country distribution network. TransIT facilitates the provision of continuous information, therefore establishing a real-time evaluation system that empowers distribution managers to enhance their monitoring of shipments, make informed decisions based on data analysis, optimise the allocation of distribution resources and assets, and utilise previous data to identify patterns and trends over a period of time. A supplementary Android application, known as the Electronic Proof of Delivery (ePOD) app, was developed with the purpose of enabling truck drivers to input data on shipments and the current state of their delivery. The ePOD application further enables drivers to submit photographs of the ePOD, its receiver, and the cargo at a designated delivery site, accompanied by a timestamp indicating the time and place (79).

The S+ platform in Uganda is an innovative software management system that boasts of 3 main strengths; a) alternative source of power in areas that have erratic power supply, b) self-generating Wi-Fi from local servers and c) real time data transmission. This has made it the inventory management tool of choice in resource constrained areas. This tool was launched as a pilot across 26 facilities. No further documents report on a larger scale implementation or uptake(80,81).

Further findings in Ghana also highlighted the Ghana National Electronic Pharmacy Portal (GNEPP). The E-Pharmacy platform commissioned by the Pharmacy Council of Ghana was rolled out to regulate internet-based pharmacy services to ensure safe access to medicines. It also seeks to leverage on digital technology to match patients to approved pharmacy service providers across the country (82). The DI involves a web-based app that allows patients to upload prescriptions after which they can view service providers within their vicinity that can provide those medications. It eliminates the inconvenience of having to travel from place to place in search for a particular medicine. The impact of this DI is yet to be assessed since it is still in the early stages of roll out. Another group of DIs that focuses on serving customers are the Medkit platform from Kenya and the Pharmarun platform that exists also as a mobile application in Nigeria(83,84). These DIs serve the private sector and aim to facilitate the

efficient movement of products from suppliers to retailers, while ensuring low pricing for consumers which benefits all participants in the supply chain. Both solutions provide very efficient processes that are data-driven, allowing for intelligent reordering, restocking, and immediate supplier reimbursement when retail products are sold. Using Artificial Intelligence (AI) algorithms, the platforms can track drug usage and compliance of patients registered on the application.

### **5.1.5 Logistics Management Information System**

Although patients are the end users of the products in the supply chain, customers at each level are crucial to the proper functioning of the entire system. From the bottom up, healthcare professionals who deal directly with patients have the responsibility of accurately entering in consumption and demand data so that this information can be used to accurately forecast and plan for future restock. The implementation of an electronic Logistics Management Information Systems (eLMIS) has become a core component of healthcare supply chains in many countries (85).

In the last 5 years, LMIS platforms, such as OpenLMIS which is an open-source software, have been deployed in countries like Angola, Malawi, and Senegal, showcasing the importance of real-time data visibility, stock management, and reporting to optimize supply chain efficiency. The transition from paper base to digital systems has not been linear across all countries. National scale implementation of an eLMIS requires 1) a country already have an effective pre-existing LMIS with clearly defined roles and responsibilities 2) adequate time and financial resources 3) appropriate staff and technical support 4) an enabling digital ecosystem with governmental backing (86). Many countries are expanding existing systems or implementing new ones to address broader supply chain challenges. An example is seen in the case of Swaziland where the MOH replaced the existing inventory management system, RxSolution and subsequently updated the existing eLMIS/ Commodity Tracking System (CTS) to meet the newly developed specifications of the inventory management tool (87). Ghana's GHiLMIS platform also has the added value of integrating stock information across all program areas reducing fragmentation of the system (88).

The timely availability of LMIS data continues to translate into improved high-level decision making, particularly to inform the quantification and supply planning processes. In Kenya, Community Health Workers (CHWs) are using a simple mHealth reporting and resupply system known as cStock/DHIS2 to enhance supply chain visibility and to capture and report logistics data efficiently(89). cStock utilises standard Global System for Mobile communication (GSM) phones that are already in possession of Community Health Workers (CHWs) to transmit data on a monthly basis via Short Message Service (SMS) to a toll-free phone line. The system is able to calculate and determine the appropriate resupply quantities for each Community Health Worker (CHW) and thereafter transmits these quantities directly to the health centre through SMS for the purpose of prepacking items. Health centres provide guidance to CHWs regarding the availability of stock for collection. The proposed solution entails the development of a web-based dashboard that offers user-friendly information, facilitating the monitoring of stock levels, reporting rates, and alerts for managers at both central and district levels. The utilisation of cloud hosting for data storage is a cost-effective, dependable, and easily manageable solution for a small-scale system such as cStock. This approach eliminates the need for the recruitment and training of Information Technology (IT) support personnel, as well as the procurement and maintenance of a physical server.

eLMIS platforms have also been found to reduce significantly the time spent on performing logistics related tasks. The MoH in Malawi has implemented the OpenLMIS system for health logistics reporting activities. This adoption has resulted in streamlined data management processes, as it enables users to conveniently report, place orders, and access LMIS results through a single application instead of three different tools (i.e., Supply Chain Manager (SCMgr) for reporting; Microsoft Excel for data aggregation, analysis, and report generation; and the Central Medical Stores Trust (CMST) online tool for ordering commodities). This modification enhances the efficiency of the nation's logistics data management system (90). Solutions such as Logistimo supply chain management (SCM) platform(91,92), are leading the way in real-time monitoring of vaccine quantity and quality. By ensuring efficient vaccine distribution, especially in remote and hard-to-reach regions, these innovations are enhancing vaccine coverage and safeguarding vulnerable populations.

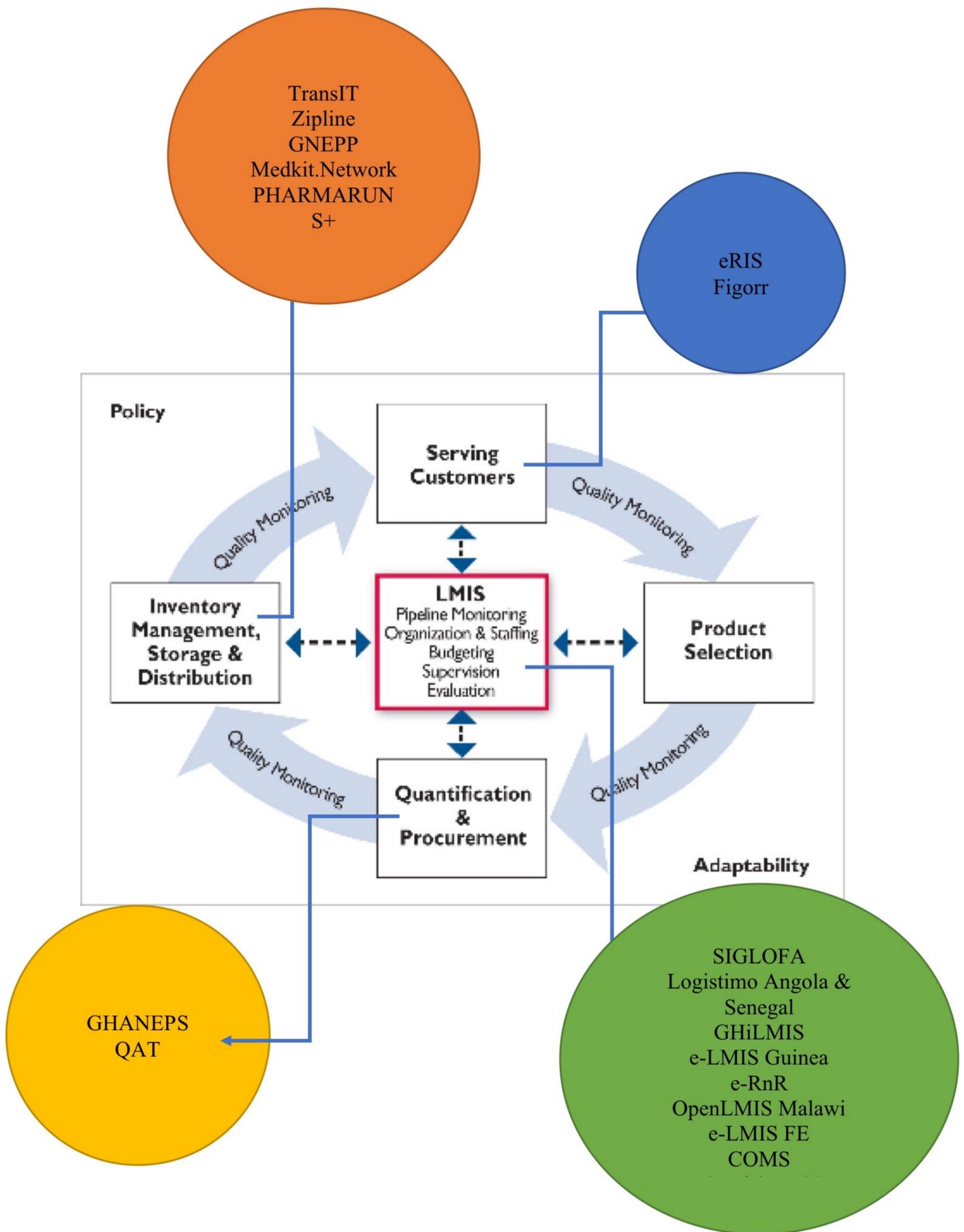


Figure 7 Summary of Digital Innovations found in sub Saharan Africa. (Authors own construct)

Table 2 Digital Innovations implemented in sub-Saharan Africa between 2017 and 2022

No	Name	Country	Year deployed	Overview of digital innovation	Logistics cycle
1	OpenLMIS Angola Sistema Informática de Gestão de Logística Farmacêutica de Angola (SIGLOFA) (93)	Angola	2019	<p>This OpenLMIS system manages HIV, Malaria, Tuberculosis, Reproductive Health, and Essential Medicine commodities from central to district to SDP.</p> <p>Partners - GHSC-PSM, VillageReach, USAID, MoH Angola</p>	LMIS
2	Angola immunization supply chain (Logistimo SCM platform) (91)	Angola	2019	<p>The SCM platform developed by Logistimo has been implemented in six provinces, including around 500 health institutions. This deployment enables the real-time monitoring of vaccine quantity and quality, with the primary objective of enhancing vaccination coverage at the last stage of delivery. The resource is provided in the Portuguese language to enhance ease of use.</p> <p>Partners - MoH Angola, GAVI</p>	LMIS
3	Transportation Management System (TransIT and electronic proof of delivery ePOD) (79)	Angola	2018	<p>The National Warehouse and Procurement Agency (CECOMA) aggregates and provides monthly distribution data for planning and delivery purposes. The utilisation of POD tracking is employed at the central level.</p> <p>Partner - Chemonics</p>	Distribution
4	Electronic Regulatory Information System (eRIS) (94)	Ethiopia	2017	<p>The Ethiopian Food and Drugs Administration (EFDA) uses the locally created and maintained open source software system electronic Regulatory Information System (eRIS) to maintain a continuous information chain from licence and registration through import and quality assurance. This means the EFDA can track drugs from</p>	Serving customers, Quality monitoring

				international (or domestic) vendors to ports, EPSA warehouses, and clinics nationwide.	
5	Ghana Electronic Procurement System (GHANEPS) (95)	Ghana	2019	This web-based, collaborative solution facilitates Ghanaian public procurement in accordance with legislation. It has replaced paper-based procurement methods by MOH and GHS despite not being health supply chain-specific.	Quantification and Procurement
6	Zipline (Drone delivery) (78,96,97)	Ghana	2019	Autonomous drones are used in Ghana to supplement the last mile distribution of emergency commodities and vaccines where facilities do not have appropriate cold chain storage. There are currently 6 distribution centres set up across the country.	Distribution
7	Ghana Integrated Logistics Management Information System (GHILMIS) (88,98)	Ghana	2020	GHILMIS is an eLMIS platform that integrates stock information across all program areas in Ghana. Currently in the roll out phase, it is being used by district hospitals and health centres to place requisitions to the RMS.	LMIS
8	GNEPP Ghana E-Pharmacy (82)	Ghana	2022	The Pharmacy Council of Ghana commissioned NEPP to allow safe and secure access to medications in the private pharmaceutical industry. It also acts as a regulating agency, ensuring that only licensed pharmacy service providers that satisfy the requirements for properly dispensing drugs over the internet are allowed to operate	Inventory management, storage, distribution
9	OpenLMIS Guinea (99)	Guinea	2018	The software uses data analysis and reporting platform DHIS2 and eLMIS (OpenLMIS v2). Integrating two programmes increases analysis and data visibility by sharing and transferring data without duplicating it. stakeholder roles, responsibilities, and commitments.  Partners - MoH Guinea, GHSC-PSM, WHO	LMIS

10	cStock/DHIS2 (89)	Kenya	2017	cStock is a simple mobile-based restocking and reporting tool for community health volunteers (CHVs) that provides supply chain visibility. Mobile technologies speed logistical data collection, reporting, and supervisor commodity refills. Decision makers may evaluate data and detect supply chain concerns using its user-friendly dashboards.	LMIS
11	Medkit.Network(83)	Kenya	2020	Similar to GNEPP in Ghana, this software is able to provide a marketplace where patients can find pharmacies that stock the medications they are looking for. It was particularly useful during the COVID 19 pandemic.	Inventory management, storage, distribution
12	Electronic Reporting and Requesting System (RnR) (100)	Lesotho	2020	The electronic RnR system monitors stock levels, expiration dates, expired or damaged products, and central warehouse deliveries in Lesotho's health commodities supply chain. Supply chain managers are able to detect supply and demand needs and shift commodities between institutions and districts using an automated method to guide replenishment amounts.	LMIS
13	OpenLMIS Malawi (101) Software Platform	Malawi	2017	electronic LMIS implemented on a countrywide scale in Malawi in collaboration to support all districts and over 650 facilities in managing health supplies.  Partners - Village Reach, GHSC-PSM	LMIS
14	Commodity Order Management System (COMS) (102)	Nigeria	2019	An information management system that provides visibility of donor funded commodities right from order shipment to last mile delivery status. It has been designed to be interoperable with existing databases and acts as the source of truth for decision making.  Partner - GHSC-PSM	LMIS, Inventory management, distribution

15	Figorr (70) Remote temperature sensors	Nigeria	2021	Developed a multipurpose real-time data logger known as the MOTE device to monitor and track COVID 19 vaccines. The device alerts users when temperatures go out of the prescribed ranges.	Storage and Distribution
16	PharmaRun) (84) (Private sector supply chain) Mobile application	Nigeria	2021	Users can order for over the counter medicines, request for vaccines, make payments and receive their medications as soon as possible using the mobile or web based app. It also tracks drug usage and compliance using AI algorithms.	Inventory Management, Distribution
17	Senegal immunization supply chain (Logistimo SCM platform) (92)	Senegal	2020	Supply chain management platform implemented in two regions in Senegal and covering around 100 health institutions. The primary objective of this platform is to enhance the overall visibility, monitoring, and accessibility of vaccines, ensuring their efficient distribution from the central level to the final delivery point. The deployment was tailored to incorporate a localised version of the programme in French.  Partner - GAVI	LMIS
18	eLMIS Facility Edition (FE) (87)	Swaziland	2018	This platform is an upgrade to Swaziland's existing eLMIS. It operates on each health facility's local area network (LAN) to allow numerous users to access the same application. Because it is a local installation within the facility, it allows for offline access from within the LAN without the need for internet. It is capable of generating a monthly report and requisition (R&R).	LMIS
19	S+ Platform (81) Software Platform, Track, and trace	Uganda	2022	The S+ solution is an innovative solar-powered digital solution for stock management developed in collaboration with UN Capital Development Fund (UNCDF), Medical Access Uganda Limited (MAUL), and Signalytic to improve access to essential medicines and promote equity and quality of health services in lower-level health facilities	Inventory management

20	Quantification Analytics Tool (QAT) (72)	Multiple countries	2020	Monitoring the purchase and shipment status of medications and supplies, as well as forecasting and quantification.	Quantification and procurement (Supply planning)
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# CHAPTER SIX: Impact of Digital Innovations in Ghana’s Health supply chain

The health supply chain plays a critical role in ensuring the availability and accessibility of essential medical supplies and equipment. In recent years, Ghana has adopted digital innovations to strengthen its health supply chain. Considerable progress has been made in ensuring that suitable products are available for service delivery at all levels. However, there are shortfalls in the procurement process for goods, services, and infrastructure in the sector that require attention. An assessment conducted by the PPA in 2016 on the state of the health supply chain in Ghana uncovered shortcomings in forecasting, quantification and procurement planning due to a lack of coordination between the central and peripheral levels.

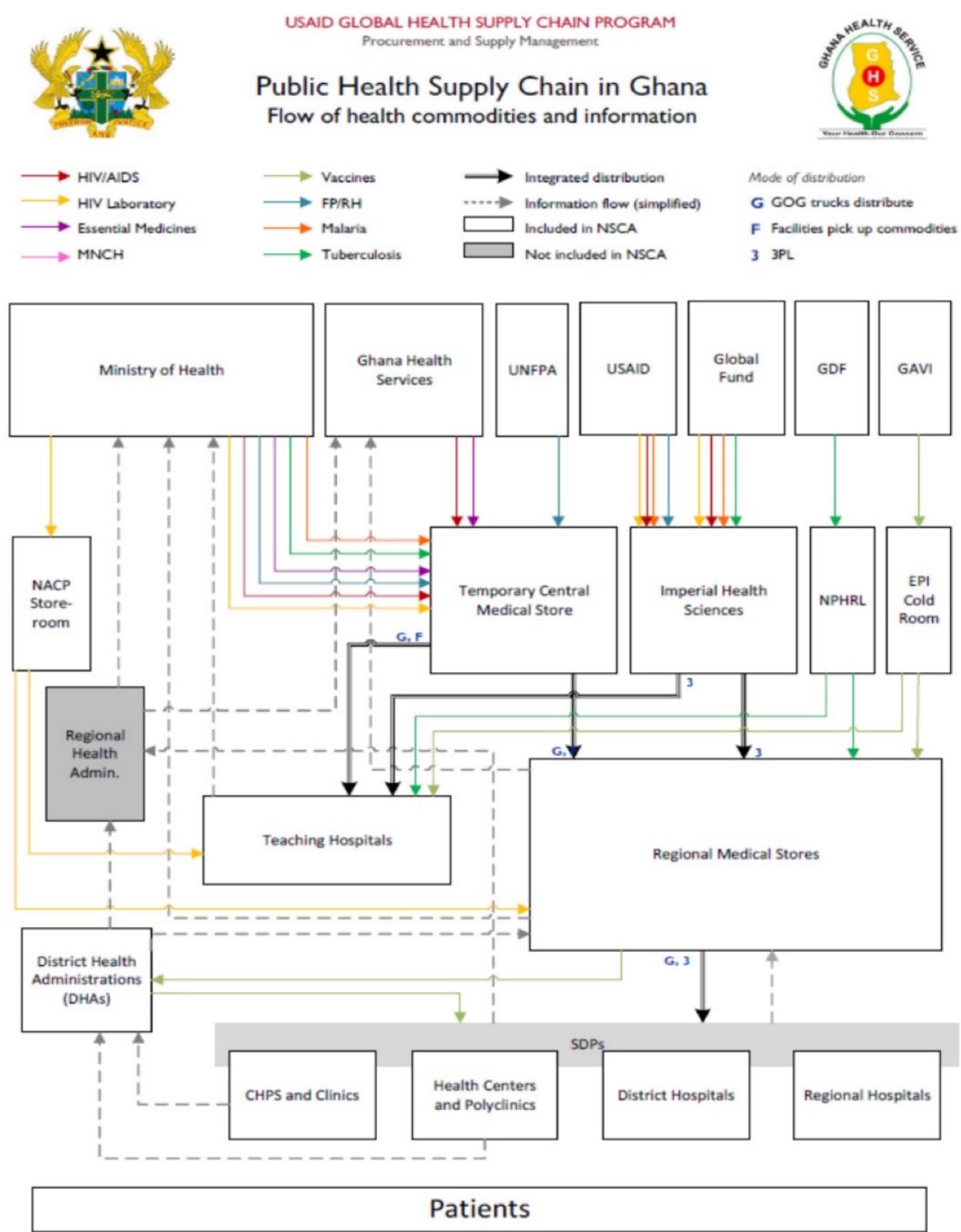


Figure 8 Flow of commodities through the Ghana health Supply Chain (34)

The National Supply Chain Assessment in 2021 reaffirmed the observation on the effectiveness of national disease programmes in forecasting and supply planning (FASP). The assessment emphasised the existence of significant variation across programmes, mostly attributed to the absence of standardised practises. As a result, there was considerable variation in the quality of predicting performance. The health system lacked clear national quantification criteria and standardised techniques for computing forecasting indicators at the product level, which was a noteworthy deficiency. Each national disease programme executed its quantification autonomously, without employing a standardised instrument or coordinated data (103). Moreover, the occurrence of delays in the reimbursement of claims by the National Health Insurance Scheme (NHIS) gives rise to a series of consequences that are evident in extended periods of unavailability of crucial medications. The subsequent results of a separate research revealed inefficiencies in the logistics of medication and vaccine distribution, insufficiency of storage space at the facility level, non-standardized practises for inventory control, and deficiencies in data gathering and reporting(76).

Figure 8 provides a visual representation of the flow of commodities across the public health supply chain in Ghana. This picture brings attention to a significant obstacle in the existing system, namely the presence of a substantial number of procurers. In Ghana's public health system, several organisations, including governmental and donor organisations, are involved in the procurement of health commodities. It is common for numerous procurers to be responsible for each programme area. The augmentation of financial resources allocated to commodities introduces a level of complexity in terms of coordination, since several institutions engage in separate procurement processes with different deadlines. The objective of this chapter is to examine the effects of three significant digital advancements, namely AI-enhanced medical drone delivery, GHILMIS, and GHANEPS, in addressing the obstacles encountered by Ghana's health supply chain.

## **6.1 AI enhanced medical drone delivery**

The utilisation of artificial intelligence (AI) to boost medical drone delivery has emerged as an innovative and transformative option to address the difficulties associated with providing timely medical supplies to distant or geographically inaccessible regions. In the context of Ghana, this initiative has played a significant role in mitigating the challenges arising from limited availability to crucial healthcare commodities, mostly attributable to insufficient transportation infrastructure serving rural regions. Initially introduced in Rwanda in 2016, to supply blood products, was subsequently expanded to Ghana in 2019. Aerial logistics has since been implemented at full scale and facilitates the timely delivery of a diverse range of medical supplies, including 170 vaccinations, blood products, and various types of medication. This service caters to over 2000 healthcare facilities, effectively reaching a population of about 22 million individuals (104).

Research conducted to evaluate the acceptability and integration of this innovation among various stakeholders at different levels demonstrated that it not only alleviated congestion at larger hospitals by reducing referrals, but also offered economic benefits by saving staff hours previously spent on transporting essential and emergency supplies from regional or district warehouses, which often took a significant amount of time (i.e., hours and days). The analysis also highlights a notable influence on the supply chain in terms of diminishing expiries and wastage. Facilities are not compelled to excessively stock inventory due to concerns about potential delays, thereby resulting in cost savings for the government. In a similar vein, Zipline offers a centralised storage facility for blood supplies with limited shelf

lives. This ensures that vital items are efficiently sent to the locations where they are most required, resulting in a reduction in both illness and death rates. Prior to the implementation of medical drones in Ghana, the unavailability of medications necessitated patients, who were ideally covered by health insurance, to bear the financial burden of purchasing drugs directly from a pharmacy or seeking alternative methods of treatment (104).

The implementation of medical drone delivery has further shown favourable effects on health outcomes. The increased speed of accessing medical supplies has contributed to enhanced disease management, particularly in cases necessitating prompt action. There was a substantial rise in vaccination accessibility in the Western North Region of Ghana. The facilities that were assisted by the drones had notable decreases in both the duration of vaccine stockouts (30%) and the recurrence of missed immunisations (44%). The utilisation of aerial logistics was found to be positively correlated with heightened levels of satisfaction pertaining to the accessibility of vaccinations. Vaccination coverage of most vaccines in the districts server increase between 13 and 38% (51).

## **6.2 Ghana Integrated Logistics Management Information System (GHiLMIS)**

The public sector supply chain in Ghana has traditionally relied on paper-based processes and lacks a centralised information system for managing supply chain data. The GOG undertook a comprehensive initiative to improve the existing manual system by implementing a centralised Logistics Management Information System (LMIS) called GHiLMIS. This endeavour involved a gradual implementation over multiple years. The primary objective of GHiLMIS is to streamline and automate many manual procedures, while also enhancing data accessibility and transparency to an unprecedented degree. However, the integration of data sources and the training process are still in progress, and the level of adoption and utilisation of GHiLMIS and its features remains uncertain. The purpose of GHiLMIS is to offer comprehensive visibility across a supply chain (105). In the past, data reporting in this context was primarily done manually and lacked digitization, such as at SDPs. Additionally, data was often isolated in separate systems, necessitating manual consolidation and verification processes. Currently, with the implementation in progress, certain manual procedures are still being carried out. Moreover, it has still to be determined if the Full Operating Capability (FOC) implementation will be successful in terms of user uptake, data compliance, and achieving complete end-to-end visibility(34).

Despite the deployment of a Logistics Management Information System (LMIS) known as GHiLMIS in Ghana, which successfully centralises and digitises the supply chain data, it falls short in properly addressing the fundamental reasons that contribute to the ongoing concerns over data quality and accuracy across the whole supply chain (85). One potential issue that may occur is the inability of SDPs without constant internet connectivity to consistently send their data on a regular basis. The absence of reliable internet connectivity may pose many issues when implementing a web-based infrastructure. The implementation of temporary procedures during the ongoing deployment of the GHiLMIS is a shared challenge for both existing implementers of comprehensive processes and data aggregators. During the period of transition, users participate in the validation of new data, as well as the collection and analysis of data using manual methods, while simultaneously maintaining their previous routines until the implementation process is completed (34). In order to minimise delays and ensure stakeholder involvement, it is imperative to establish explicit standards and schedules

for data validation and process modifications during interim usage. This is a regularly observed practise in the context of extensive software projects, including the present one. Despite the implementation of the GhiLMIS system, there are still several essential sources of information such as the IHS warehouse and Cristian Health Association of Ghana (CHAG) centres, that remain excluded from the data and reporting streams, likewise, information from private for profit and not for profit organisations that directly contribute to the public health supply chain (105). In order to have a comprehensive understanding of the entire public health medicine landscape both governmental and non-governmental service providers would need to collaborate and integrate their processes.

### **6.3 Ghana Electronic Procurement System (GHANEPS)**

Under the Digital Ghana Agenda, the GoG has rolled out a number of solutions with the aim of digitising governmental services. These reforms include the establishment of a biometric National Identity register, the implementation of a digital property addressing system, the promotion of mobile money interoperability, and the institutionalisation of paperless port operations, among other initiatives(106). Based on these accomplishments, the Government of Ghana (GoG) embarked on an endeavour to implement an automated system for the public procurement process, referred to as e-Procurement. This initiative aimed to facilitate the modernization of Ghana's public procurement agencies. The system enabling the implementation of e-procurement is commonly referred to as "GHANEPS." The platform functions as a consolidated medium, interface, and access point for procurement entities in Ghana, facilitating their participation in negotiations that yield enhanced contractual conditions, decreased expenses, and the achievement of optimal cost-effectiveness. In a general sense, e-procurement systems encompass additional elements that extend beyond mere data exchange for the purpose of order fulfilment. These elements include: (a) the capacity to enhance the visibility of data for various stakeholders; (b) the facilitation of increased automation in procurement processes and transactions; and (c) the integration of additional technologies aimed at preventing fraud and counterfeit activities(107).

Initial studies that have been conducted to assess its impact in Ghana so far have been limited to small scale hospital studies. Nonetheless, Boateng et al in a study asserted that the use of an e-procurement system in the acquisition of medicines and medical supplies in Ghana, has the potential to address the existing problems and fluctuations in demand for products and services in hospital procurement practises. He also noted that the introduction of the e-procurement platform improved overall organizational performance and customer satisfaction (108). This was buttressed in a similar study in Rwanda (74). Implementation and adoption of the system has not been completely smooth sailing. In a study conducted in a teaching hospital in the Northern Region of Ghana, findings show that the system was not being utilised to its full extent because of structural issues such as erratic power and internet supply, external bureaucratic interferences and low digital literacy by the people responsible to use it (75).

# CHAPTER SEVEN: DISCUSSION, RECOMMENDATIONS AND CONCLUSION

## 7.1 Discussion

It is no secret that when quality essential medicines and vaccines get to their intended destination at the right time and in the right condition, health outcomes are improved. For instance, lifesaving medications such as ARTs have been proven to improve the quality of life of people living with HIV and prolong disease progression. It is therefore a great disservice to humanity if years' worth of research is unable to make the impact it was developed for due to supply chain bottlenecks which are usually within human control. The COVID 19 pandemic also revealed many shortcomings of health supply chain systems not only in getting emergency health supplies where they were needed but also halting distribution of existing health supplies. Health commodity supply chains have traditionally been paper based which leaves room for human errors and delays. This is magnified in low resource and conflict settings where human capacity may be limited. In order to be able to meet UHC for all, it has become necessary that supply chain processes are improved to be more efficient, resilient, and equitable.

DIs have been shown to have the potential to eliminate various time consuming and duplicated processes in multiple sectors. The health sector has benefited tremendously from DIs. With the click of a button, a doctor can provide consultation to a patient or have access to their medical records. It has been documented that DIs in health date as far back as the 1890s with the advent of telephone consultations, ultrasound imaging techniques and DNA sequencing. These innovations have evolved over the years in many forms with a good majority catering to the service delivery block of the WHO framework for health systems strengthening. DIs specific to the supply chain of EMs and vaccines play a critical role in providing solutions to improve access, quality, and efficiency. This review sought to uncover DIs in SC of EMs and vaccines in the SSA region over the last five years.

Twenty distinct DIs were found documented across various websites and databases with the aim of solving problems at different levels of the SC.12 countries. Most of these were electronic versions of the country's' LMIS or in the case of Swaziland an upgrade of its existing LMIS to improve use and functionality at the facility level. Another layer of innovation is the track and trace technology integrated into the architecture of the eLMIS platform as seen in Nigeria. By combining different innovations onto one platform impact, time and resources can be maximised. When it comes to vaccine and medicine management, end to end visibility provides program managers and policy makers with leverage and decision-making power that ensure that enough health commodities go where they are needed. In Angola and Senegal, there was the existence of a separate LMIS platform for vaccines. The possibility of merging this with existing eLMIS could be interesting to explore although they are sourced and procured under different mechanisms.

Some digital innovations found via electronic databases were absent in the global digital health repositories. This highlights the limited exchange and distribution of information in the implementation of digital health initiatives in SSA. Several digital tools that were previously indicated as being in an early pilot or experimental phase lack further reports on their outcomes, hence hindering the ability to determine the reasons for their failure or lack of implementation. This leads to me to wonder: what is the extent of undocumented digital

innovations produced in sub-Saharan Africa? One of the obstacles to fully realising the advantages of digital innovation in sub-Saharan Africa is the lack of coordinated adoption of digital health technologies across countries. Pilots and trials are commonly conducted inside controlled conditions. The process of implementing evidence-based therapies inside the real health systems introduces a distinct array of obstacles, encompassing factors such as governmental laws and the termination of financing cycles by donors. This leads me to hypothesise that government-led initiatives have an edge over commercial interventions due to the durability of financing in the realm of digital health.

Sustainability of the utilisation of a DI speaks to how long the said tool can continue to be used effectively once deployed on a national scale and any external funding is withdrawn. Findings from this study showed that about 50% of the DIs implemented were either funded or technically supported by International Development agencies. While this is not a problem, countries need to be able to take control once the pilot phase is completed. This is possible when the goal of the DIs is aligned with the priority health needs as spelt out by the MoH. Several barriers and facilitators for the sustainability of DIs in LMICs have been identified by researchers. Challenges related to infrastructure, equipment, internet connectivity, consistent power supply, skilled personnel, and the design of the digital interventions themselves act as barriers to utilization. The facilitator with the biggest impact was found to be commitment and involvement of multisectoral stakeholders accompanied by fair and efficient governance or leadership systems. The decision to implement a DI should be one backed by evidence of its feasibility, impact, and priority. This will ensure that governments take on what they can handle at a time using the scarce resources available.

DIs should be considered a fundamental component of the broader SC ecosystem, with the potential to provide ethical, equitable, safe, secure, and sustainable benefits to individuals. DIs have the potential to significantly impact health outcomes, provided that they get enough investment in terms of governance, institutional support, and labour capability. The importance of monitoring and evaluation in the implementation, scaling up, and sustainability of DIs cannot be overstated. It is crucial for ensuring that the desired outcomes are achieved at all levels. It is essential that maturity levels of digital tools are monitored and assessed against a predefined standard. These standards or key performance indicators will aid in the systematic monitoring of the impact of digital health in multiple areas.

## **7.2 Recommendations**

In Ghana, the current DIs that have been implemented in SC have so far shown promising results as discussed in chapter 6. However, there is more room for improvement. In this section I highlight three areas where opportunity exists for Ghana to improve its public health SC efficiency.

### **7.2.1 Track and Trace technology**

Ghana can build on its integrated LMIS by adopting track and trace technology to improve end to end visibility as demonstrated in Nigeria. In my experience working with GHiLMIS, stocks are only manually entered into the system once they arrive at the warehouse. This means information about suppliers, lead time and customs are coordinated elsewhere. This does not allow easy tracking and may result in information lags. The COMS platform acts as a one stop shop from supplier to patient. This aids in product recall during post market

surveillance and ensures that all actors are held accountable. While the underlying notion of traceability is very straightforward and the hardware costs are generally affordable for most participants in the supply chain, the implementation of traceability systems is a substantial undertaking that necessitates substantial initial financial commitment. It is however feasible that countries with an LMIS in place could use them as a backbone for a data-sharing network. Moving from pilot to full scale may be a challenge if not all SC actors are within the network as the integrity of the data is questionable. In Ghana, vaccines are currently not processed through GhiLMIS. Although this may take some time, it will be beneficial if the EPI supply actors could be onboarded, so all information resides in one database.

### **7.2.2 Improving use of DIs at PHC centres**

Information needs to flow both ways for its usefulness to be realised. SC managers depend heavily on data that is provided from PHC centres (CHPS, HFs and DHs). The process of doing this must be as seamless as possible so it doesn't act as a barrier for health workers to do their jobs. In Kenya and Swaziland, the MoH has found a way to improve DI utilization. In Kenya, cStock is a digital supply chain strengthening platform, available via web and mobile phone which allows CHVs to monitor stock and report back to supervisors. Similar in Swaziland, a facility edition of their eLMIS which comes with an offline data entry version has been developed. Similarly, the S+ platform comes with the option of being powered by solar energy which is particularly useful in rural areas. This ensures barriers such as internet connectivity and availability of electricity and computers at all PHC centres is no longer a barrier. Once accurate and timely information is being collected and sent upstream, forecasting, quantification and supply planning can be done confidently to meet the needs of patients.

### **7.2.3 Human Resource Capacity building**

For all these DIs to work as they should, it is pertinent to invest in the training of logistics staff across all levels of the SC. Digitized SCs still need expertise and technical know-how in order to run. On the job trainings, workshops and certifications with periodic assessment can be one way of achieving this. In Kenya and Tanzania, inSupplyHealth, a local organisation has developed e-learning packages that provide SC training for staff at their own pace, creating a standard of knowledge and expectation among all staff members.

## **7.3 Strengths and Limitations of study**

My study was specific to improving access to medicines from the SC perspective. I was able to highlight new technology implemented recently in low resource settings. Similar studies have focused on digital technologies as a whole which have overshadowed SC related innovations. My study was also able to map the DIs to the level of the SC it impacted, which brings awareness to the gaps and areas that may need new innovations. This will serve as a baseline for further research to strength public health SCs

The study had three main limitations. Firstly, the study was a literature review which took evidence from published reports, journals, and websites. There is a probability that the way these DIs work in reality is not what is accurately reported. Further research should include experiences from key informants who are knowledgeable about these digital tools and their impact on the SC.

Secondly, although the SSA region was selected for the scope on new innovations, only literature available in English was considered. This may mean that more information regarding the use of tools in other languages may exist. Consequently, other tools in other parts of the world focused on SC were not covered.

There was limited studies and peer reviewed journals available on the impact of DIs in SSA. In addition, some DIs were not available in known databases but were mentioned in government reports making corroboration a challenge. In Ghana, majority of documents that described the supply chain were quite outdated.

## **7.4 Conclusion**

The objective of this study was to explore how digital innovations were being used specifically in health supply chain management across sub-Saharan Africa and how Ghana could tap into this breadth of knowledge to strengthen her own supply chain. Although the solutions are numerous, digital innovations in supply chain management only have so much power. Their impact will only be wholly felt when they are implemented in tandem with the right technical infrastructure and alongside a well-trained and committed workforce. Exploring sustainable private and public partnerships that can overcome some barriers will go a long way to improving supply chain efficiency.

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