# ENSIGN GLOBAL COLLEGE, KPONG

# EASTERN REGION, GHANA

## FACULTY OF PUBLIC HEALTH

## DEPARTMENT OF COMMUNITY HEALTH


# A SYSTEMATIC REVIEW OF DIGITAL HEALTH INTERVENTIONS IN GHANA


**MCLORD SELASI AZALEKOR**

**(237100261)**


**SEPTEMBER, 2024**

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# A SYSTEMATIC REVIEW OF DIGITAL HEALTH INTERVENTIONS IN GHANA

**BY**

**MCLORD SELASI AZALEKOR**

**(237100261)**

mclord.azalekor@st.ensign.edu.gh

**A THESIS SUBMITTED TO THE FACULTY OF PUBLIC HEALTH, DEPARTMENT OF COMMUNITY HEALTH, ENSIGN GLOBAL COLLEGE, KPONG IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF**

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## DECLARATION

I, McLord Selasi Azalekor, hereby declare that this dissertation for my Master of Public Health degree is the result of my independent research work, except where references to other people's works and publications are made, which have been duly acknowledged. To the best of my knowledge, this work has not been submitted, wholly or in part, for any degree or academic honor at any other institution.

**McLord Selasi Azalekor**
(237100261) …… 30/9/2024……
(Student) Signature Date

Certified by:
**Dr. Millicent Ofori Boateng** …… 30/09/2024……..
(Supervisor's Name) Signature Date

Certified by:
**Dr. Stephen Manortey** …… ……..
(Head of Academics Program) Signature Date .

## DEDICATION

I dedicate this work to the Almighty God, my source of wisdom, strength, and inspiration. This thesis is also dedicated to my family and friends, whose unwavering support, sacrifices, and encouragement have been my greatest strength.

A special dedication goes to my supervisor, Dr. Millicent Ofori Boateng, whose guidance have been invaluable throughout this journey.

Finally, for all those who strive to make a difference in the field of public health, this work is a tribute to their passion and commitment.

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First and foremost, I express my deepest gratitude to God for his guidance and blessings throughout this journey. I extend my sincere appreciation to my advisor, Dr. Millicent Ofori Boateng, for her invaluable insights, support, and encouragement throughout this study.

We thank the faculty and staff of the Department of Community Health at Ensign Global College for providing a nurturing academic environment. Your expertise and dedication are nothing short of being spectacular.

I also acknowledge my fellow students and colleagues for their camaraderie and stimulating discussions.

## DEFINITION OF TERMS

| | |
|---|---|
| **Artificial Intelligence (AI) in Healthcare** | The use of complex algorithms and software to emulate human cognition in analyzing, interpreting, and understanding complicated medical data. |
| **Big Data in Healthcare** | Large and complex datasets generated from digital health systems, EHRs, medical imaging, and other sources, requiring advanced data processing for interpretation. |
| **Blockchain in Healthcare** | Distributed ledger technology that allows for secure, transparent, and tamper-proof storage and sharing of healthcare data. |
| **Digital Health Literacy** | The ability to seek, find, understand, and appraise health information from electronic sources and apply the knowledge to solve a health problem. |
| **Health Information Exchange (HIE)** | The electronic movement of health-related information among organizations according to nationally recognized standards. |
| **Health Information System (HIS)** | A system designed to manage healthcare data, including the collection, storage, management, and transmission of patient EHRs and hospital operational data. |
| **Interoperability** | The ability of different IT systems and software applications to communicate, exchange data, and use the information exchanged. |
| **Remote Patient Monitoring (RPM)** | The use of digital technologies to collect health data from individuals in one location and securely transmit it to healthcare providers in another location. |

## LIST OF ABBREVIATIONS

| | |
|---|---|
| **DHIs** | Digital Health Interventions |
| **eHealth** | Electronic Health |
| **EHRs** | Electronic Health Records |
| **eDSS** | Electronic Decision Support Systems |
| **HIS** | Health Information Systems |
| **mHealth** | Mobile Health |
| **WHO** | World Health Organization |
| **MeSH** | Medical Subject Headings |
| **MCH** | Maternal and Child Health |
| **PICOS** | Population, Intervention, Comparator, Outcomes, Study Design) |
| **PRISMA** | Preferred Reporting Items for Systematic Reviews and Meta-Analyses |
| **UHC** | Universal Health Coverage |
| **ICT** | Information and Communications Technology |
| **SDGs** | Sustainable Development Goals |

## ABSTRACT

**Background:** Digital health interventions have gained significant attention in recent years as a means of improving health care delivery and outcomes. In Ghana, where access to quality healthcare services remains a challenge, exploring the strengths, and limitations of digital health interventions is crucial.

**General Aim:** This systematic review aimed to explore the trends, strengths, and limitations of digital health interventions in Ghana. By analyzing the characteristics of the included studies, targeted populations, intervention strategies, comparators, outcomes, and study designs, this study offers a comprehensive overview of the status of digital health initiatives in the country.

**Methodology:** Employing a systematic review methodology, this study involved a literature search across multiple databases, data extraction, quality appraisal, and synthesis. Two independent reviewers screened and assessed studies for inclusion, with data extraction forms pilot-tested for accuracy and consistency. The analysis utilized the PICOS framework, focusing on both qualitative and descriptive synthesis.

**Findings:** This review identified 29 relevant studies, published between 2004 and 2024, which address diverse health interventions using digital technologies across Ghana. 22 digital health interventions were identified in Ghana. These DHIs include mHealth, telemedicine, health information management systems, and electronic health records (EHRs), predominantly targeting general healthcare delivery, maternal and child health, disease surveillance, and specific conditions like dermatology and ophthalmology. 54.5% of these interventions were directed at both rural and urban areas, highlighting the country's effort to address healthcare disparities. Findings indicate that DHIs enhance patient care, data management, and access to healthcare, especially in remote regions. They facilitate improved communication between patients and healthcare providers,

reduce logistical barriers, and streamline healthcare processes. However, several limitations were identified, including infrastructural challenges like unreliable power supply and internet connectivity, human resource constraints, financial limitations, and the need for improved user training and system design. These factors hinder the full utilization and impact of DHIs, particularly in rural settings. Despite these barriers, the study concludes that digital health interventions hold significant potential for improving healthcare delivery in Ghana, provided that technical and operational challenges are addressed.

**Conclusion:** Digital health interventions hold substantial promise for addressing healthcare challenges in Ghana. This systematic review provides a detailed analysis of current initiatives, revealing their potential to improve healthcare accessibility, efficiency, and outcomes. The study underscores the need for strategic planning, stakeholder engagement, and policy support to foster the sustainable integration of DHIs into the healthcare system. The insights gained can guide future research, policy formulation, and implementation of digital health strategies in Ghana, contributing to the achievement of universal health coverage and the Sustainable Development Goals.

**Keywords:** Digital health, eHealth, mHealth, Telemedicine, Ghana

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# CHAPTER 1

# 1.0 INTRODUCTION

## 1.1 Background Information

Digital health, dubbed a prominent domain of practice, denotes the application of digital technologies in healthcare, leveraging both conventional and cutting-edge forms of information and communications technology (ICT) to tackle health issues effectively. Digital health has become an essential component of global healthcare systems, with initiatives such as the WHO Global Strategy for Digital Health emphasizing the importance of effective public participation and transparency in decision-making processes (Godinho *et al.*, 2023).

The term digital health was introduced as "a broad umbrella term encompassing eHealth (which includes mHealth), as well as emerging areas such as the use of advanced computing sciences in 'big data,' genomics, and artificial intelligence". Digital health includes categories such as mobile health (mHealth), health information technology, wearable devices, telehealth, telemedicine, personalized medicine, eHealth, self-tracking, artificial intelligence, and information systems in healthcare (Shin, 2019; Guo *et al.*, 2020; Wienert, Jahnel and Maaß, 2022).

In the pursuit of universal health coverage (UHC), Science, Technology, and Innovation, such as digital health, play a pivotal role in achieving the Sustainable Development Goals (SDGs) outlined in the 2030 Agenda. Specifically, Sustainable Development Goal 3.8 underscores the significance of ensuring access to quality, safe, effective, and affordable healthcare for all (Osei, Kuupiel and Mashamba-Thompson, 2020; Bekyieriya, Isang and Baguune, 2023).

The WHO's global strategy on digital and mobile health for 2020 to 2025 stresses the significance of employing digital technologies in healthcare. Digital health interventions offer opportunities to

target specific groups, reduce implementation costs, and enhance population health (Parums, 2021; Stark, Geukes and Dockweiler, 2022).

Existing evidence indicates that digital health applications may be useful in improving maternal, neonatal, and child health, including increased antenatal care attendance, facility usage, skilled attendance at birth, and postnatal care (Sondaal *et al.*, 2016; Osei *et al.*, 2021). The utilization of digital health services has significantly increased globally, particularly owing to the challenges brought about by the COVID-19 pandemic (Rosenlund, Kinnunen and Saranto, 2023).

In the 2018 Digital Health Consumer Adoption survey by Rock Health in the US, 89% of consumers reported adopting at least one digital health tool, in early 2020, healthcare systems rapidly adopted new digital services to manage the COVID-19 pandemic (Shah, Nghiem and Ranney, 2021). The digital health adoption rate in Africa varies across regions and countries. However, 53.4% of digital health solutions have been established in Sub-Saharan Africa (Karamagi *et al.*, 2022).

Limited resources in Ghana pose significant challenges, particularly for hard-to-reach populations, leading to concerns about inadequate access to and quality of healthcare services. Additionally, Ghana, like other Sub-Saharan African countries face the dual burden of infectious and non-infectious diseases, weakening the already fragile healthcare systems (Agyemang-Duah *et al.*, 2019; Osei *et al.*, 2024). In an attempt to combat issues with the healthcare system, the Government of Ghana has demonstrated a commitment to enhancing the digitization of healthcare systems, increasing the training and deployment of skilled health professionals to rural communities, and expanding mobile network coverage in rural areas of the country (de-Graft Aikins *et al.*, 2014; Osei *et al.*, 2021).

In July 2010, the Ministry of Health (MoH) launched an eHealth strategy to guide digital health, specifically e-health adoption in Ghana. The plan focused on four key areas: streamlining regulations for health data management, enhancing sector capacity for eHealth solutions, using Information and Communication Technology to improve access and equity in healthcare, and transitioning to a paperless records system (Ministry of Health, 2010). The adoption of digital health in Ghana has progressed more slowly than anticipated, particularly in contrast to the rapid integration of ICT in other sectors of business and society. Digital health remains in its early stages, with most hospitals only partially digitalized. This slow adoption has been viewed as having significant negative impacts on healthcare delivery in the modern era (Achampong, 2012a).

Ghana is home to several digital health interventions. These initiatives vary in scale, reach, and purpose, ranging from community health worker (CHW)-operated registration and data collection tools to SMS appointment reminders as well as targeted patient messaging and applications for monitoring essential medicine supplies. Given the persistent shortage of healthcare workers to meet the increasing demand, there is an urgent need for innovative healthcare delivery models, such as digital health, that aim to enhance patient experience, achieve cost savings, and improve accessibility of care (Hampshire *et al.*, 2017).

However, no single systematic review has provided a comprehensive overview of existing digital health interventions in Ghana. This systematic review bridges this gap by critically examining the existing evidence on digital health interventions in Ghana.

### 1.2 Problem Statement

The advent of digital health interventions has shown significant potential in improving healthcare delivery, accessibility, and outcomes across various regions globally. In Ghana, where healthcare challenges such as limited access to healthcare facilities, inadequate healthcare personnel, and a

high disease burden persist, digital health interventions could play a transformative role (Kesse-Tachi, Asmah and Agbozo, 2019; Peprah *et al.*, 2020; Demuyakor, 2021; Adachi *et al.*, 2022; Agormedah *et al.*, 2022).

Despite numerous pilot projects and initiatives aimed at integrating digital health solutions within the Ghanaian healthcare system (Hampshire *et al.*, 2017), a thorough search of the Google Scholar and PubMed databases shows a lack of comprehensive evidence synthesizing their impacts, effectiveness, and scalability. Moreover, there is a limited understanding of the contextual factors that limit or strengthen the adoption and success of these interventions, including infrastructural barriers.

Without a systematic review specific to Ghana, the country may miss valuable insights into behavior change techniques, user engagement strategies, and design processes that have proven effective in other contexts.

This lack of evidence hinders policymakers, researchers, and healthcare providers' understanding of the full spectrum of digital health outcomes and limits their ability to identify barriers, facilitators, and effective solutions for implementing context-specific digital health interventions in Ghana. Conducting a systematic review focusing on digital health in Ghana is essential to inform evidence-based decision making, policy formulation, and the successful implementation of digital health initiatives in the country.

### 1.3 Rationale of Study

Leveraging digital health technologies such as mHealth initiatives aims to enhance healthcare access, communication, and service delivery (Peprah *et al.*, 2020; Hampshire *et al.*, 2021). This systematic review of digital health interventions in Ghana is highly relevant to the United Nations

SDGs. Specifically, it addresses SDG 3 - "Ensure healthy lives and promote well-being for all at all ages" (Afarikumah, 2014a; Kesse-Tachi, Asmah and Agbozo, 2019).

This study directly contributes to improving population health outcomes in Ghana. The findings from this review also have significant policy relevance for Ghana. The Ghana eHealth Strategy, published in 2010, is the official policy framework guiding the country's use of digital health (Kesse-Tachi, Asmah and Agbozo, 2019). However, this strategy lacks clarity on addressing digital health inequalities faced by end-users, especially those in rural communities and vulnerable populations.

This review provides important insights that can inform revisions to the eHealth Strategy and guide the development of more inclusive digital health policies in Ghana. It is not only timely, but the rationale for conducting a systematic review of digital health interventions in Ghana is rooted in the need to address healthcare disparities, understand target populations, track evolution and trends, and assess their strengths and limitations.

By synthesizing the findings from various studies, this review sheds light on what works, what does not work, and why it does in Ghana.

## 1.4 Conceptual Framework

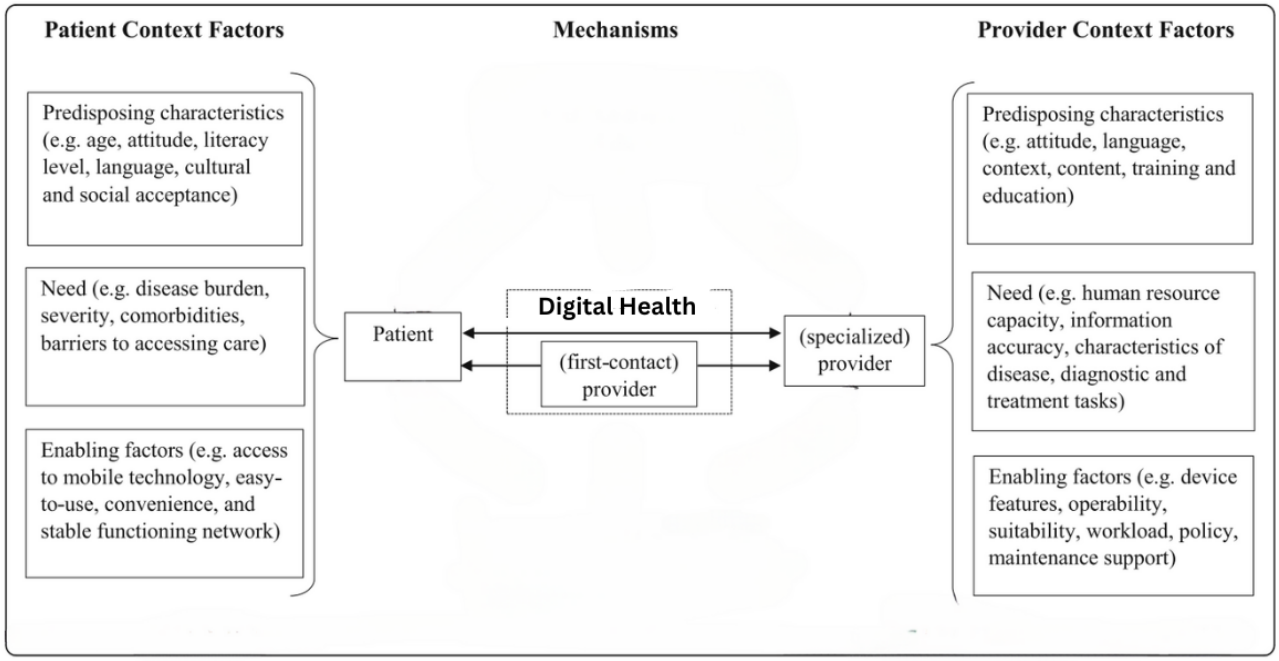


*Figure 1.1 Digital health predisposing characteristics, needs, and enabling resources framework [modified from (Opoku, Stephani and Quentin, 2017)].*

This is a framework for understanding the contribution of digital health interventions to improved access to care for patients and explains how, why, for whom, and in what circumstances digital health interventions work in this context. This shows that the main contribution of digital health is that it facilitates (remote) access to previously unavailable and often specialized services. The framework consists of three main elements: predisposing characteristics (such as positive attitude, basic knowledge, and fluency in language); needs (such as a high burden of disease and a lack of capacity of first-contact providers); and enabling resources such as the availability of a stable communication network, accessible maintenance services, and regulatory policies.

The framework shows that the predisposing characteristics, need, and enabling resources influence the perceived usefulness and ease of use of digital health interventions, which in turn determine

the sustained use of digital health interventions and improved access to care for patients. The framework also shows that digital health interventions can take different forms, such as patient-to-provider or provider-to-provider consultations, and can target different types of health conditions. The framework can help policymakers and program managers to design, implement, and evaluate digital health interventions in Ghana, taking into account the context-specific factors that affect their success.

### 1.5 Research Questions

1. What are the characteristics (Population, Intervention, Comparators, Outcomes, Study design) of studies on digital health interventions in Ghana?
2. Which specific health conditions are targeted and addressed through digital health interventions in Ghana?
3. How have digital health interventions evolved over time in Ghana?
4. What are the strengths and limitations associated with the utilization of digital health interventions in Ghana?

### 1.6 General Objective

To explore the trends, strengths, and limitations of digital health interventions in Ghana.

### 1.7 Specific Objectives

1. To describe the characteristics (Population, Intervention, Comparators, Outcomes, Study design) of digital health studies in Ghana.
2. To identify the specific health conditions targeted and addressed through digital health interventions in Ghana.
3. To investigate trends in digital health interventions in Ghana.

4. To assess the strengths and limitations of digital health interventions in Ghana.

### 1.8 Profile of Study Area

Ghana, officially known as the Republic of Ghana, is a country in West Africa. It abuts the Gulf of Guinea and Atlantic Ocean to the south, sharing borders with the Ivory Coast in the west, Burkina Faso in the north, and Togo in the east. Ghana covers an area of 239,535 $km^2$ (92,485 sq. mi), spanning diverse biomes ranging from coastal savannas to tropical rainforests. With over 32 million inhabitants, Ghana is the second most populous country in West Africa after Nigeria. The capital and largest city is Accra; other major cities are Kumasi, Tamale, and Sekondi-Takoradi.

Ghana is characterized by rich cultural heritage and diverse geographic regions. The country has been divided into 16 regions, 261 metropolitan, municipal, and district assemblies, and 275 constituencies that focus on population size, share and growth, sex composition, population density, number of households, and household size by region, district, and type of locality.

More than half of the population is from the Greater Accra Region (17.7%), Ashanti Region (17.6%), Eastern Region (9.5%), and Central Region (9.3%), and other citizens are from the Northern Region (7.5%), Western Region (6.7%), Volta (6.7%), Upper East (4.2%), Bono Region (3.9%), Upper West (2.9%), Western North (2.9%), Oti Region (2.4%), and Northeast Region (2.2%). The Savannah Region (2.1%) and Ahafo Region (1.8%). Overall, there were more females (8,961,329; 51.3%) in urban areas than males (8,511,201; 48.7%). Nevertheless, in rural areas, there were slightly more males (50.1%) than females (49.9%).

Regarding Ghana's healthcare landscape, healthcare accessibility and quality vary considerably between regions. Urban centers, such as Accra, Kumasi, and Tamale, boast relatively better

healthcare infrastructure, including well-equipped hospitals and clinics. In contrast, rural and remote areas often face limited access to healthcare, transportation, and availability of healthcare providers (GSS, 2021). Figure 1.2 presents the map of the study area, Ghana.


*Figure 1.2 Map of Ghana [Source: (Andoh et al., 2020)]*

## 1.9 Scope of Study

The scope of this systematic review of digital health interventions in Ghana covers a comprehensive exploration of various digital health initiatives implemented within the Ghana healthcare landscape. This study focused on a wide range of digital health interventions, including, but not limited to, mobile health (mHealth) applications, telemedicine platforms, electronic health records (EHRs), health information systems (HIS), and electronic decision support systems (eDSS).

## 1.10 Organization of Report

This thesis is structured into six chapters. Chapter 1 introduces the study by outlining the background of digital health interventions in Ghana, identifying challenges in healthcare delivery, and setting the objectives and scope of the research. Chapter 2 reviews the relevant literature, organized by the main study variables, such as intervention strategies, to offer a theoretical foundation and context for the research.

Chapter 3 details the systematic review methodology employed, emphasizing the rigorous literature search, data extraction, and quality appraisal processes. It covers research methods, data-handling processes, data analysis strategies, and ethical considerations. Chapter 4 presents the findings from the systematic review, summarizing key variables and trends in digital health interventions in Ghana.

Chapter 5 discusses these findings in relation to the research questions and objectives, highlighting their strengths, limitations, and implications for healthcare policies and practices. Finally, Chapter 6 concludes with a synthesis of key insights and provides actionable recommendations for policymakers, healthcare providers, and researchers aiming to guide future digital health strategies in Ghana.

# CHAPTER 2

# 2.0 LITERATURE REVIEW

## 2.1 Introduction

The rapid advancement of digital technologies has significantly impacted the delivery of healthcare services worldwide, with digital health interventions emerging as a promising approach to address various healthcare challenges. This chapter presents a thorough review of the existing literature on digital health interventions, with a specific focus on identifying the health conditions targeted, the evolution of these interventions over time, and the strengths and limitations inherent in their utilization. This literature review serves as the foundation for addressing the research questions, guiding the subsequent analysis and discussion within the thesis.

## 2.2 What is Digital Health?

In recent years, digital health has emerged as a transformative force in healthcare. However, the term "digital health" has been defined and interpreted in various ways, leading to ambiguity and potential confusion, which can be a hurdle for research, policy, and practice in this field (Fatehi, Samadbeik and Kazemi, 2020).

The term “Digital Health” came about as an attempt to provide an all-encompassing definition that included all these aspects of technological development. One of the first to use the term was Seth Frank in 2000, who said it was the combination of Internet-based apps and media being used to improve medicine (Walker, 2024).

Early definitions emphasized the use of information and communication technologies (ICT) in healthcare. These definitions highlight the role of technology in data collection, analysis, and communications. With the rise of mobile health (mHealth) and wearable devices, newer definitions

have shifted the focus towards empowering individuals. The World Health Organization (WHO) defines digital health as a comprehensive term that includes eHealth, mHealth, and the utilization of advanced computing sciences such as big data, genomics, and artificial intelligence (WHO, 2019a). This broader definition encompasses not only clinical applications but also digital tools that individuals use for self-management and wellness.

Meskó *et al.* (2017) too defined digital health as "the cultural transformation of how disruptive technologies that provide digital and objective data, accessible to both caregivers and patients, leads to an equal level doctor-patient relationship with shared decision-making and the democratization of care".

Recent definitions acknowledge the multifaceted nature of digital health. The US Food and Drug Administration (FDA) defines digital health as "the broad scope of digital health includes categories such as mobile health (mHealth), health information technology (IT), wearable devices, telehealth and telemedicine, and personalized medicine" (Shin, 2019). This definition reflects the diverse range of technologies and services that fall under the umbrella of digital health.

Neves and Burgers (2022) define digital health as "the convergence of digital technologies with health, healthcare, living, and society, aiming to deliver high quality care". Kostova also defined digital health as the "use of information and communications technologies to improve human health, healthcare services, and wellness for individuals and across populations (Kostkova, 2015).

Healthcare Information and Management Systems Society (HIMSS) stated that "Digital health connects and empowers people and populations to manage health and wellness, augmented by accessible and supportive provider teams working within flexible, integrated, interoperable and digitally-enabled care environments that strategically leverage digital tools, technologies and services to transform care delivery" (Evans *et al.*, 2022). Unlike other definitions focus more on

individual technologies or applications, HIMSS's definition considered the broader healthcare ecosystem.

Eric Topol defined Digital Health as "the convergence of smartphone-enabled mobile computational and connectivity capabilities is only one aspect of digital medicine; it also encompasses genomics, information systems, wireless sensors, cloud computing, and machine learning that can all be incorporated into new systems of health management, built around real-world, patient-generated data" (Topol, 2012, 2016).

Some common themes appear in these definitions. All definitions acknowledge the fundamental role of digital technologies in healthcare. There is also a consistent focus on enhancing health, wellness, or care quality. The majority of these definitions recognize digital health as an umbrella term encompassing various technologies and applications (Fatehi, Samadbeik and Kazemi, 2020).

A comprehensive review of digital health definitions conducted by Fatehi, Samadbeik and Kazemi (2020) revealed common themes emerging around the use of technology to improve health outcomes, with a particular emphasis on mobile health, data-driven approaches, and wellbeing.

The concept of digital health has undergone significant evolution since its inception in the 1990s. Initially, digital health primarily referred to the digitization of health information and libraries. However, with the advent of the internet in the 2000s and subsequent advancements in computer science and informatics, the concept expanded to cover a broader range of technologies and applications (Fatehi, Samadbeik and Kazemi, 2020).

### 2.3 Types of Digital Health Interventions

Digital health interventions vary, with mobile apps and computer-based programs being the most reported, while others, such as videocassettes and IoT, are less common. These interventions,

which include web-based cognitive-behavioral therapy, teleconsultation, and mobile apps, offer alternatives to traditional face-to-face interventions (Berry, Bucci and Lobban, 2017; Sasseville *et al.*, 2021a; Ibrahim *et al.*, 2022). Figure 2.1 presents the diverse subsets of digital health and how interrelated they are. Here is a comprehensive overview of the different types of digital health interventions:

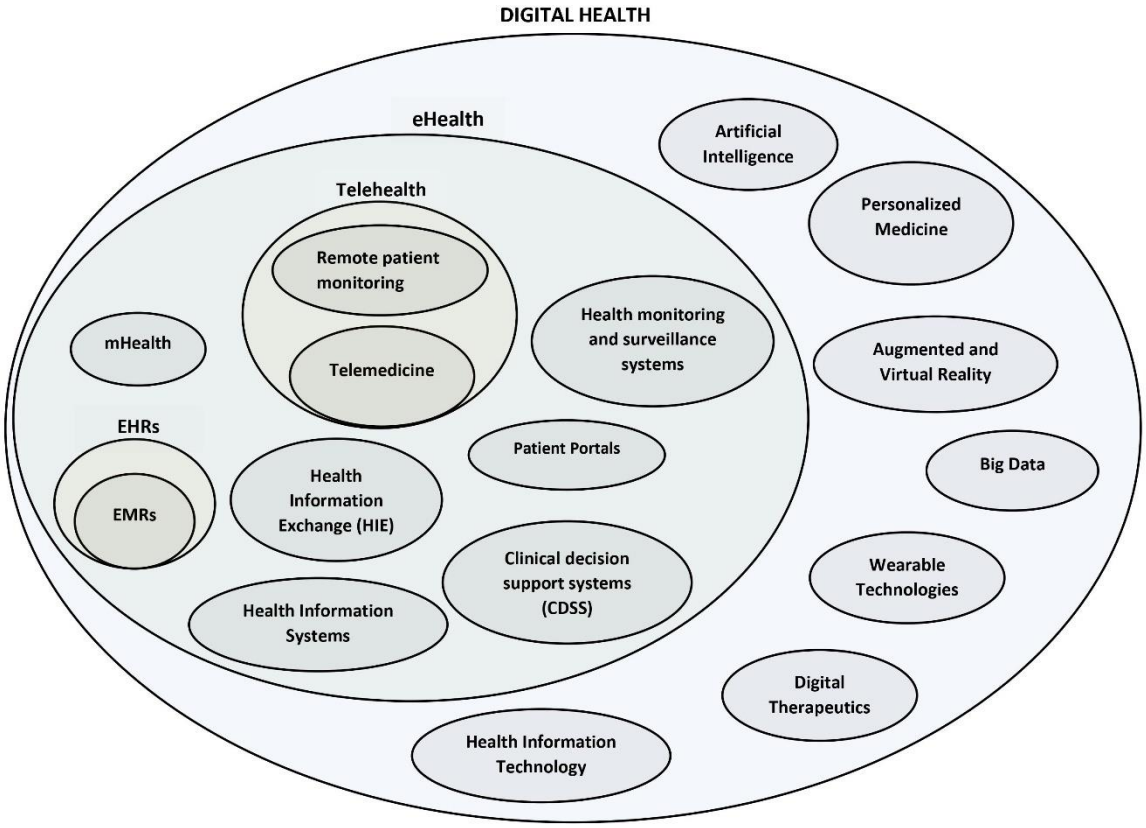


*Figure 2.1: Subsets of Digital health [based on* (Shin, 2019; WHO, 2019b)*]*

### 2.3.1 Mobile Health (mHealth)

Mobile health (mHealth) is a subset of eHealth and is defined as "the use of mobile wireless technologies for health. The WHO defined m-health as a 'medical and public health practice

supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices' (WHO, 2019a; Istepanian, 2022).

Examples of mHealth interventions include mobile applications that provide health-related information, self-management tools, and access to healthcare services; SMS or Text messaging-based interventions for health promotion, appointment reminders, medication adherence, and disease management; and remote consultations between patients and healthcare providers using mobile devices and video conferencing (Labrique *et al.*, 2013).

### 2.3.2 Telemedicine

Telemedicine involves the delivery of health care services, where patients and providers are separated by distance. Telemedicine is defined by three characteristics: (1) using information and communication technologies, (2) covering a geographical distance, and (3) involving professionals who deliver care directly to a patient or a group of patients (Timpel *et al.*, 2020; WHO, 2023)

Broadly, there are three main types of telemedicine: store-and-forward (asynchronous exchange of medical information, such as images or test results, for review and consultation by healthcare providers), remote monitoring, and real-time interactive services (Garavand *et al.*, 2022).

### 2.3.3 Electronic Health Records (EHRs)

An electronic health record is defined as an electronic version of a medical history of the patient as kept by the health care provider for some time period and it is inclusive of all the vital administrative clinical data that are in line to the care given to an individual by a particular provider such as demographics, progress reports, problems, medications, important signs, medical history, immunization reports, laboratory data and radiology reports (Keshta and Odeh, 2021).

These are usually computerized records of the patient's medical history in an organization and is used by specialists, pharmacists, and laboratory services of that specific organization. EHRs are made up of widespread patient IDs linked to lifetime medical history that is valid and may be shared across numerous organizations (Bajeh *et al.*, 2021).

### 2.3.4 Health Information Systems (HIS)

Health information systems (HISs) are computing systems that capture, store, manage, or transmit this vast amount of information as it pertains to the health of individuals, clinical care, or the activities of health-related organizations. HISs can be divided into 4 categories namely foundational systems, financial systems, departmental systems, and electronic medical records (EMRs) (Sirintrapun and Artz, 2016).

Health information systems produce information aimed at supporting decision-making and actions at each level of a health system and healthcare organization. These systems include Hospital management systems and Public health surveillance systems (Rodrigues and Gattini, 2017).

### 2.3.5 Wearable Devices

Wearables are seamlessly embedded portable computers worn on the body. Examples include consumer products promoted as wellness gadgets, like Apple smartwatches and Fitbit activity trackers, as well as more specialized medical devices that can monitor electrolyte levels or detect cancer cells in blood samples. In the medical sector, wearable devices are utilized for monitoring patients and aiding in diagnoses, empowering individuals to take an active role in their health and gain better control over their lives (Kang and Exworthy, 2022).

There are different types of wearable devices including different noninvasive wearables (including skin-based wearables), biofluidic-based wearables (including saliva, urine, and tears) (Iqbal *et al.*, 2021).

### 2.3.6 Health Education and Training

Digital health interventions also encompass tools and platforms for health education and training, targeting both healthcare professionals and the general public (WHO, 2019a).

These include E-learning modules (interactive, web-based educational resources for healthcare workers and patients), health information websites, and virtual reality (VR) training simulations for healthcare professional training and patient education (Car *et al.*, 2022; Pang, Lee and Murshed, 2023).

### 2.3.7 Digital Therapeutics

Digital therapeutics, is a subdivision of digital health, defined by the Digital Therapeutics Alliance (DTA) as "delivering evidence-based therapeutic interventions to patients that are driven by software to prevent, manage, or treat a medical disorder or disease. They are used independently or in concert with medications, devices, or other therapies to optimize patient care and health outcomes" (Abbadessa *et al.*, 2022).

Digital therapeutics are evidence-based digital health tools, often Food and Drug Administration approved that can collect a high volume of user data from a variety of sources, ranging from traditional clinical biomarkers to physiologic sensors and social patterns. Digital Therapeutics tools include diverse screen devices such as smartphones, tablets, computers, and videogame platforms that converge with software algorithms and that can be applied for improvement of

therapy management and rehabilitation (Khirasaria, Singh and Batta, 2020; Kuwabara, Su and Krauss, 2020).

### 2.4 Health Conditions Addressed by Digital Health Interventions

Digital Health Interventions (DHIs) have been employed to address a wide spectrum of health conditions across diverse global contexts. In developed nations, chronic diseases and mental health have been primary focuses, while in developing countries, infectious diseases and maternal-child health have received significant attention. These interventions leverage digital technologies to provide accessible and scalable solutions for various health issues by promoting behavioral change, improving health outcomes, and enhancing healthcare delivery in terms of effectiveness, efficiency, accessibility, safety, and personalization (Murray *et al.*, 2016; Michie *et al.*, 2017; WHO, 2018, 2019a).

Spatz *et al.(*2024) demonstrated the efficacy of wearable devices and remote monitoring systems in managing hypertension, heart failure, and atrial fibrillation in the western world. These findings were corroborated by a subsequent scoping review by Soon *et al.* (2020) emphasizing the potential of wearable devices for remote vital signs monitoring in outpatient settings.

Diabetes has also been addressed through DHIs. In the United States, Bennett *et al.* (2018) conducted a randomized controlled trial evaluating a smartphone application that incorporated interactive voice response, SMS text messaging, and smart scale integration to facilitate behavior change and provide tailored feedback for weight management. Similarly, Ofili *et al.* (2018) reported on "Health 360x," an app-based intervention that demonstrated sustained improvements in systolic blood pressure, blood glucose levels, and physical activity over a 12-week period.

In Germany, Kempf *et al.* (2017) highlighted the TeLiPro telemedicine lifestyle intervention program for advanced type 2 diabetes, which decreased medication use among participants. Similarly, Agarwal *et al.* (2019) explored the use of a mHealth intervention called Bluestar for self-management of type 2 diabetes in Canada.

A study conducted in Saudi Arabia by Al Hayek, Robert and Al Dawish (2021) examined the FreeStyle Libre flash glucose monitoring system, finding out that it led to increased healthcare utilization among patients with type 2 diabetes. In Europe, Poppe *et al.* (2019) evaluated "MyPlan" in the Netherlands, a web-based intervention promoting physical activity and healthy eating among adults with type 2 diabetes. In the United Kingdom, Cooper *et al.* (2022) explored "myCOPD," a digital health intervention for managing chronic obstructive pulmonary disease (COPD), further expanding the application of DHIs to respiratory conditions.

Mental health conditions have been increasingly targeted by DHIs in developed nations. In the United States, Dahne *et al.* (2019) revealed that a smartphone app adaptation of Brief Behavioral Activation for depression resulted in a significant decrease in Beck Depression Inventory-II scores compared to usual care. Yu *et al.* (2018) reported on an app delivering guided cognitive behavioral therapy for anxiety, which led to a mean reduction in GAD-7 scores over two months.

In Germany, Baumeister et al. highlighted the effectiveness of WARD-BP, a guided internet- and mobile-based intervention for patients with chronic back pain and depression. In Sweden, Bonnert et al. explored an exposure-based online treatment targeting excessive avoidance behavior to reduce asthma-related anxiety.

In sub-Saharan Africa, DHIs have predominantly addressed infectious diseases and maternal-child health. Karamagi *et al.* (2022) and Manyazewal *et al.* (2023) noted that HIV/AIDS, malaria,

tuberculosis, and maternal and child health were the most common health conditions targeted by DHIs in this region.

In Western Kenya, a mobile phone-based intervention was implemented to deliver individual counseling services and facilitate peer support for adolescents living with HIV (Chory *et al.*, 2022). In Mozambique, Nhavoto, Grönlund and Klein (2017) highlighted an SMS-based intervention supporting adherence to both HIV and TB treatment.

Similarly, Lesotho saw the implementation of SMS reminders to support HIV/TB treatment in the START study (Hirsch-Moverman *et al.*, 2017). South Africa has seen DHIs applied to cancer screening, with Moodley *et al.* (2019) exploring the use of SMS reminders to improve adherence to follow-up colposcopy appointments after abnormal cervical cancer screening results.

Malaria management has been addressed through DHIs targeting healthcare provider behavior. In Kenya, Zurovac *et al.* (2011) highlighted the use of SMS reminders to ensure health workers' adherence to malaria treatment guidelines. A similar intervention was evaluated in Malawi by Kaunda-Khangamwa *et al.* (2018) for malaria, pneumonia, and diarrhea case management.

In Nigeria, an mHealth application boosted antenatal care attendance and outcomes by sending educational and reminder messages to pregnant women via mobile phones (Olajubu *et al.*, 2020). Beyond infectious diseases, some digital health interventions have targeted non-communicable diseases in Africa. In Nigeria, Nelissen *et al.* (2018) explored a pharmacy-based hypertension care model which involved using a smartphone app to support blood pressure monitoring and medication management for hypertensive patients.

## 2.5 Evolution of Digital Health Interventions

According to Sophie *et al.* (no date), digital health's roots trace back to the 1970s with the advent of computational biology. In the 1970s, the foundations of digital health were laid with the emergence of computational biology and bioinformatics, which leveraged the growing computational power to complement traditional biological research. These early computational approaches paved the way for the development of more sophisticated tools and disciplines, such as systems biology and computational genomics, that could generate, store, and interpret vast amounts of medical data.

A study by Wall, Hetherington and Godfrey (2023) on the rise of wearables and smartphones in decentralizing healthcare revealed that wearable technology and smartphones are driving a transformative shift in patient monitoring and personalized healthcare, signaling a new era in digital health. Wearable devices, equipped with advanced sensing technologies such as accelerometers for tracking movement and optical sensors for monitoring heart rate, are gaining recognition for their vast potential in remote patient monitoring, diagnostics, and therapeutic applications. Similarly, smartphones, which have evolved far beyond their original role as communication devices, are now pivotal instruments in health monitoring. With their integrated sensing capabilities and Internet of Things (IoT) connectivity, smartphones are facilitating a seamless shift from conventional healthcare practices to a more interconnected, digitally-driven healthcare landscape.

Wilson and Maeder (2015) revealed in their study on recent directions in telemedicine, that telemedicine has transitioned from a niche technology to a critical component of healthcare delivery across various specialties. Although its adoption began in the 1990s, early development was limited by inadequate telecommunications infrastructure and high costs of peripheral devices.

In the twenty-first century, advancements in technology have facilitated widespread use of telehealth. Today, telemedicine is integral to healthcare in both developed and an increasing number of developing countries, encompassing diverse settings from mobile patient applications to complex clinical interactions in tertiary hospitals.

A study conducted by Alam *et al.* (2020) on the adoption of mHealth services in Bangladesh has demonstrated a growing popularity of mHealth in developing countries. Many governments are increasingly acknowledging the potential benefits of mHealth and have incorporated it into their strategies to achieve health system objectives, including Sustainable Development Goals (SDGs). Additionally, the study highlights variability in acceptance rates of mHealth services across different age groups, with younger users showing a higher propensity for engagement due to their reliance on smartphone technology.

In his study on high-performance medicine, Topol, (2019) highlighted the emergence of AI and ML as transformative technologies in healthcare. These technologies offer advanced capabilities in diagnostics, treatment planning, and personalized medicine. Over the past decade, AI and ML algorithms have been increasingly utilized to analyze complex datasets, including medical images and genomic information, resulting in more accurate and timely diagnoses.

## 2.6 Strengths and Limitations of Digital Health Interventions

Digital health interventions have several strengths associated with their implementation. A qualitative study conducted by O'Brien *et al.* (2023) in Sub-Saharan Africa reported that digital health technologies enhance the accessibility of healthcare at the patient level. The authors further explained that DHIs ensured both the accessibility and continuity of care, particularly in relation to hard-to-reach populations and during the COVID-19 pandemic. Additionally, it was observed that improved accessibility through digital platforms not only expands reach but also increases patient usage and adherence to healthcare interventions.

A scoping review by Palacholla *et al.* (2019) on digital health technology adoption for hypertension management revealed that DHIs enhance patient monitoring to prevent adverse health outcomes. The study found that some patients benefited from using digital health technologies to monitor their blood pressure readings, which helped alleviate health-related anxiety. Similarly, in their study on remote monitoring and digital health tools in cardiovascular disease management, Cowie and Lam (2021) highlighted a closed-loop system that integrates remote monitoring with patch technology. This system continuously tracks blood sugar levels and is connected to a wearable insulin pump, offering advanced care for patients with type 1 diabetes mellitus.

Another strength of digital health interventions (DHIs), particularly electronic health records (EHRs), is their ability to enhance decision-making in clinical practice. A study by Kataria and Ravindran (2020) highlights that the structured and processed format of patient information, combined with real-time tracking, offers busy clinicians unparalleled decision-making opportunities compared to the cumbersome nature of paper-based records. Additionally, the study reported that EHRs provide time-sensitive alerts and reminders that align with patient

management, prevention, and screening protocols, which have been shown to improve the quality of care, especially in managing chronic diseases.

Digital health interventions (DHIs) have significantly improved communication between patients and healthcare providers, particularly in remote or hard-to-reach areas. A study by Hirsch-Moverman *et al.* (2017) focusing on the use of mHealth for HIV and tuberculosis (TB) treatment support in Lesotho exemplifies this. Mobile phone technology, a key component of DHIs, facilitates easy and remote communication between health workers and patients in communities where access to healthcare is limited due to poor infrastructure or transportation challenges.

Another notable strength of DHIs is their role in promoting the self-management of disease conditions. A study by Nhavoto, Grönlund and Klein (2017) on a mobile health treatment support intervention for HIV and TB patients in Mozambique highlighted how mHealth reminders from health workers helped patients adhere to treatment protocols. These reminders ensured that patients collected their medication on time and attended clinical appointments regularly, ultimately supporting better disease management and improving health outcomes.

However, the implementation of digital health interventions has certain limitations that must be carefully addressed. A study conducted by LoBuono *et al.* (2023) in the northeast US identified poor product design as a significant barrier to the effective use of digital health platforms. Participants reported that the design of many technological devices was not suitable for the population. Specific design issues included screens that were too small for those with impaired vision, as well as touchscreens and buttons that were either too small or incompatible with conditions such as tremors. These design flaws limit the accessibility and usability of digital health technologies, particularly for vulnerable groups.

Poor internet connectivity, compounded by unreliable electricity supply, poses significant challenges to the adoption and implementation of digital health technologies in Sub-Saharan Africa (SSA). A study by Owhor, Abdulwahab and Oluwaseun (2023) on Digital Health in Sub-Saharan Africa highlights that inadequate electricity supply is a major obstacle to the effective use of digital health interventions across the region. Frequent power outages are prevalent in countries such as Nigeria, South Sudan, Chad, Malawi, Niger, and Sierra Leone, severely limiting the consistent operation of digital health platforms and telemedicine services. Onsongo *et al.* (2023) corroborated this in a similar study in Kenya stating thar internet connectivity in many parts of Africa remains either non-existent or slow, further constraining the quality and reliability of digital health services. The combination of these infrastructural challenges significantly impedes the region's ability to fully harness the potential of digital health technologies.

A study conducted by Kasoju *et al.* (2023) in India, reported interoperability as another significant challenge in the evolution of digital health, as many digital health systems struggle to effectively communicate with one another. This lack of compatibility hinders the seamless exchange of patient data between different healthcare platforms, creating barriers to efficient care delivery. The inability to integrate and share crucial health information can impede healthcare providers' access to comprehensive patient records, which in turn can negatively impact patient outcomes.

A systematic review by Kaboré *et al.* (2022) revealed that the high cost of services associated with digital health interventions poses a significant challenge to their sustainability, particularly in low- and middle-income countries. This financial burden limits the long-term viability of these technologies in resource-constrained settings. Similarly, a study by Onsongo in Kenya identified the high cost of equipment, software, and initial setup as a substantial barrier to the adoption of telemedicine. These expenses create obstacles for healthcare systems and providers seeking to implement digital health solutions, further complicating efforts to scale and sustain these interventions in economically disadvantaged regions.

Another significant limitation of DHIs is their lack of integration with existing healthcare systems. A scoping review by Whitelaw *et al.* (2021) identified the poor integration of DHIs with electronic medical records as a key clinician-level barrier to their adoption. This disconnect complicates the seamless use of digital tools in clinical practice. Additionally, findings from study by Onsongo *et al.* (2023) in Kenya emphasized that the limited or non-existent integration of telemedicine services into the daily workflow of healthcare providers poses a major obstacle to their widespread adoption. This lack of alignment between digital health technologies and existing healthcare operations hinders their effective utilization and acceptance by practitioners.

A qualitative study by Kaihlanen et al. (2022) exploring the experiences of vulnerable groups in accessing digital health services during the COVID-19 pandemic found that many participants faced significant barriers due to a lack of suitable devices. This lack of access to essential technology, such as smartphones or computers, hindered their ability to utilize digital health services effectively. Similarly, a scoping review by Godwin et al. underscored that the absence of smartphones and computers was a fundamental barrier to the adoption and use of mobile health applications.

# CHAPTER 3

# 3.0 METHODOLOGY

This chapter explains the methods employed in conducting this systematic review encompassing various components including study design, selection criteria for inclusion and exclusion of studies, search strategy, data extraction methods, and synthesis techniques.

## 3.1 Study Design

A systematic review was conducted to capture all studies on digital health interventions implemented in Ghana. This study was primarily qualitative and descriptive, with no statistical analysis conducted. Systematic reviewing is a method used to synthesize the available scientific evidence to address a clearly formulated research question. It enables researchers to collate relevant studies, assess the quality of evidence, and generate conclusions and/or identify knowledge gaps. The current review employed methods informed by Cochrane guidance on conducted reviews and results are reported in line with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Page *et al.*, 2021). The protocol for this systematic review was published in the PROSPERO Database in June 2024 (reference: CRD42024555221).

## 3.2 Study Site

The study site for this systematic review was Ghana. The research included all eligible studies conducted within the geographical boundaries of Ghana.

## 3.3 Study Population

The study population for this systematic review included all digital health interventions implemented in the Ghana. This includes but was not limited to mobile health (mHealth) applications, text message-based programs, telemedicine platforms, electronic health records (EHRs), health information systems (HIS), electronic decision support systems (eDSS), and other digital health solutions aimed at improving healthcare delivery, patient outcomes, and health system efficiency in Ghana.

### 3.4 Inclusion Criteria

Studies that met all of the above criteria were included in this systematic review:

a. The study must be conducted in Ghana

b. The study must focus on digital health interventions

c. Studies must be published in English

d. Studies must be published between the years 2004 and 2024

This systematic review considered all primary study designs including observational studies like cross-sectional studies, case studies, and cohort studies.

### 3.5 Exclusion Criteria

a. Studies conducted outside of Ghana

b. Studies not focusing on digital health interventions

c. Studies published before 2004 or after 2024

d. The review excluded studies that were not primary research, including systematic reviews, meta-analyses, and secondary analyses.

e. Studies not published in English

### 3.6 Sample Size

Due to the nature of this study, there was no traditional sample size calculation. Instead, this review involved the synthesis of existing literature rather than the collection of primary data. The review strived to be as inclusive as possible, incorporating all relevant studies meeting the predetermined inclusion criteria. 29 eligible studies were identified through systematic search strategies across various databases and sources.

### 3.7 Data Collection Methods and Instruments

This section outlines the strategies and tools that were employed to collect, select, and extract data pertinent to the research objectives. This section is further divided into three integral subsections: "Search Strategy", "Selection Process", and "Data Extraction".

#### 3.7.1 Search Strategy

The search strategy attempted to balance sensitivity with specificity in its results. Keywords were used to ensure more specificity in the search. Previous systematic reviews conducted on digital health studies, alongside insights from review helped inform the search strategy. The electronic databases of PubMed, Google Scholar, ProQuest, and The Lens were searched on 4-6th April 2024 to find relevant studies. The complete search strings are included in Table 3.7. Some of the keywords and terms used included 'digital health, 'eHealth, 'mHealth', 'telemedicine,' 'Ghana,' and 'Electronic Health Records. Groups of keywords relevant to a specific category (for instance, setting) type were combined using the 'OR' Boolean term (e.g., mobile health OR mHealth OR eHealth) and categories of keywords were then combined using the AND Boolean operand (see Table 3.7). Restrictions were placed on country of origin, language, and accessible

peer-reviewed papers published since 2004. Additionally, the research team scanned the reference lists of included papers and contacted experts in the field to help identify other potentially relevant studies.

***Table 3.7 Database search results***

| Database | Intervention Terms (OR) | Setting (AND) | Results |
|---|---|---|---|
| **Google Scholar** | digital health, ehealth, electronic health records, mHealth, m-Health, mobile health, mobile-based care, telemedicine, telehealth, telenursing, teleconsultation, health technology | Ghana | 30,200 |
| **PubMed** | digital health, ehealth[MeSH Terms], mHealth, m-Health, telemedicine[MeSH Terms], telehealth[MeSH Terms], telenursing[MeSH Terms], electronic health records[MeSH Terms], mobile health[MeSH Terms], mobile-based care, teleconsultation[MeSH Terms], health technology[MeSH Terms] | Ghana | 353 |
| **The Lens** | digital health, ehealth, electronic health records, mHealth, m-Health, mobile health, mobile-based care, telemedicine, telehealth, telenursing, teleconsultation, health technology | Ghana | 28,000 |
| **ProQuest** | digital health, ehealth, mHealth, m-health, mobile health, Electronic Health Records, Telemedicine, telehealth, health technologies | Ghana | 825,613 |

### 3.7.2 Selection Process

The online specialized systematic review website, Rayyan, was employed to manage the review. Rayyan enables multiple reviewers to independently screen records, it displays conflicts and tracks the number of papers excluded and reason for exclusion at each phase of the systematic review (Ouzzani *et al.*, 2016). Two reviewers independently screened record titles and abstracts based on the eligibility criteria. Where there was any disagreement or ambiguity, a third reviewer assessed the relevant records and consensus was reached on eligibility through discussion, and, where appropriate, retrieval and review of the full-text document. Studies were excluded when access to

full-text articles were not available, even after having attempted to contact the corresponding author by email. The reasons for rejecting papers at each stage were be recorded.

### 3.7.3 Search results

This systematic review followed a comprehensive search and selection process, as illustrated in the PRISMA flow diagram (Figure 3.1). The PRISMA flow diagram effectively illustrates the systematic and thorough nature of the study selection process, ensuring that the most relevant and high-quality studies were included in the final review.

The initial search of databases yielded a total of 884,166 studies, demonstrating the broad scope of the initial search strategy. The screening process involved several steps. From the initial pool of 884,166 studies, 560 duplicates were identified and removed, leaving 883,606 unique records for further screening.

A thorough review of titles and abstracts led to the exclusion of 883,392 studies. These were excluded based on predefined criteria that deemed them irrelevant to the review's objectives. The remaining 214 studies were assessed for eligibility through full-text review. During this phase, an additional 185 studies were excluded for various reasons, including insufficient detail in describing the digital health intervention, not being peer-reviewed, inaccessibility of full texts, lack of relevance to the review objectives, and absence of reported intervention outcomes.

After the rigorous screening and assessment process, a total of 29 studies met all eligibility criteria and were included in the final review. These studies comprised 17 quantitative studies, 8 qualitative studies, 1 mixed-method study, and 3 descriptive articles.

This final set of 29 studies forms the basis for the in-depth analysis and synthesis of findings in this systematic review. The varied range of study types included allows for a comprehensive examination of digital health interventions in Ghana from multiple methodological perspectives.

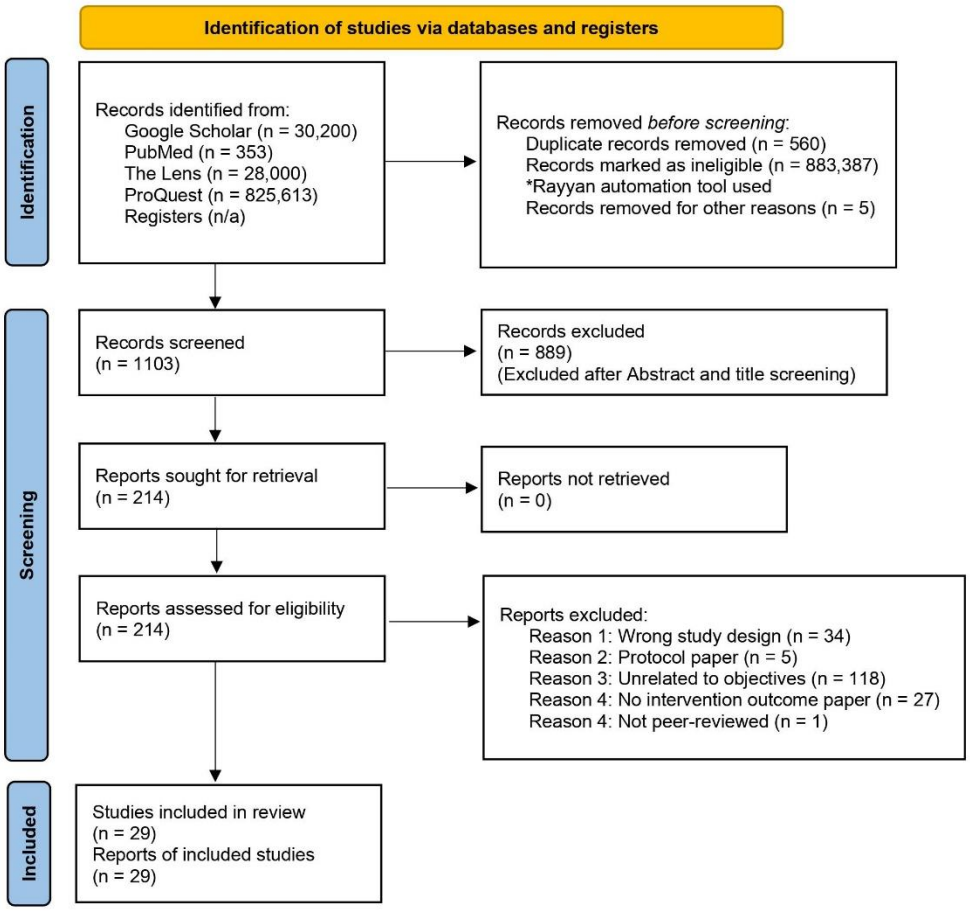


*Figure 3.1: PRISMA 2020 flow diagram for new systematic reviews which included searches of databases and registers only*

### 3.7.4 Data Extraction

A structured data extraction form to capture information from the relevant records was developed in Microsoft Excel 2021. Consistent with recommendations for best practice for systematic reviews of interventions (Hoffmann *et al.*, 2017), the data extraction template collected

information relevant to: study details (country of study, setting/context); study design, characteristics of study populations (PICOS), and limitations and strengths of digital health interventions; duration of intervention(s). The data extraction form was shared and allowed both reviewers to extract data independently and enabled comparisons between reviewers.

### 3.8 Pre-testing

Before full-scale data extraction, the research team conducted a thorough pretesting of the data extraction forms. This crucial step ensured the forms' reliability, consistency, and ability to capture all relevant information accurately. A sample of 5 different studies from the initial search results were used for this process. Two independent reviewers extracted data from these studies using the draft forms. The results were compared to identify any discrepancies, ambiguities, or missing elements in the forms. Based on this feedback, the forms were refined and adjusted as necessary.

### 3.9 Data Handling

This section delineates the procedures and protocols that were used to manage, document, and protect the data used in this study. The section is structured into two key subsections: "Management and Documentation of Search Results" and "Confidentiality and Privacy," each offering a transparent account of the prospective data handling process.

#### 3.9.1 Management and Documentation of Search Results

All references from the electronic searches were imported into Endnote reference management software, where duplicates were identified and automatically removed. A manual revision was done for verification. This software was also used to manage the inclusion and exclusion process. Each included and excluded study was documented with reasons for exclusion.

For further screening and collaboration, the references were imported into Rayyan. Rayyan was used to manage the flow of articles within the review, facilitate blinded screening, tagging, and categorizing of studies. The complete search strategy for each database has been included in table 3.7 to ensure transparency and reproducibility. This included the search terms used and the number of results returned for each term or combination of terms.

### 3.9.2 Confidentiality and Privacy

All data collected during the review process, including study records, extracted data, and any other related documents, were securely stored in password-protected electronic folder accessible only to authorized members of the review team. While individual participant confidentiality is not a primary concern in systematic reviews, measures were taken to anonymize and remove personal identifying information from the data extraction forms to maintain privacy. Regular backups of all data were maintained to prevent data loss. Additionally, all steps involved in data handling have been documented to ensure transparency and reproducibility, in alignment with PRISMA guidelines. The data will be retained for a period of 5 years after the completion of the review, in accordance with institutional policies and relevant regulations, providing sufficient time for reference in the publication process.

## 3.10 Quality Appraisal

As appropriate to the study design, methodological quality assessment frameworks including an adapted version of the Critical Appraisal Skills Programme (CASP) Qualitative tool (CASP-UK, no date), a 14-item "Standard Quality Assessment Checklist for Quantitative Studies" (Duden, Gersdorf and Stengler, 2022), CRAAP test (Esparrago-Kalidas, 2021), and the Mixed Method Appraisal Tool (MMAT) (Pace *et al.*, 2012) were used to evaluate the quality of included studies.

The CASP was employed to evaluate the 17 qualitative studies in the review. This 10-item checklist was systematically applied to each study, with responses recorded as "Yes," "No," or "Can't Tell" for each criterion. The cumulative scores, out of a possible 10, provided an overall quality assessment for each study. Those meeting all 10 criteria were deemed of the highest quality, while studies meeting 9 out of 10 were still considered high quality but with minor limitations. The CASP checklist facilitated a thorough examination of key aspects of qualitative research, including clarity of aims, methodological appropriateness, recruitment strategies, data collection methods, researcher-participant relationships, ethical considerations, analytical rigor, clarity of findings, and the overall value of the research.

For the evaluation of the 9 quantitative studies, the Standard Quality Assessment Checklist for Quantitative Studies was utilized. This 14-item checklist was applied to each study, with responses recorded as "Yes," "No," "Partial," or "N/A" (Not Applicable) for each applicable criterion. The overall quality of each study was determined by tallying these responses against the total number of applicable criteria. Studies meeting all applicable criteria were considered to be of the highest quality, while those with "Partial" or "No" responses in certain areas were noted to have specific limitations. This checklist assessed various aspects of quantitative research, including clarity of objectives, appropriateness of study design, subject description, outcome measures, sample size, analytic methods, reporting of results, and support for conclusions.

The CRAAP test was employed to assess the quality of 3 descriptive studies included in the review. Each study was evaluated on the five CRAAP criteria, with scores ranging from 1 to 5 assigned for each criterion. An overall score out of 5 was then calculated by averaging the scores across all criteria. Studies scoring above 3.8 were considered to demonstrate good overall quality and

credibility. This test was particularly valuable for assessing the overall credibility and relevance of information sources in descriptive studies that may not adhere to strict research methodologies.

The Mixed Methods Appraisal Tool (MMAT) was used to evaluate the single mixed methods study in the review. The study was assessed against all applicable criteria in the tool, with responses recorded as "Yes," "No," or "Can't Tell." The overall quality was determined based on the number of criteria met, with particular attention paid to the integration of qualitative and quantitative components.

In all cases, two reviewers independently applied these tools to each study, and any disagreements were resolved through discussion or consultation with a third reviewer. This process ensured a rigorous and consistent approach to quality assessment across all included studies.

### 3.11 Data Analysis

As this review includes studies with large heterogeneity in interventions and measures, a statistical analysis was inappropriate (Campbell *et al.*, 2019). A thematic synthesis was employed to describe the outcomes of evidence for each study. Thematic analysis was employed to identify and explore themes aligned with each study objective.

The analysis of data extracted from the 29 included articles followed a rigorous thematic analysis approach, facilitated by ATLAS.ti software. This method was chosen for its flexibility and capacity to identify, analyze, and report patterns within data (Maguire and Delahunt, 2017). The process adhered to the six-phase framework proposed by Braun and Clarke (Maguire and Delahunt, 2017), ensuring a systematic and comprehensive analysis of the strengths and limitations of digital health interventions in Ghana.

Initially, the researchers immersed themselves in the data through repeated reading of the articles, noting preliminary ideas and potential coding schemes. This familiarization phase was crucial in developing a holistic understanding of the content and context of the studies. Subsequently, the coding process commenced, utilizing ATLAS.ti to assign codes to relevant excerpts from the articles. The coding was inductive, allowing themes to emerge from the data, and deductive, guided by the research objective of assessing digital health interventions in Ghana.

As the coding progressed, related codes were clustered to form potential themes. This iterative process involved constant comparison and refinement, ensuring that the emerging themes accurately represented the coded data and addressed the research question. The themes were then reviewed for coherence and distinctiveness, with some being merged, split, or discarded as necessary. Each theme was subsequently defined and named to capture its essence and relevance to the strengths and limitations of digital health interventions.

The PICOS (Population, Intervention, Comparators, Outcomes, Study design) framework was used to analyze each included study as well. Results were reported in accordance with PRISMA guidelines and current recommendations on the description of interventions in systematic reviews. Descriptive analysis was also conducted, including the development of a charts using Excel version 2021 and R software to depict trends in studies and DHIs.

### 3.12 Dissemination of results

The results of this study were shared with Ensign Global College, the Ghana Health Service, and relevant NGOs. Findings from this systematic review are set to be presented at health conferences, seminars and in a peer-reviewed journal.

## 3.13 Ethical Considerations

Given the nature of systematic reviews, there was no direct interaction with patients or access to individual patient data. Instead, it involved the analysis of previously published data which mitigated privacy concerns. Confidentiality was maintained by anonymizing data and securely storing all research materials. Findings from included studies were objectively reported exactly as the author(s) reported. Additionally, ethical approval was sought from the Institutional Review Board of Ensign Global College to ensure compliance with ethical research standards.

## 3.14 Limitations of Study

Potential limitations of this systematic review include publication bias, heterogeneity, language and accessibility. The review might have been subject to publication bias, as studies with positive findings are more likely to be published. The diversity in study designs, interventions, and outcome measures might limit the comparability of findings. Also, studies published in languages other than English and those not readily accessible were excluded, which might limit the comprehensiveness of the review.

## 3.15 Assumptions

The review assumes that the included studies accurately reported their findings and that the search strategy was comprehensive enough to capture all relevant studies.

# CHAPTER 4

# 4.0 RESULTS

## 4.1 Introduction

This chapter presents the results of this systematic review. The findings are organized to address the specific research questions and objectives outlined in the introduction. The results are drawn from a comprehensive analysis of selected studies, highlighting the characteristics, strengths, and limitations of digital health interventions in the Ghanaian context. This chapter has two key sections: Section 1 – Description of included digital health studies (sub-heading 4.2), and Section 2 – Assessment of Digital Health Interventions in Ghana (sub-headings 4.3, 4.4, and 4.5).

## 4.2 Description/Characteristics of Included Studies

A total of 29 studies were included in this systematic review. These studies were selected based on predefined inclusion and exclusion criteria and further appraised using standard quality assessment tools to ensure the relevance and rigor of the evidence collected. The studies utilized various research designs, including observational studies, qualitative studies, and mixed-methods studies. Figure 4.1 shows the distribution of study designs of included studies.

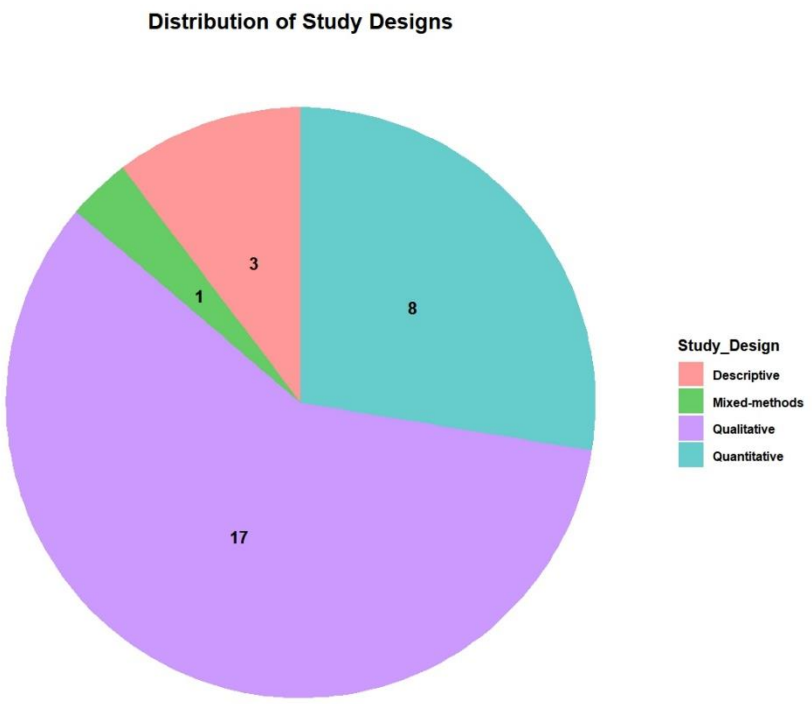


*Figure 4.1: Distribution of Study Designs*

The publication years of these studies ranged from 2004 to 2024 with the majority (17) of them published in the last 5 years, accounting for approximately 58.6%. Refer to Appendix 1.0 for more details. The characteristics of the included studies are summarized in Table 4.1. The included studies were diverse in terms of their population, intervention types, outcomes measured, and study designs. The DHIs described in these papers varied widely across key populations in Ghana including healthcare providers, such as doctors and nurses; patients and caregivers; the general population; and health system administrators.

Regarding the outcome component in PICOS, the included studies covered outcomes including usability and acceptability of digital health technologies, impact on healthcare quality and efficiency, user satisfaction (both healthcare providers and patients), health outcomes (like

maternal and child health indicators), cost-effectiveness and resource utilization, data quality and completeness, as well as healthcare access and utilization patterns

Regarding interventions, the digital health interventions studied in Ghana included telerehabilitation, teleconsultation, health information management systems, Electronic Health Records (EHR), and mobile health (mHealth).

With reference to the comparators' component in the PICOS framework, majority of the studies did not explicitly define comparators, as many were observational or qualitative in nature. However, some studies implicitly compared digital health interventions with standard practices or no intervention scenarios. Key comparators identified were traditional paper-based systems (particularly for EHR studies), standard care without digital support, as well as, pre-intervention baselines.

***Table 4.1 Characteristics of Included Studies***

| Author/Year (Citation) | Title | Study Design | Purpose/Rationale | Target Population | Setting | Key Findings | Conclusion |
|---|---|---|---|---|---|---|---|
| (Paul *et al.*, 2024) | Views of Service Users, Their Family or Carers, and Health Care Professionals on Telerehabilitation for People with Neurological Conditions in Ghana: Qualitative Study | Qualitative Study | Investigate the views of service users, their family or carers, and health care professionals (HCPs) on telerehabilitation for people with neurological conditions in Ghana. | Service users with neurological conditions (stroke and Parkinson's disease), their family or carers, and healthcare professionals (speech and language therapists, physiotherapists, occupational therapists, medical staff, nurse, industry representative) | Ghana/Komfo Anokye Hospital, Kumasi | Participants generally had a positive view of telerehabilitation, favoring a hybrid model that combines initial in-person sessions with subsequent telerehabilitation. They noted benefits such as convenience, lower costs, higher therapy doses, and improved access for remote individuals. However, they also identified challenges including unstable internet connections, the cost of phones and data packages, and low literacy levels. Implementation issues involved ensuring cultural relevance, managing information governance, and increasing familiarity with the platforms used (mainly WhatsApp). Additionally, many participants were unaware of telerehabilitation. | Telerehabilitation, especially in a hybrid model, has potential in Ghana for neurological rehabilitation. Challenges such as reliable internet, cultural relevance, and costs need to be addressed. Clinical trials of low-cost, contextualized telerehabilitation interventions are required. |
| (Opoku, Scott and Quentin, 2015) | Healthcare Professionals' Perceptions of the Benefits and Challenges of a Teleconsultation Service in the Amansie-West District of Ghana | Qualitative Study | To assess healthcare professionals' perceptions of the benefits and challenges of a teleconsultation service and identify possible areas for improvement | Community health nurses (CHNs) and teleconsultation center (TCC) healthcare professionals | Amansie-West District, Ghana | The teleconsultation service improved the quality of care at health centers, reducing the need for patient referrals to the district hospital. Practical challenges included inadequate information over the phone, delays in responding to calls, and additional workload for teleconsultation staff. | Teleconsultation services can enhance the quality of care in rural communities but face operational challenges that need to be addressed to ensure sustainability. Adequate training and workload management are essential. |
| (Okyere Boadu *et al.*, 2024) | Healthcare providers' perception towards utilization of health information applications and its associated factors in healthcare delivery in health facilities in Cape Coast Metropolis, Ghana | Descriptive cross-sectional study | To investigate healthcare professionals' perceptions of health information applications and their associated factors in Cape Coast Metropolis health facilities | Healthcare professionals | Ghana (Cape Coast Metropolis) | Barriers included insufficient computers, frequent system downtime, low system performance, and inadequate staff training. Bivariate regression analysis indicates that education, work experience, profession, and IT training significantly influence attitudes towards IT adoption. | While healthcare professionals in the Cape Coast Metropolis acknowledge the moderate benefits of IT in healthcare, they encounter significant barriers such as inadequate resources and insufficient training. Therefore, targeted interventions and policies are essential to enhance IT utilization and maximize its potential benefits in this region. |
| (Mensah, Boadu, *et al.*, 2023) | Electronic health records post-implementation challenges in selected hospitals: A qualitative study in the Central | Qualitative study | To explore post-implementation challenges affecting the deployment of EHRs and their use in selected health facilities in Ghana | Health workers and facility management members using EHR systems in two selected hospitals | Ghana (Central Region) | Key challenges identified: 1) Lack of technical support, 2) Inadequate equipment, 3) Unfriendly software design, 4) Poor user-interface and workflow issues, 5) Unreliable internet/network connectivity, 6) | While EHR post-implementation challenges facing health facilities are surmountable, managerial support backed with requisite logistical and technical support is needed. Health institutions should prioritize emerging EHR post-implementation challenges in their operating budgets. |

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| | Region of southern Ghana | | | | | Unreliable power supply, 7) Lack of funding, 8) Inadequate training | |
| (Hammond *et al.*, 2020) | Challenges encountered with the use of mobile phones to deliver public health services in the Greater Accra Region of Ghana- A qualitative study | Qualitative Study | To explore the challenges encountered in the use of the mobile phone to deliver public health services in the Greater Accra Region of Ghana. | Healthcare providers (doctors, nurses, pharmacists, administrators, public health officers, community health workers, policy makers) | Ghana/Greater Accra Region | Key challenges include management and leadership issues, financial costs, access, infrastructure, technical and human resources. | Despite the high adoption of mobile phones by healthcare providers, there are significant challenges constraining the uptake of mHealth for public health services. A new analytical framework was developed to aid analysis of mHealth challenges. |
| (Frimpong, 2021) | Evaluation of the Implementation of Electronic Health Record System: Case Study of the Presbyterian Hospital at Dormaa Ahenkro of Bono Region, Ghana | Mixed methods cross-sectional study | To evaluate the implementation of electronic health records at Presbyterian Hospital in Dormaa Ahenkro, Bono Region, Ghana | Staff and management of Presbyterian Hospital (n=50) | Ghana / Presbyterian Hospital in Dormaa Ahenkro, Bono Region | Factors like performance expectancy, effort expectancy, social influence and facilitating conditions highly influenced adoption of HER. EHR improved accuracy of patient data, staff access to information, quality of care, and administrative reporting. Main challenges were frequent power outages and login issues. Management addressed challenges through procuring generators and system updates | Successful EHR implementation depends on staff skills/knowledge. Strategies like reliable power, backup systems and regular upgrades are needed to improve healthcare delivery |
| (Gyamfi *et al.*, 2017) | Barriers and facilitators to Electronic Medical Records usage in the Emergency Centre at Komfo Anokye Teaching Hospital, Kumasi-Ghana | Qualitative study | To identify the facilitators and barriers to EMR implementation in Komfo Anokye Teaching Hospital's Emergency Centre and to identify lessons learned for implementing EMR in similar settings. | Core implementers and end-users of EMR | Ghana, Komfo Anokye Teaching Hospital, Kumasi | Facilitators included providing training to staff, availability of some logistics, and staff commitment. Barriers were funding, full-time information technology expertise, and automatic data and power backups. With adequate human and financial resources, challenges were overcome, and EMR adoption improved. | The EMR implementation was a partial success. Training, provision of logistics, and staff commitment are crucial facilitators. Barriers like lack of funding, IT expertise, and data/power backups need to be addressed for successful EMR implementation. Lack of funding is a significant limiting factor. |
| (Acquah-Swanzy, 2015) | Evaluating Electronic Health Record Systems in Ghana: the case of Effia Nkwanta Regional Hospital | Interpretive Case Study | To evaluate the implemented EHR by assessing preparations made prior to introduction, factors that impede or promote usability and satisfaction, and the impact of EHR on healthcare delivery. | Users of the EHR system and system administrators | Ghana/Effia Nkwanta Regional Hospital | Adequate preparations included studying other systems, establishing an IT department, and training staff. Drawbacks included inadequate computers and training, and non-involvement of users in design. Benefits included reduced errors and missing files, reduced work tasks, and reduced paper costs. Challenges included poor network connections, illegible handwriting, unstable power supply, and increased work tasks. Funding was not a major challenge due to budgetary allocations and payment plans with vendors. | While the EHR system showed significant benefits, including reduced errors and operational efficiencies, challenges such as infrastructure issues and user training need to be addressed. Recommendations were made to ensure the sustainability of the EHR. |
| (Acquah-Gyan *et al.*, 2022) | User experiences of a mobile phone-based health information and surveillance system (mHISS): A case of caregivers of children | Exploratory qualitative study | To explore user experiences of a mobile phone-based interactive voice response (IVR) system among caregivers of children under-five in rural communities in the Asante Akim North District of Ghana. | Caregivers of children under-five who had used the IVR system implemented by the "MobChild project" at least once. | Asante Akim North District, Ghana | The mHISS system was found to be acceptable and positively received by caregivers. The system improved access to healthcare, communication with health professionals, and awareness about self-management of childhood illnesses.Major barriers | The mHISS system was generally acceptable and could help improve access to healthcare and identify children with severe health conditions during outbreaks of diseases. |

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| | under-five in rural communities in Ghana | | | | | were poor network quality, unstable electricity supply, and dropped/cut calls. | |
| (Mensah, Adzakpah, *et al.*, 2023) | Perceived impact of digital health technology on health professionals and their work: A qualitative study in Southern Ghana | Qualitative (exploratory) study | To explore the perception of health professionals about DHT and its impact on their work, and to recommend steps to mitigate any negative impacts. | Healthcare professionals working in three selected health facilities in Ghana | Ghana (Volta, Eastern, and Central Regions) | DHT reduced workload and ensured continuity of care. DHT was perceived as fast and ensured quality and accurate information accessible for better decision making. Poor internet connectivity and erratic power supplies were major impediments causing delays and frustrations. | DHT has a positive effect on the work of health professionals. However, poor internet connectivity and unstable power supply caused delays in care provision and work process disruptions, threatening to erode the potential benefits of DHT. Measures are needed to improve infrastructure to support the effective use of DHT. |
| (Abejirinde *et al.*, 2018) | Pregnant women's experiences with an integrated diagnostic and decision support device for antenatal care in Ghana | Qualitative Study | To explore the experiences of pregnant women with Bliss4Midwives (B4M), and its influence on service utilization ("pull effect") and woman-provider relationships ("woman engagement"). | Pregnant women and health workers | Upper East region, Ghana | Women's first impressions of the device ranged from excitement to fear. While it is inconclusive if B4M increased ANC registration, women valued the availability of diagnostic services at the point-of-care. The intervention fostered engagement, making women feel listened to and cared for, enhanced trust in diagnostic recommendations, and motivated referral compliance. | mHealth diagnostic and decision support devices enhance woman engagement and trust in health workers' skills. Further inquiry is needed into how these interventions influence maternal health service utilization and women's expectations of pregnancy care. |
| (P. Peprah *et al.*, 2020) | Lessening barriers to healthcare in rural Ghana: providers and users' perspectives on the role of mHealth technology. A qualitative exploration | Qualitative Study | To explore the role of mHealth technology in reducing healthcare barriers in rural areas from the perspective of healthcare users and providers in rural Ghana. | Healthcare users and providers | Birim South District, Eastern Region of Ghana | All healthcare users had functioning mobile phones, but knowledge and awareness about mHealth were low. Both healthcare users and providers were willing to use mHealth services involving phone calls in the future. Perceived barriers associated with mHealth included illiteracy, language barrier, trust, quality of care, and mobile network connectivity. | Support for mHealth services presents an opportunity for collaboration between health policy planners and mobile network companies in Ghana to design efficient, localized, user-friendly, and cost-effective mobile phone-based health programs to aid in reducing healthcare barriers in rural Ghana. |
| (Tchao *et al.*, 2019) | On Telemedicine Implementations in Ghana | Descriptive Review | To present telemedicine applications and implementations in Ghana and provide recommendations to mitigate challenges. | General population with a focus on rural areas and healthcare providers in Ghana. | Ghana | The study found that telemedicine in Ghana is hindered by lack of resources, limited government support, and absence of structured frameworks and policies. Other challenges include low investment in fast internet and data transmission infrastructure, especially in rural areas. However, telemedicine has the potential to improve healthcare access and quality. | Telemedicine can address healthcare disparities in Ghana, particularly in rural areas, but requires more resources, government support, and structured frameworks for successful implementation. |
| (Rothstein *et al.*, 2016) | Qualitative Assessment of the Feasibility, Usability, and Acceptability of a Mobile Client Data App for Community-Based Maternal, Neonatal, and Child Care in Rural Ghana | Qualitative study | To qualitatively assess the feasibility, usability, and acceptability of a mobile Client Data App used by community health nurses (CHNs) for maternal, neonatal, and child care | Community health nurses (CHNs), midwives, and district health officers | Rural Ghana, specifically Awutu Senya and Gomoa West districts | The app was easily integrated into care, improved CHN productivity, and facilitated client follow-up, data reporting, and decision-making. However, high client volumes, staff shortages, and software/device challenges hindered feasibility and usability. | Successful integration of mobile client data apps in rural and resource-poor settings requires real-time monitoring, program investments, and targeted changes in human resources. |

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| (Ginsburg *et al.*, 2016) | mPneumonia, an Innovation for Diagnosing and Treating Childhood Pneumonia in Low-Resource Settings: A Feasibility, Usability and Acceptability Study in Ghana | Design-stage qualitative pilot study | To assess the feasibility, usability, and acceptability of the mPneumonia mobile health application for diagnosing and treating childhood pneumonia in low-resource settings | Health administrators, healthcare providers (HCPs), and caregivers of children | Ghana, specifically in six health centers and five community-based health planning and services centers in Kintampo North and South Districts | Health administrators reported feasibility with approval from decision makers; HCPs found the application easy to use and beneficial for patient care; challenges included electricity requirements and time to complete the application; caregivers had mixed reactions to the new technology | mPneumonia is a promising innovation for improving the quality of care in frontline health facilities and is valued by users despite some challenges |
| (Achampong, 2012b) | The State of Information and Communication Technology and Health Informatics in Ghana | Descriptive Review | To discuss the state of ICT and health informatics in Ghana, and to analyse the past and present state of health informatics compared to other African countries. | General population, healthcare providers, health informatics stakeholders | Ghana | ICT has driven down healthcare costs and improved delivery and effectiveness of healthcare services. Ghana is a regional leader in ICT since the first internet connection in 1989. Internet penetration is low at household level but increasing due to internet cafes. ICT infrastructure in healthcare facilities is present but not fully integrated. Government policies like ICT4AD and ehealth strategies are in place to harness ICT for health improvements. | There are significant opportunities for ICT to improve health systems in Ghana, but challenges such as low computer ownership and internet penetration at the household level need to be addressed for widespread adoption. |
| (Osei, Kuupiel and Mashamba-Thompson, 2020b) | Availability and Use of Mobile Health Technology for Disease Diagnosis and Treatment Support by Health Workers in the Ashanti Region of Ghana: A Cross-Sectional Survey | Cross-Sectional Survey | To examine the availability and use of mobile health (mHealth) for disease diagnosis and treatment support by healthcare professionals in the Ashanti Region of Ghana. | Healthcare professionals including clinicians, nurses, laboratory scientists, pharmacists, physiotherapists, radiologists, etc. | Ashanti Region, Ghana | 64.91% of healthcare professionals indicated that mHealth is available to them. 98.4% of those with access to mHealth use it to support healthcare delivery. Factors such as availability of mobile wireless devices, phone calls, text messages, and mobile apps are significantly associated with HIV, TB, medication adherence, clinic appointments, and others. Low level of mHealth use for disease diagnosis and treatment support by healthcare professionals at rural clinics. | Policymakers are encouraged to promote the implementation of mHealth in rural clinics to improve healthcare delivery and patient outcomes. The study suggests integrating mHealth applications into the normal clinical flow to promote universal health coverage. |
| (Carney, 2016) | Delivering Healthcare to Rural Ghana: telmedx and Mahiri Mobile Serve Patients in Remote Areas | Descriptive Case Study | To describe the implementation and impact of the Mahiri-telmedx telemedicine platform in delivering healthcare to remote areas in Ghana. | Rural population of Ghana | Ghana (Tamale and Nsawam) | Improved access to healthcare in rural areas. Treatment of various medical conditions through telemedicine. High-quality video and image resolution. Over 700 patients treated in less than two months. Patients and community show positive reception towards telemedicine. | The Mahiri-telmedx telemedicine platform has significantly improved healthcare delivery in rural Ghana and has been positively received by both healthcare providers and the community. This technology represents a cost-effective and efficient way to provide medical care to underserved areas. |
| (Owusu *et al.*, 2023a) | The role of digital surveillance during outbreaks: the Ghana experience from COVID-19 response | Descriptive Study | To provide an extensive description of the digital systems employed to enhance Ghana's paper-based disease surveillance system during the COVID-19 response. | General population and health workers in Ghana | Ghana | Ghana implemented various digital surveillance tools which significantly contributed to the country's success in responding to the COVID-19 pandemic by improving case detection, reporting, analysis, and information dissemination. | The adoption of digital systems was crucial in providing up-to-date information for making informed public health decisions. The study underscores the importance of leveraging digital technologies in outbreak responses. |

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| (Nichols *et al.*, 2019) | Post-intervention qualitative assessment of mobile health technology to manage hypertension among Ghanaian stroke survivors | Qualitative study | To explore post-intervention perspectives and gather in-depth insights into the experiences of stroke survivors and their caregivers following participation in a mHealth blood pressure management study. Also, to assess the contextual and organizational facilitators and barriers encountered in the implementation of the intervention. | Stroke survivors and their caregivers; clinicians involved in the intervention | Ghana, Komfo Anokye Teaching Hospital in Kumasi | Overwhelming receptivity toward home blood pressure monitoring and the use of mobile health technology. Benefits noted in having access to equipment and message prompts facilitating adherence. Post-intervention adherence declined, indicating a need for increased exposure to facilitate long-term behavioral change. Participants conveyed a heightened awareness of the importance of BP monitoring and lifestyle changes. | Mobile health technology shows promise in improving BP monitoring and medication adherence among stroke survivors in resource-constrained settings. However, sustained exposure and supportive measures are needed to ensure long-term adherence and behavioral change. |
| (Mensah, 2022) | Understanding the Drivers of Ghanaian Citizens' Adoption Intentions of Mobile Health Services | Quantitative study using the Technology Acceptance Model (TAM) | To examine the factors influencing citizens' adoption of mobile health services in Ghana. | Ghanaian citizens | Ghana | Perceived usefulness and ease of use were significant predictors of the behavioral intention to use and recommend mobile health services. Perceived risk was negatively significant in predicting the intention to use and recommend adoption. Mobile self-efficacy significantly determined the behavioral intention to use, intention to recommend, perceived usefulness, and perceived ease of use of mobile health services. Word-of-mouth positively impacted both the intention to use and recommend. Intention to use had no significant impact on recommendation intention. | Mobile self-efficacy and word-of-mouth communication are critical factors in the adoption and recommendation of mobile health services. Perceived usefulness and ease of use are pivotal, while perceived risk negatively influences adoption intentions. |
| (Brinkel *et al.*, 2017) | An investigation of users' attitudes, requirements and willingness to use mobile phone-based interactive voice response systems for seeking healthcare in Ghana: a qualitative study | Population-based cross-sectional study with qualitative focus group discussions | To specify the requirements of caregivers of children in order to use a symptom-based interactive voice response (IVR) system for seeking healthcare. This included investigating attitudes towards mobile phone use and user experiences and assessing facilitators and challenges to use the IVR system. | Male and female caregivers of at least one child between 0 and 10 years of age | Ghana (peri-urban and rural towns in Shai Osudoku and Ga West district, Tema, and Accra Metropolitan Assembly) | Participants showed a positive attitude towards using mobile phones for seeking healthcare, despite having no previous experience with IVR for health information. The majority saw a significant potential for improving health performance. Identified barriers included concerns about costs, lack of familiarity with the technology, social barriers such as lack of human interaction, and infrastructural challenges. Recommendations included establishing a toll-free number and providing training prior to IVR system use. | Caregivers in the socio-economic environment of Ghana are interested and willing to use mobile phone-based IVR to receive health information for child healthcare. Important user needs should be considered by health program implementers and policymakers to facilitate the development and implementation of IVR systems for seeking healthcare. |
| (Attafuah *et al.*, 2022a) | Satisfied or not satisfied? Electronic health records system implementation in Ghana: Health leaders' perspective | Qualitative Study | To explore the views of health leaders on the implemented electronic health records system in nine hospitals within three regions in Ghana, focusing on the challenges and successes of EHR system implementation. | Hospital leaders who are heads of clinical or non-clinical units with EHR experience | Ghana (Bono, Greater Accra, and Upper East regions) | The study found poor quality of records, lack of involvement of frontline clinicians in the development of the EHR system, inadequate training of staff, and limited workstations as some of the challenges associated with the use of EHR in | It is recommended that addressing inputs from end-users as well as circulating more computers will motivate EHR usage and acceptance. Provision of additional workstations for the various units and involvement of staff in the system development would be most prudent to |

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| | | | | | | hospitals. Health leaders were generally not satisfied with the EHR system. | enable health workers to accept the EHR system in improving the quality of care. |
| (Afarikumah, 2014b) | Electronic Health in Ghana: Current Status and Future Prospects | Descriptive study | To provide an overview of eHealth activities in Ghana, gather information on eHealth projects and initiatives, and assess the current status and future prospects of eHealth in Ghana. | Health care providers, policy makers, and remote communities in Ghana | Ghana | 22 eHealth projects identified, using mobile devices ranging from PDAs to smartphones. Projects at various stages of implementation, with most being donor-initiated. Data collection from March 2010 to June 2013. | eHealth has a limited current role in Ghana, but there is growing interest and potential for improving health service delivery and access, especially in remote areas. |
| (Adu *et al.*, 2023) | Expanding access to early medical abortion services in Ghana with telemedicine: findings from a pilot evaluation | Mixed-methods process evaluation and qualitative study | To understand the feasibility and acceptability of providing early medical abortion (EMA) services through telemedicine in Ghana. | Women seeking early medical abortion services and healthcare stakeholders, including telemedicine and in-person patients, healthcare managers, and service providers | Ghana (Accra and Kumasi) | Telemedicine for EMA is feasible and acceptable. 97% of patients had a successful EMA at home. 36% of the 878 patients during the pilot reported no other option for accessing an abortion. 84% would opt for the telemedicine service again. 83% were very likely to recommend the service. Telemedicine provides access to patients who feel they do not have other safe service options, meeting specific patient needs in terms of discretion, convenience, and timing. | Telemedicine for EMA can be delivered effectively in a low-resource setting like Ghana, expanding and improving access to critical sexual and reproductive health (SRH) services. |
| (Adjei *et al.*, 2021) | Determinants of a mobile phone-based Interactive Voice Response (mIVR) system for monitoring childhood illnesses in a rural district of Ghana: Empirical evidence from the UTAUT model | Cross-sectional study, nested in the MOBCHILD project | To identify key determinants and moderators of mIVR system use among caregivers in a rural district of Ghana using the Unified Theory of Acceptance and Use of Technology (UTAUT) model | Caregivers of children under-five living in rural communities | Asante Akim North District, Ghana | 101 (28.5%) caregivers had used the system, and 328 (92.7%) had the intention to use the mIVR system. Performance expectancy (PE), effort expectancy (EE), and social influence (SI) positively influenced behavioral intention (BI) to use the mIVR system. Facilitating conditions (FC) and behavioral intention (BI) had a positive influence on user behavior (UB). Mobile phone experience and household wealth significantly moderated the effect of PE, EE, SI, and FC on behavioral intention and usage of mIVR systems. | The perceived usefulness of the mIVR system, ease of use, social influences, and facilitating conditions are key determinants of users' attitude and use of mIVR system. These relationships are significantly moderated by users' phone experience and wealth status. |
| (Essuman *et al.*, 2020) | Factors associated with the utilization of electronic medical records in the Eastern Region of Ghana | Cross-sectional survey | To examine the factors associated with the use of Electronic Medical Records (EMR) in public hospitals in the Eastern Region of Ghana | Healthcare professionals including physicians, physician assistants, nurses, laboratory technicians, radiologists, pharmacists, record managers, and ICT staff | Eastern Region of Ghana | Approximately 59% of health professionals indicated low use of EMR services in their hospitals. Significant negative relationships were found with lack of computer competence ($p<0.001$), poor communication ($p=0.050$), cost of EMR resources ($p<0.001$), lack of technical personnel ($p<0.001$), and lack of EMR software packages ($p<0.001$). | Utilization of EMR services is low among healthcare professionals in the Eastern Region. The Ghana Health Service needs to provide training and resources to encourage and support EMR utilization, enhancing healthcare delivery in the region. Mixed method studies are recommended for better understanding. |
| (Abotsi, Agbemafle | Positive Outcomes and Challenges of Electronic Health Record Systems: | Descriptive cross- | To investigate the function of AlphaChem Hospital's EHRS in delivering high-quality care and | Healthcare professionals | Ghana/AlphaChem Hospital | EHRS enhances patient record accuracy, enables simultaneous care of multiple patients, streamlines | Most healthcare providers were satisfied with the EHRS and preferred it over paper-based records. However, challenges such as |

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| and Ayimey, 2024) | A Case of A Ghanaian Hospital | sectional Study | identify both positive outcomes and challenges associated with its use. | | | appointment scheduling, and reduces care time while maintaining high user satisfaction. Challenges include lack of technical training, lack of technical support, and unstable internet connectivity. | lack of technical training, insufficient technical support, and unstable internet connectivity need to be addressed. Facility administrators should ensure proper orientation and training for all staff members to improve EHRS utilization. |
| (Amoateng and Achampong, 2024) | Impact of the Lightwave Health Information Management Software on the Dimensions of Quality of Healthcare Data | Non-experimental, cross-sectional design | To determine the impact of using LHIMS on the improvement of healthcare data quality since its implementation at Cape Coast Teaching Hospital (CCTH) | Doctors at Cape Coast Teaching Hospital (CCTH) | Cape Coast Teaching Hospital, Central Region of Ghana | Most doctors found LHIMS convenient and improved data accessibility and timeliness. Major challenges included erratic power supply, inadequate logistics, and poor internet connectivity. LHIMS did not significantly improve data comprehensiveness. | LHIMS must be upgraded to include more decision support systems and additional add-ons like radiological and laboratory reports to make patient health data more comprehensive. |

### 4.2.1 Quality Appraisal Results

Due to the small number of relevant studies that met the inclusion criteria and the variety of study designs included, no studies were excluded from the review based on the quality assessment outcome. The results of the quality appraisal are described for each type of study as follows.

#### 4.2.1.1 Quality Appraisal for Qualitative Studies

The Critical Appraisal Skills Programme (CASP) Qualitative Checklist was applied to 17 qualitative studies. The results demonstrate a generally high quality across the appraised studies. Notably, 12 out of 17 studies (70.6%) met all 10 criteria of the CASP checklist, indicating robust methodological quality. Four studies (23.5%) met 9 out of 10 criteria, with the primary limitation being in the "value of the research" category. Only one study (Afarikumah, 2014b) showed significant methodological weaknesses, meeting only 5 out of 10 criteria with 4 criteria that could not be determined based on the available information. Refer to appendix 1.6.1 for more details.

#### 4.2.1.2 Quality Appraisal for Quantitative Studies

Eight quantitative studies were evaluated using the Standard Quality Assessment Checklist for Quantitative Studies. All studies (100%) clearly stated their research questions or objectives and employed appropriate study designs. However, only one study (Frimpong, 2021) explicitly described random allocation procedures. A single study (Adjei *et al.*, 2021) also reported blinding of investigators, while none of the studies mentioned blinding of subjects. Majority of studies (87.5%) reported variance estimates, with one exception (Essuman *et al.*, 2020). Five studies (62.5%) fully addressed confounding control, while three (37.5%) only partially accounted for potential confounders. Refer to appendix 1.6.2 for more details.

#### 4.2.1.3 Quality Appraisal for Descriptive Studies

Three descriptive studies were evaluated using the CRAAP Test. All three studies scored above 3.8 out of 5, suggesting they were current, relevant, from authoritative sources, and had clear purposes. The study by Carney (2016) and Owusu *et al.* (2023) scored particularly high (4.2/5), indicating excellent overall quality and credibility. Refer to appendix 1.6.3 for more details.

#### 4.2.1.4 Quality Appraisal for Mixed Method Studies

Only one mixed methods study (Adu *et al.*, 2023) was appraised using the Mixed Methods Appraisal Tool (MMAT). The study demonstrated clear research questions, appropriate data collection and analysis methods, and effective integration of qualitative and quantitative components. However, there were some uncertainties regarding the representativeness of the sample and the risk of nonresponse bias. Refer to appendix 1.6.4 for more details.

### 4.3 Health Conditions and Focus Areas Targeted and Addressed by DHIs in Ghana

This section presents the findings from the systematic review conducted on digital health interventions (DHIs) in Ghana. The results are organized into these subsections: the types of DHIs identified, the specific health conditions addressed through DHIs, along with their focus areas. Refer to appendix 1.1 for more details.

#### 4.3.1 Types of Digital Health Interventions in Ghana

The Digital Health Interventions (DHIs) in Ghana identified in this systematic review came in different forms and functions. These interventions can be classified into four main categories: mHealth, eHealth and Health Information Systems, Telemedicine, and Hybrid Interventions. Figure 4.6 shows the distribution of each type of DHI identified.

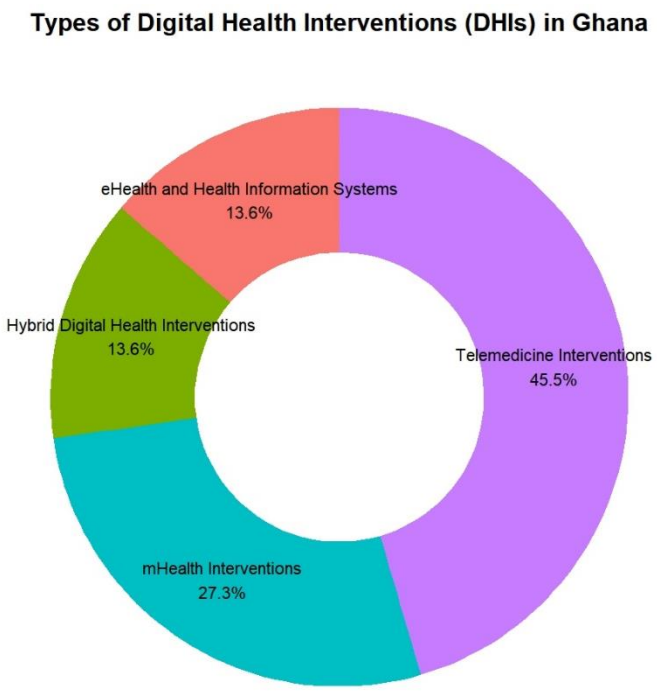


*Figure 4.6 Types of DHIs in Ghana*

Telemedicine interventions (10) emerged as the predominant type of digital health intervention in Ghana, followed by mHealth interventions (6) as the second most-prominent type of DHI. The remaining types, "eHealth and Health Information Systems" and "Hybrid Digital Health Interventions" were the least predominant with each having 3 identified interventions. Refer to appendix 1.2 for more details.

### 4.3.2 Health Conditions & Focus of Digital Health Interventions in Ghana

The digital health interventions identified in Ghana targeted a range of health conditions and addressed different foci including general healthcare delivery and access, disease surveillance and outbreak response, immunization, maternal and child healthcare, dermatology as well as eye care. Figure 4.4 illustrates the focus of DHIs in Ghana. Based on data from this review, we can categorize them into the focus areas below:

**General Healthcare (7 interventions, 31.8%):** This is the most common focus of DHI in Ghana. Interventions like ReACH (Remote Asynchronous Communication for Healthcare), GCN (Ghana Consultation Network), and Mahiri focus on providing general healthcare services. These platforms typically offer remote consultations, addressing a wide range of medical conditions. For instance, Mahiri covers conditions from skin disorders and infections to neurological conditions and prenatal care.

**Maternal and Child Health (4 interventions, 18.2%):** MOTECH (Mobile Technology for Community Health) and MVHS (Millennium Villages and Mobile Telemedicine) are examples of interventions targeting pregnant women and newborns. These interventions typically provide prenatal care information, appointment reminders, and health education to improve maternal and child health outcomes.

**Health Information Management (3 interventions, 13.6%):** DHIs like LHIMS (Lightwave Health Information Management System) and DHIS 2 (District Health Information Software 2) focus on efficient medical record management and health data reporting.

**Supply Chain Management (2 interventions, 9.1%):** Interventions including SMS for Life and GhILMIS (Ghana Integrated Logistics Management Information System) address the critical issue of medicine and supply chain management.

**Disease Surveillance (1 intervention, 4.5%):** The Early Warning System (EWS) focuses on disease outbreak surveillance and are crucial for early detection and response to potential epidemics.

**Immunization (1 intervention, 4.5%):** The Sene PDA Project specifically targets immunization at initial levels of care, likely tracking and improving immunization coverage.

**Dermatology (1 intervention, 4.5%):** Mobile Teledermatology (africa.telederm.org) focuses on skin conditions. It helps addresses the shortage of dermatologists, especially in rural areas, by enabling remote diagnosis and treatment recommendations.

**Eye Care (1 intervention, 4.5%):** The Tele-Ophthalmology intervention focuses on eye care. Similar to teledermatology, this helps extend specialized eye care services to areas lacking ophthalmologists.

**Pharmaceutical Authentication (1 intervention, 4.5%):** mPEDIGREE focuses on authenticating pharmaceutical drugs. This intervention addresses the critical issue of counterfeit medications, helping to ensure patient safety and the integrity of the pharmaceutical supply chain.

**Education and Telemedicine (1 intervention, 4.5%):** The Pan African eNetwork targets both medical education and telemedicine. This dual-purpose intervention helps in capacity building of healthcare professionals while also providing telemedicine services.

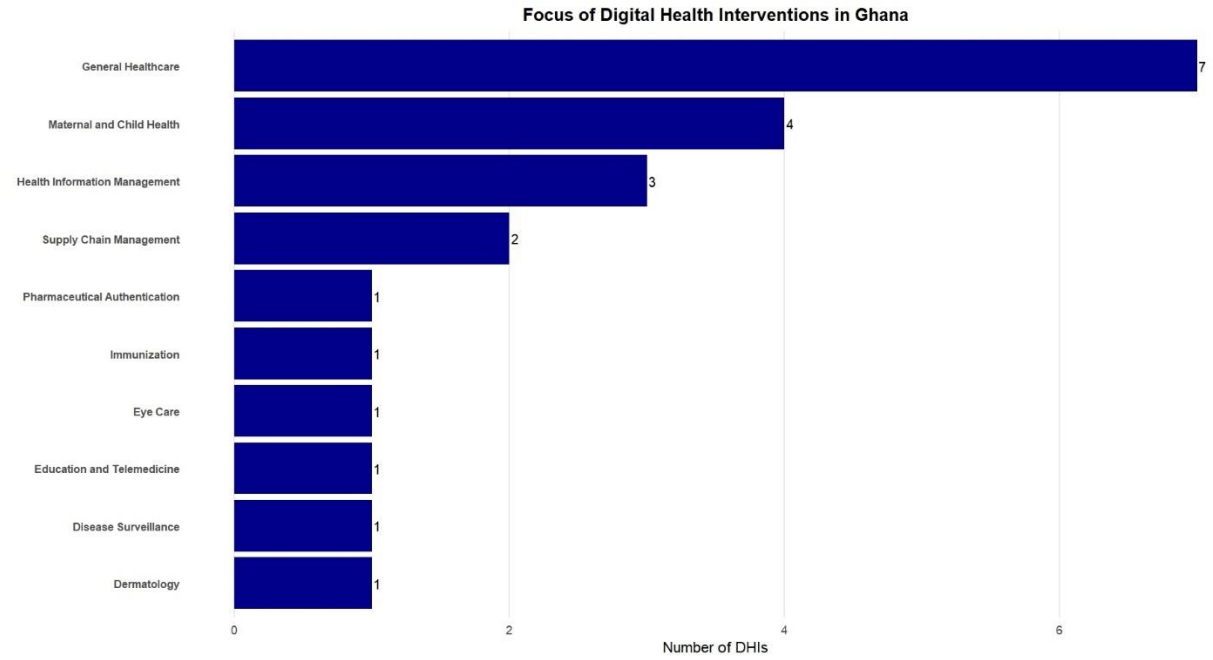


*Figure 4.4 Focus of DHIs in Ghana*

Digital health interventions (DHIs) in Ghana were implemented across various settings, with a focus on both rural and urban areas. A significant number of DHIs (54.5%) targeted both urban and rural populations, including nationwide initiatives like DHIS 2, GhILMIS, SMS for Life, and Vodafone Healthline. Urban areas, particularly major cities such as Accra, Kumasi, and Tamale, were prominent sites for DHIs due to their technological infrastructure and higher digital literacy. Of the 22 DHIs analyzed, 22.7% focused exclusively on urban areas, including initiatives like Lightwave Health Information Management System and Mobile Teledermatology. Similarly, 22.7% were dedicated to rural populations, with projects like Millennium Villages and Mahiri Mobile addressing specific rural healthcare needs. Refer to appendix 1.3 for more details.

DHIs in Ghana also target a wide range of populations. Many DHIs, such as the Lightwave Health Information Management System (LHIMS) and the Ghana Integrated Logistics Management Information System (GhILMIS), aim to improve overall healthcare delivery and management, serving the general population. A significant emphasis is placed on maternal and child health, with interventions like MOTECH and the Millennium Villages and Mobile Telemedicine (MVHS) specifically focusing on improving outcomes in prenatal and child healthcare. Rural communities are another critical target, with interventions like the Sene PDA Project and ReACH designed to enhance healthcare access in remote areas.

Additionally, several DHIs are directed at healthcare providers, such as the Pan African eNetwork and the Ghana Consultation Network (GCN), aiming to enhance provider capacity, communication, and decision-making. Disease-specific interventions also play a role, with projects like Mobile Teledermatology and Tele-Ophthalmology focusing on specialized care for dermatological and eye conditions. Moreover, some DHIs target the broader health system, with

initiatives like DHIS 2 and eHISS working to strengthen data management and health insurance processes. Refer to appendix 1.4 for more details.

### 4.4 The Trend in Digital Health Interventions in Ghana

Several trends can be observed across multiple dimensions, including the focus areas of interventions, their geographical reach, and their evolution over time.

#### 4.4.1 General Trends in Digital Health Interventions in Ghana

One prominent trend is the specificity of DHIs. Despite the diversity of interventions, there is a clear movement towards more specialized applications. It has been observed that majority of interventions target specific health areas such as maternal and child health, dermatology, ophthalmology, immunization, and pharmaceutical authentication. Other interventions are geared towards strengthening the overall health system. Systems like LHIMS and DHIS 2 aim to enhance data management and reporting, while interventions like SMS for Life and GhILMIS address critical logistical challenges. This trend towards system-level interventions suggests a maturation in the approach to digital health, moving beyond individual-focused applications to those that can have a broader impact on healthcare infrastructure.

Additionally, the geographical distribution of DHIs also reveals a trend towards inclusivity. A majority of the interventions (54.5%) are designed to serve both urban and rural areas, with equal representation (22.7% each) for specifically urban or rural interventions. For example, the LHIMS and Vodafone Healthline serve both urban and rural areas and have been in operation till date.

### 4.4.2 Temporal Trends in Digital Health Interventions in Ghana

Figure 4.7 illustrates the temporal trends of Digital Health Interventions (DHIs) in Ghana from 2001 to 2020. This visualization provides valuable insights into the evolution and adoption of digital health technologies in the country over nearly two decades.

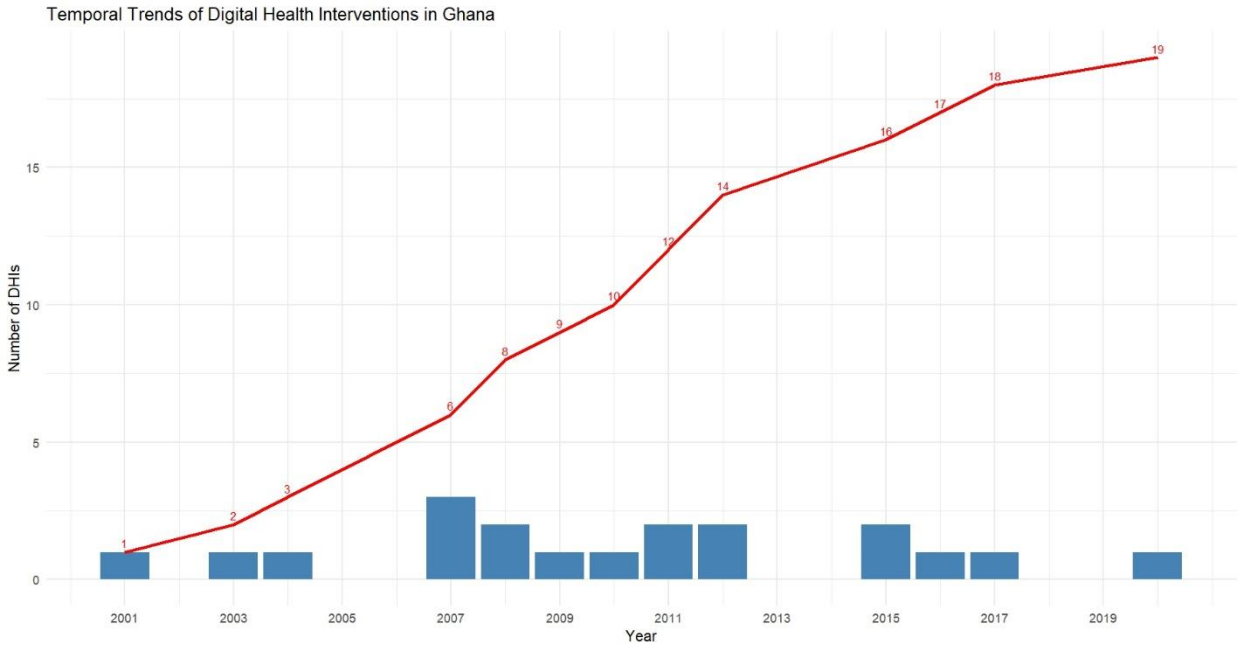


*Figure 4.7 Temporal Trends of DHIs in Ghana*

**Introduction of New DHIs in Ghana**

The blue bars in the chart represent the number of new DHIs introduced each year. The introduction of new digital health interventions can be expressed in three phases including early adoption, accelerated growth, and fluctuating introduction.

The introduction of new DHIs in Ghana exhibits distinct patterns over the observed period. The early adoption phase, spanning from 2001 to 2004, marked the inception of Ghana's journey with DHIs. The initial intervention, likely SATELLIFE in Accra, was introduced in 2001, followed by

singular interventions in 2003 and 2004. This period represents the nascent stage of digital health implementation in the country.

A phase of accelerated growth ensued from 2007 to 2012, characterized by a notable increase in new DHI introductions. Both 2007 and 2008 witnessed the implementation of more than one new intervention each year. This period marks the start of a more active integration of digital health solutions, likely driven by global advances in mHealth and digital innovations. Between 2009 and 2012, additional interventions were introduced, culminating in a steady rise in DHI implementation during this phase.

The period from 2015 to 2020 displayed fluctuations in the introduction of new DHIs. Two interventions were introduced in 2015, followed by single interventions in 2016, 2017 and 2020. This fluctuation suggests that while digital health remained a focus, the rate of new intervention introductions slowed down, compared to the preceding growth phase.

**Cumulative Growth of DHIs**

The red line on the chart represents the cumulative number of DHIs over time, providing a clear picture of the overall growth trend. The cumulative growth of DHIs in Ghana presents a clear trajectory of overall expansion and is expressed in three phases namely slow initial growth, accelerated growth phase, and continued expansion. The slow initial growth from 2001 to 2004 was gradual, with the total number of DHIs increasing from 1 to 3. This slow progression reflects the exploratory nature of digital health adoption during this early stage.

A significant acceleration in cumulative growth occurred between 2007 and 2012. This is the accelerated growth phase. Between 2007 and 2012, there was a significant acceleration in the cumulative number of DHIs, rising from 6 to 14. This noticeable increase in the number of new

DHIs during this period indicates a possibly growing recognition of the potential of digital health and increased investment in the sector.

The final phase is the continued expansion phase. The period from 2012 to 2020 shows a steady increase, with the cumulative number reaching 19 by 2020. The new DHIs continued to be introduced in recent years, albeit at a slower pace than during the acceleration period. The overall upward trend in both new and cumulative DHIs indicates a growing recognition of the potential of digital health solutions in Ghana's healthcare system. Figure 4.8 also shows the trends of the various types of digital health interventions introduced in Ghana over the years.

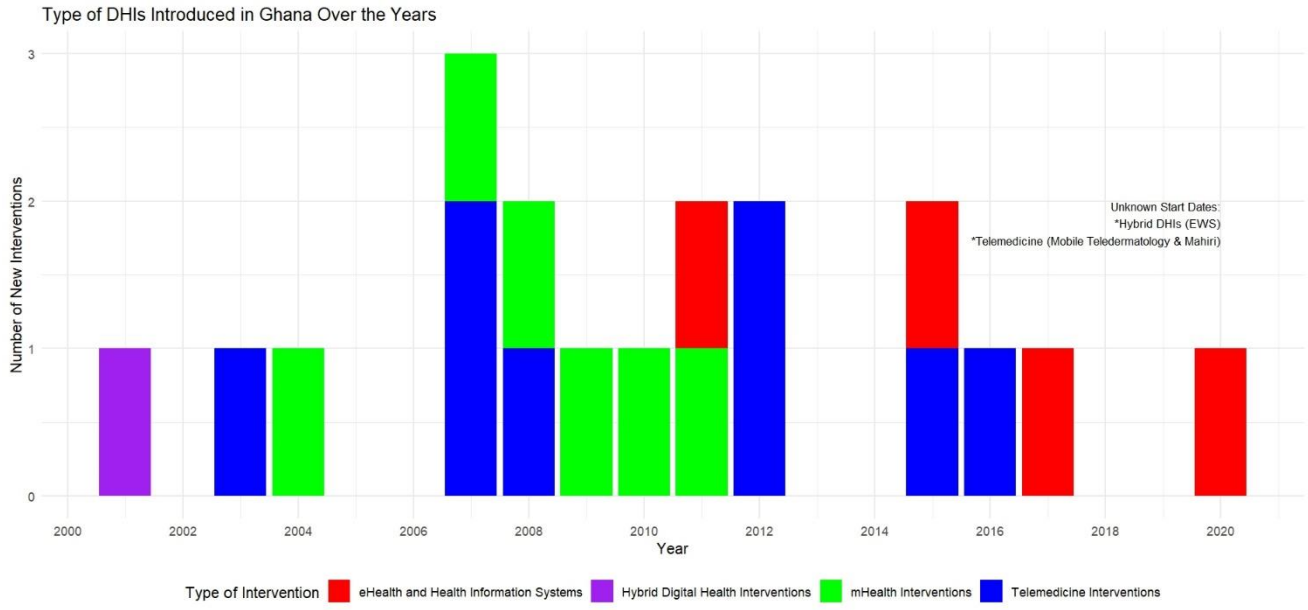


*Figure 4.8 Types of DHIs Introduced in Ghana Over the Years*

## 4.5 Strengths and Limitations of Digital Health Interventions in Ghana

This section presents a comprehensive description of the strengths and limitations of digital health interventions in Ghana, derived from the studies included in this review. The thematic analysis of the 29 included articles identified 17 key themes that highlight both the strengths and limitations of digital health interventions in Ghana. These themes encompass various aspects of healthcare

improvement, challenges in implementation, and the broader impact on healthcare delivery. Kindly refer to appendix 1.5 for more details.

### 4.5.1 Limitations of Digital Health Interventions in Ghana

Digital Health Interventions in Ghana, while promising, face several limitations that hinder their optimal implementation and utilization. Figure 4.9 presents themes related to limitations of Digital Health Interventions in Ghana.

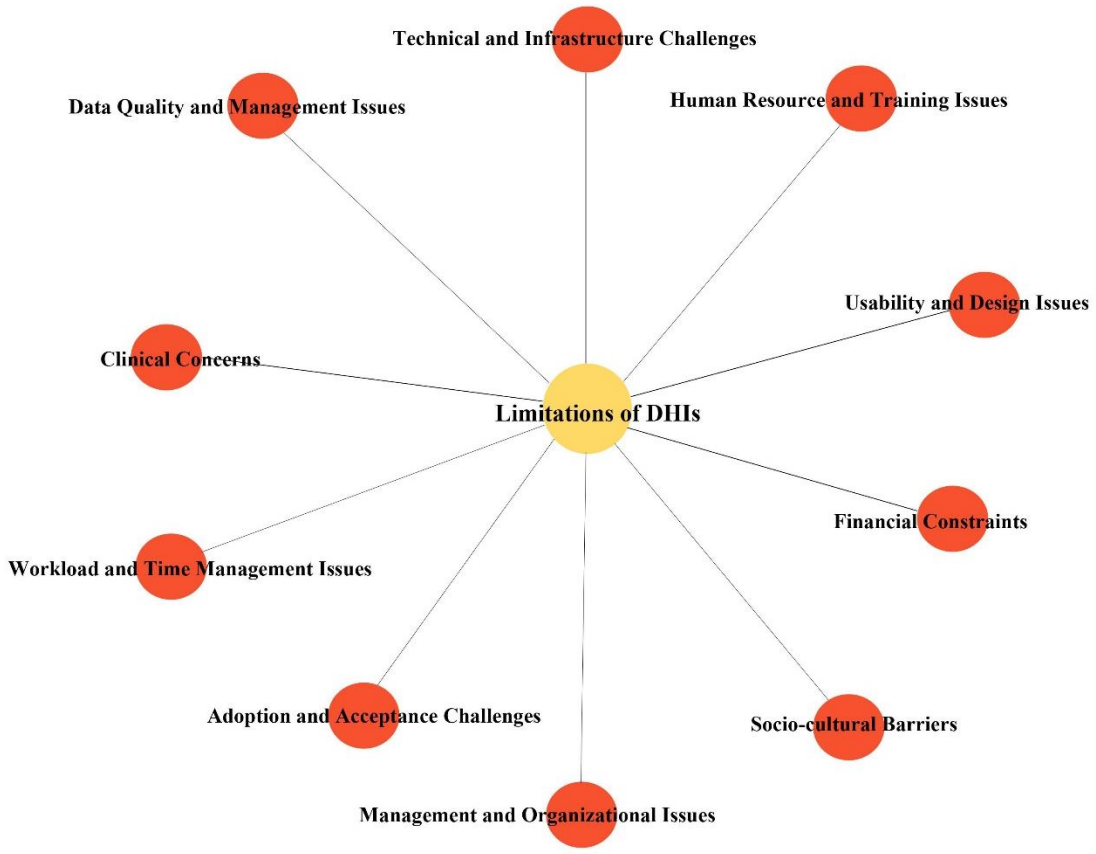


*Figure 4.9 Limitations of Digital Health Interventions in Ghana*

**Technical and Infrastructure Challenges**

This theme covers codes like "unreliable power supply", "inadequate computers and equipment", "availability of equipment", "lack of a reliable internet connection", "complex interface designs", and "device management problems" among others, making up a total of 17 items." The predominant codes are "lack of a reliable internet connection (n=35)" and "unreliable power supply (n=20)". One major limitation of DHIs in Ghana is the inadequate technical and infrastructure setup, particularly in rural healthcare facilities.

*"…my main challenge is when the light goes out or you are working and it [system] happens to go off; you are not able to continue from where you ended up with; you will have to enter everything all over again; that's the main challenge"* (Mensah *et al.*, 2023).

Essential equipment, such as computers and mobile devices, are often lacking, and internet connectivity is unstable. System performance is further hindered by inefficient hardware, frequent breakdowns, and software issues, worsened by users' limited proficiency with digital tools. Unreliable power supply and insufficient technical support disrupt the continuity of care. Additionally, the lack of standardization across EHR systems worsens interoperability issues, leading to fragmented healthcare data and operational inefficiencies, frustrating healthcare providers.

**Human Resource and Training Issues**

Codes like "Inadequate personnel", "Inadequate training", "Limited Digital Literacy", "Requires Technical training", "User Adaptation issues", and "Frequent Need for IT Support" fall under this theme. "Inadequate training (n=9)" and "Limited Digital Literacy (n=9)"" were the most predominant codes.

The effective use of DHIs in Ghana is hindered by inadequate human resources and insufficient training. Many healthcare workers and patients lack the digital literacy and technical skills needed to operate DHI systems efficiently.

*"Some health participants expressed feeling adequately trained on the EHR"* (Attafuah *et al.*, 2022b).

*"Sometimes they are not very tech savvy so we need to see them in-person. And we have had some patients try it but most are not tech savvy so we haven't been able to expand this to all our clients"* (Paul *et al.*, 2024).

This gap often leads to a reliance on IT support, adding to the workload of an already overburdened staff, resulting in burnout and reduced efficiency. Procedural issues, such as low user dexterity, further contribute to the inefficient use and underutilization of DHIs, affecting both adoption rates and effective system utilization.

**Data Quality and Management Issues**

Predominant codes emerging under this theme are "Incomplete Data Coverage (n=4)", and "Data entry errors (n=3)". Data quality and management pose significant challenges, with issues like critical data omissions, entry errors, and recording delays being common. The high volume of required data entry can overwhelm staff, leading to fatigue and increased errors, such as typographical mistakes and incorrect data input.

*"Sometimes one person having different registration numbers. Data entries challenges - data entered incorrectly or incompletely. For instance, entry of date of birth and unknown details as brought in by some 'good Samaritans'"* (Gyamfi *et al.*, 2017).

*"Participants expressed frustrations with incomplete records. These incomplete records from the professionals as narrated by NM11 were attributed to laziness as well as not having adequate knowledge in computing"* (Attafuah *et al.*, 2022c).

Insufficient data capture can result in inadequate understanding of patient history. Additionally, concerns about data security persist, as many systems lack robust mechanisms to protect sensitive patient information.

**Usability and Design Issues**

This theme included codes like "delayed response times", "difficult access", "typing efficiency", "unfriendly software design", and "usability challenges". Prominent among these were "unfriendly software design (n=5)", "delayed response times (n=5)", and "difficult access (n=4)". The usability and design of digital health tools are crucial for effective use, but many systems suffer from poor design, making navigation difficult.

*"Participants often complained that the patient's records were not easily accessible as they had to go through a series of navigations to get to them, they added that difficult access led to delays during consultation"* (Attafuah *et al.*, 2022d).

Users found the interfaces cluttered and non-intuitive, hindering quick access to necessary tools and information. Delayed response times, frequent software freezes, and slow performance disrupted patient-provider interactions, leading to inefficiencies. Additionally, users with limited digital literacy struggled to access the full functionality of the devices, resulting in underutilization. Manual data entry was time-consuming and error-prone due to inefficient typing interfaces, further slowing processes and increasing the risk of inaccuracies.

**Workload and Time Management Issues**

Prominent codes emerging here include “Increased Workload (n=7)”, and “Time Delays (n=6)”. The introduction of DHIs has increased workload and time management challenges for healthcare providers, affecting overall efficiency. While beneficial, DHIs added tasks like learning the system, manual data entry, and result interpretation, leading to longer working hours and added stress for already burdened healthcare workers.

*“During the daily unit runs, it was observed that the introduction of the EHR has rather doubled the task of its users”* (Acquah-Swanzy, 2015).

The need for more time per patient interaction further exacerbated these issues. In antenatal care (ANC), DHIs extended consultations by 10 to 30 minutes per patient, due to time spent operating the system and processing data. These delays resulted in longer patient wait times and reduced daily patient capacity, impacting clinic efficiency.

**Financial Constraints**

Codes that emerged under this theme were “Expensive”, “Financial Cost”, and “Lack of funding” with “Lack of funding” being the most dominant with a frequency of 6. Financial constraints significantly hindered the widespread adoption and effective use of DHIs. The systems were expensive, making them unaffordable for many healthcare facilities, particularly in low-resource settings, thereby limiting their accessibility and potential benefits.

*“Lack of funds stalled implementation and affected re- placement of equipment and parts, extending down time of operations whenever the system went down. We don’t have budget, when the things spoils then we tell management and they buy it. Sometimes it delays but…we get it done, but we don’t have budget specifically tailored for IT”* (Mensah *et al.*, 2023).

Beyond the initial costs, ongoing expenses for maintenance, software updates, and training further strained limited budgets. The lack of adequate funding worsened these financial challenges, preventing many facilities from investing in and scaling up DHIs, despite recognizing their potential benefits.

**Adoption and Acceptance Challenges**

This theme covers the following codes: “Fear of the unknown”, “Lack of Awareness”, “Lack of trust”, “Low utilization of digital health”, “Patient Acceptance Challenges”, and “Resistance to change”. “Lack of Awareness (n=5)” and “Low utilization of digital health (n=5)” emerged as the most dominant codes in the literature reviewed. Adoption and acceptance challenges hindered the integration of DHIs into healthcare practices and patient routines.

*“a lack of trust in mHealth services was reported by some of the users largely because they will not be able to see the person they will be communicating with and therefore fear their calls may not be received by qualified medical professionals”* (Peprah *et al.*, 2020).

Many users experienced fear and apprehension due to unfamiliarity with the technology, concerns about its complexity, and doubts about its reliability. This fear led to resistance among both healthcare providers and patients, who were often hesitant to move away from traditional methods, slowing the adoption process and limiting the device's impact.

Additionally, a lack of information about how these interventions worked and their benefits prevented widespread acceptance. Patients also struggled with the longer ANC processes associated with some digital interventions, leading to impatience and reduced satisfaction. Trust issues further impeded adoption, as both patients and providers often doubted the accuracy and reliability of the new technology, preferring familiar methods.

**Socio-cultural Barriers**

This theme encompasses codes including “Illiteracy (n=3)” and “Language barrier (n=3)”. Socio-cultural barriers significantly affected the adoption and effective use of digital health interventions in Ghana, impacting both healthcare providers and patients. Illiteracy among patients and some healthcare workers hindered understanding of how to use the devices, interpret results, and follow procedures, limiting the interventions' effectiveness and accessibility in communities with high illiteracy rates.

*“With mHealth service which involves reading, it will be very difficult for some of us to use. This is because we cannot read nor write, so we will hardly get the message that will be sent to us. I always delete any message I receive as soon as it comes because I can- not read”* (Peprah *et al.*, 2020).

Language barriers also played a critical role, as the device's interface and instructions were often unavailable in local languages, complicating usability for diverse linguistic populations. This lack of linguistic accessibility further reduced the acceptance of DHIs among non-native speakers.

**Clinical Concerns**

Codes emerging under this theme were “Inaccessible therapeutics following consultation”, “Inaccurate Information”, “Interrupted Interaction”, “Less Patient Engagement”, and “Risk of Misdiagnosis”, with “Inaccurate Information (n=5)” being the most dominant. Several clinical concerns associated with digital health interventions (DHIs) impact the quality and effectiveness of patient care in Ghana.

Users reported risks of misdiagnosis due to incorrect or incomplete data entry, which can lead to inaccurate clinical decisions, compromising patient safety and treatment effectiveness.

Additionally, patients often face difficulties accessing prescribed therapeutics due to availability, cost, or logistical issues, resulting in poor adherence to treatment plans and suboptimal health outcomes.

*"At times, the child may be severely sick. So when we call and the line drops, then it becomes a great challenge"* (Acquah-Gyan *et al.*, 2022).

In mHealth interventions, dropped calls can disrupt patient-provider interactions, negatively affecting communication and patient engagement. Furthermore, DHIs that lack user-friendliness or add complexity to consultations reduce patient engagement, as overwhelmed or confused patients are less likely to participate actively in their care.

**Management and Organizational Issues**

The codes under this theme include “Inadequate Compensation (n=1)”, “Inadequate logistics (n=1)”, and “Resource Constraints (n=1)”. Problems like inadequate compensation and logistical support for healthcare workers demotivate staff from engaging fully with digital health systems implemented in their facilities.

*“We attend to most of the cases we receive through telemedicine without further consultations with a doctor. What pains me is the little remuneration we receive at the end of the month”* (Opoku, Scott and Quentin, 2015).

Inadequate logistics, including poor infrastructure, lack of necessary supplies, and inefficient workflows, hinder the seamless integration and operation of digital health interventions. Additionally, it was pointed out that broader management challenges including poor leadership and lack of clear policies impede the sustained utilization of new technologies.

### 4.5.2 Strengths of Digital Health Interventions in Ghana

Despite the aforementioned limitations of digital health interventions in Ghana, DHIS in Ghana have demonstrated significant strengths in the healthcare system. Figure 4.10 presents themes related to strengths of Digital Health Interventions in Ghana. These strengths include:

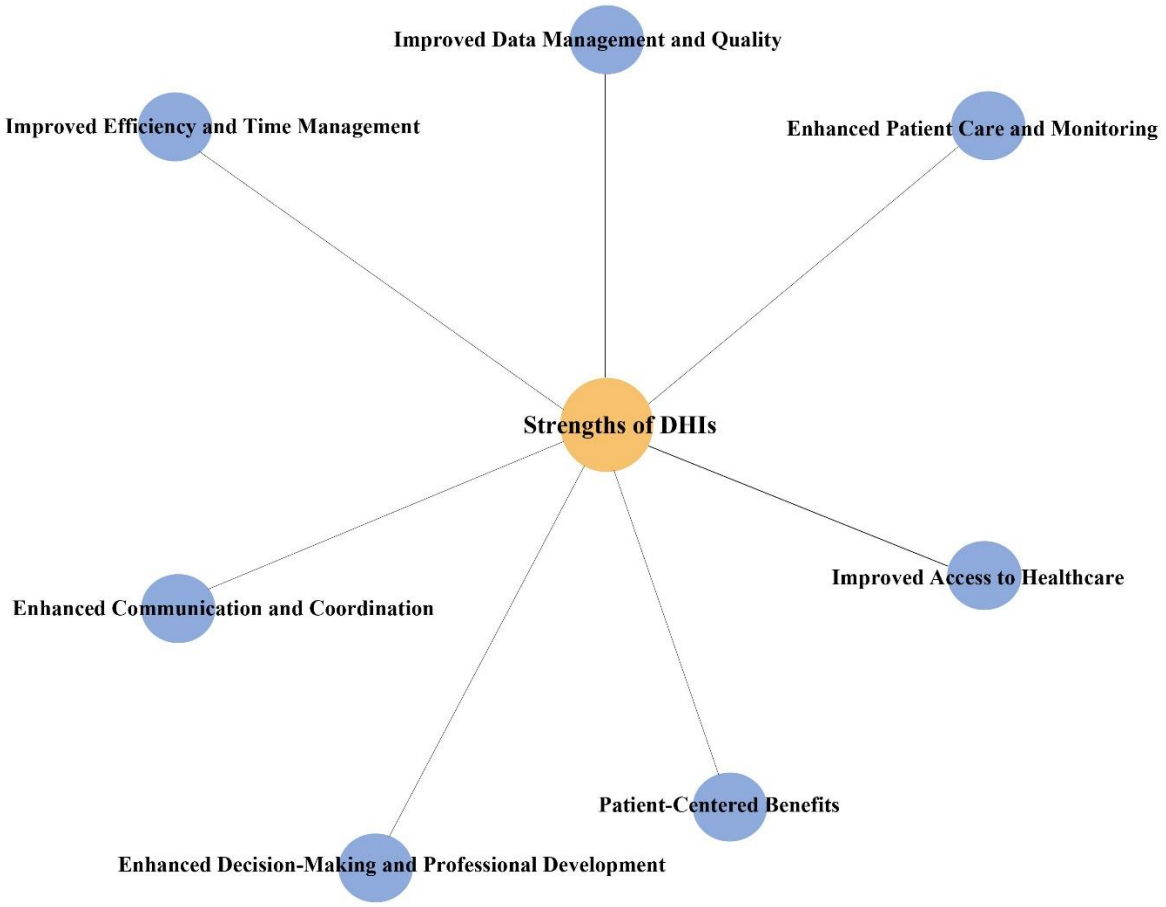


*Figure 4.10 Strengths of Digital Health Interventions in Ghana*

**Improved Data Management and Quality**

Prominent codes under this theme include "minimizes loss of information (n=6)", "accuracy (n=5), "medical records management (n=4)", "improved data accuracy (n=3)", and "improved data

quality (n=3)". A key strength of DHIs in Ghana is their enhancement of data management and quality. They have improved healthcare by ensuring access to comprehensive patient information, supporting better diagnosis and care planning.

*"and it has also reduced loss of patient health information since it is not paper record which can get wet or get lost in storage"* (Mensah *et al.*, 2023).

*"the LHIMS at CCTH has increased the accuracy of patient health records"* (Amoateng and Achampong, 2024).

DHIs promote secure storage, efficient retrieval, and proper organization of data, minimizing the risk of information loss. They also provide timely access to accurate, up-to-date data while safeguarding patient information against breaches, maintaining confidentiality and trust. Additionally, some systems can generate reports from health records to aid in healthcare planning, monitoring, and evaluation.

**Enhanced Patient Care and Monitoring**

Dominant codes under this theme include "enhanced patient monitoring (n=12)", "ensures self-monitoring (n=11)", "caregiver education (n=6)", "ensures continuity of care (n=6)", "defaulter tracking (n=5)", "improved quality of care (n=5)", and "automated reminders (n=5)". The use of digital health interventions (DHIs) in Ghana has notably improved patient care and monitoring. Automated reminder systems enhance adherence to treatment plans by sending timely notifications about medications and appointments, thereby reducing missed visits.

*"Participants reported that the system taught them about the management of certain common childhood disease symptoms"* (Acquah-Gyan *et al.*, 2022).

*"While participants expressed the technology was extremely helpful in their ability to monitor their BP and improve their medication adherence"* (Nichols *et al.*, 2019).

DHIs also track defaulters to identify patients who do not follow treatment plans. Advanced diagnostic tools facilitate timely disease detection, especially in remote areas with limited specialist access. Additionally, DHIs provide educational resources for caregivers, improving home care quality for chronic conditions. Continuous monitoring features, including communication channels with healthcare providers, support better patient adherence.

**Improved Efficiency and Time Management**

Perceived time savings (n=12), cost savings (n=11), ease of use (n=11), reduction in errors (n=10), completing tasks faster (n=9), and reduced waiting time (n=7) are the most dominant codes under this theme. Enhanced efficiency is a key strength of DHIs in Ghana, streamlining workflows and reducing administrative burdens to boost healthcare staff productivity. By automating routine tasks and providing decision support, DHIs enable providers to concentrate more on patient care.

*"saving time and money that would have been otherwise expended on diagnostic referrals"* (Abejirinde *et al.*, 2018).

*"…the system has reduced errors and redundancy in patient information"* (Acquah-Swanzy, 2015).

Furthermore, DHIs are cost-effective, minimizing the need for physical infrastructure and reducing operational costs through optimized resource use, fewer unnecessary referrals, and lower travel expenses. Their user-friendly interfaces and intuitive designs enhance accessibility for both healthcare providers and patients, increasing adoption rates and reducing errors. These systems facilitate faster access to accurate patient information, improving care timeliness and reducing

delays in data entry and retrieval, resulting in shorter consultations and decreased patient waiting times.

**Enhanced Communication and Coordination**

The most dominant codes under this theme include “Enhanced Communication with health professionals (n=3)”, and “Facilitates Communication (n=3)”. DHIs enhance communication among healthcare professionals, enabling seamless coordination and collaboration, which is vital for comprehensive patient care. These improved communication channels allow providers to easily share information, discuss cases, and make informed decisions collaboratively.

*"When I called, it went through, and I was able to communicate with the Doctor. He asked me questions about the conditions of my child and then asked me to go to the hospital tomorrow"*

(Acquah-Gyan *et al.*, 2022).

Additionally, DHIs improve patient communication by enabling easy access to healthcare providers, allowing patients to ask questions and receive timely responses. Although not all DHIs in Ghana are interoperable, those that are ensure different healthcare systems and platforms can communicate and share information seamlessly. This interoperability supports integrated and coordinated care across the country, further improving departmental coordination through integrated platforms for information sharing and task management.

**Improved Access to Healthcare**

This theme has dominant codes including “easier access to records (n=16)”, “improved access to healthcare (n=8)”, “improved access to records (n=6), “reduction in transportation costs (n=6)”, and “reduction in travel (n=5)”. One key strength of DHIs in Ghana is their ability to improve access to healthcare by reducing geographical and logistical barriers. DHIs enable services like

telerehabilitation, particularly benefiting patients in remote and underserved areas. They provide healthcare providers with easy access to patient records, ensuring that critical information is readily available regardless of location, supporting timely and accurate clinical decisions.

*"…it has made it easy to locate patients' folder and I believe it would reduce waiting time if implemented properly"* (Acquah-Swanzy, 2015).

*"a patient came to the hospital and reported of his missing folder ID card, so we just asked for his health insurance card, type the number, then we search for his details and brought out every information needed about the patient and his number from the system…"* (Acquah-Swanzy, 2015).

Additionally, DHIs facilitate access to specialists through teleconsultations and referral systems, reducing the need for physical visits and long-distance travel, thereby saving patients transportation costs and offering greater convenience. These digital tools also support accurate diagnosis and treatment planning, reducing unnecessary referrals and ensuring that patients receive appropriate care when needed.

**Enhanced Decision-Making and Professional Development**

"Improved Decision-Making (n=8)", and "Encourages Professional Creativity and Innovation (n=2)" were dominant codes under this theme. By providing decision support tools and access to comprehensive patient data, DHIs improve clinical decision-making, leading to better patient outcomes. These interventions encourage healthcare professionals to adopt innovative approaches to care delivery, fostering creativity and innovation in medical practice.

*"Almost all participants reported that the system supported them in making decisions regarding whether their children's health condition is severe or not and whether taking the child to a health facility is necessary"* (Acquah-Gyan *et al.*, 2022).

*"the system has ensured both user and patient satisfaction"* (Frimpong, 2021).

Additionally, DHIs offer continuous education opportunities, keeping healthcare providers updated on the latest medical knowledge and best practices. They also provide real-time training and skill development, allowing providers to enhance their competencies while delivering care. This leads to higher user satisfaction as DHIs streamline workflows, reduce administrative burdens, and improve patient outcomes. Furthermore, DHIs support the implementation of effective clinical protocols, enabling healthcare providers to deliver higher-quality care with fewer obstacles.

**Patient-Centered Benefits**

This theme encompasses "emotional support to caregivers (n=3)", "ensures patients' privacy and confidentiality (n=5)", and "helps assess client's environment for adaptation (n=1)". DHIs in Ghana offer several patient-focused strengths. They provide valuable resources and support for caregivers, helping them better manage the emotional and physical challenges of caregiving.

*"The system was found to have relieved some participants of fear and anxiety. It made them feel relaxed and supported when their children were sick due to the opportunity to communicate with a Doctor"* (Acquah-Gyan *et al.*, 2022).

*"I think it will give the opportunity to assess the clients' environment for recommendations for possible adaptations to enhance function because when the person comes in-person, they may describe the home environment and we don't know exactly how it looks but through telerehab*

*with video conference or picture you can see how the environment really looks like for recommendations for the adaptations"* (Paul *et al.*, 2024).

Additionally, DHIs prioritize patient privacy and confidentiality, ensuring that sensitive information is protected and shared only with authorized personnel. Furthermore, DHIs facilitate the assessment of patients' home environments, enabling tailored interventions that enhance comfort and safety while receiving care in familiar settings.

# CHAPTER 5

# 5.0 DISCUSSION

## 5.1 Introduction

This chapter discusses the findings presented in the previous chapter in relation to the existing literature on digital health interventions in Ghana. It further interprets the results, examines their significance, and highlights their implications for policy, practice, and future research. The discussion also contextualizes key findings within the broader framework of digital health implementation in low- and middle-income countries (LMICs).

## 5.2 Types of Digital Health Interventions

The systematic review identified four main categories of DHIs in Ghana: mHealth, eHealth and Health Information Systems, Telemedicine, and Hybrid approaches. This variety reflects the multifaceted approach Ghana is taking to leverage digital technologies in addressing its healthcare challenges. Mobile health (mHealth) interventions were prominent, leveraging high mobile phone penetration in Ghana for purposes ranging from patient care to supply chain management.

This trend aligns with the global surge in mobile technology adoption and its potential to reach underserved populations. A study by Goldstein *et al.* (2023) states that there is a proliferation of mHealth interventions in low- and middle-income countries (LMICs), emphasizing their potential to improve healthcare delivery and outcomes through enhanced communication, data collection, and patient monitoring. Similarly, Schwab and Langell (2018) pointed out that mobile technologies and applications are becoming increasingly available worldwide, offering solutions to markets and demographics that previously had limited access to resources such as healthcare.

Aside from the country's high mobile phone penetration rate, the focus on mHealth in Ghana likely reflects the relative ease of implementing such interventions compared to more infrastructure-intensive solutions.

Telemedicine emerged as another significant type of DHI in Ghana, particularly through telerehabilitation for neurological conditions such as stroke and Parkinson's disease. This is consistent with regional trends in telemedicine, as observed in a study by Dodoo, Al-Samarraie and Alzahrani (2021), which highlighted significant progress in the adoption of telemedicine in healthcare practice in Sub-Saharan Africa with evidence of variants of telemedicine such as teleeducation, teleconsultation, teledermatology, teleradiology, telecardiology, teleophtamology, teleoncology, and telepsychiatry. Similarly, a review on development of telemedicine programs in Sub-Saharan Africa by Dodoo, Al-Samarraie and Alsswey (2022) stated that telemedicine interventions were effective in improving patient outcomes across various health conditions. The authors suggest a renewed effort towards the implementation of telemedicine systems in SSA, in particular as an alternative healthcare route in the era of COVID-19 crises.

The implementation of Electronic Health Records (EHR) systems in various healthcare settings across Ghana represents a significant step towards digital health transformation. This finding is consistent with global efforts to digitize health information systems. A comprehensive review by Kumar and Mostafa (2019) on EHR implementation in LMICs including Sierra Leone, Malawi, and India found that these systems had the potential to improve healthcare quality and efficiency. The authors emphasized that the integration of electronic health records (EHRs) in the national health care systems of low- and middle-income countries (LMICs) is vital for achieving the United Nations Sustainable Development Goal of ensuring healthy lives and promoting well-being for all people of all ages.

This review also identified hybrid digital health interventions in Ghana. This aligns with global efforts to integrate different digital health technologies into cohesive systems to improve healthcare delivery and outcomes. This is consistent with a study by Taha *et al.* (2022) which highlights a successful integration in Abu Dhabi, where health systems utilized mobile applications to manage telemedicine consultations during the COVID-19 pandemic. These applications were integrated with existing health IT systems to enhance patient satisfaction and streamline care delivery.

### 5.3 Health Conditions & Focus of Digital Health Interventions

Maternal and child health emerged as a significant focus area for DHIs in Ghana. This is consistent with a study by Knop *et al.* (2024) on the impact of mHealth interventions on maternal, newborn, and child health interventions in LMICs which found that mobile health applications were particularly effective in improving antenatal care attendance, child immunization timeliness, skilled birth attendance, and postnatal care utilization. Additionally, a scoping review by Till *et al.* (2023) suggests that digital health technologies are creating opportunities to address the social determinants of MCH by facilitating access to information and providing other forms of support throughout the maternity journey.

Chronic diseases emerged as another important focus area for Digital Health Interventions (DHIs) in Ghana. This finding is consistent with a systematic review by Mao *et al.* (2020) which states that mobile health applications and telemedicine significantly improve the management of chronic conditions like diabetes and hypertension by providing continuous monitoring, patient education, and remote consultations. This finding is also consistent with a rapid scoping review conducted by Murthy *et al.* (2023) during the COVID-19 pandemic found that DHIs were crucial in managing non-communicable diseases (NCDs). These interventions included telehealth consultations,

remote monitoring of medical conditions, and digital platforms for patient education and support. The review noted that such innovations were vital in maintaining continuity of care during the pandemic and could be adapted for ongoing chronic disease management in LMICs.

This review also found that infectious diseases were addressed through DHIs in Ghana. This is consistent with a review by (Aizaz *et al.* (2023) which revealed that digital health technologies (DHTs) have shown promising outcomes in limiting the spread of infectious diseases and have proven beneficial in the surveillance and diagnosis of these diseases.

Beyond specific health conditions, this review reveled many DHIs in Ghana focused on general health system strengthening. This focus aligns with WHO's call to harness innovative digital solutions to strengthen healthcare systems to drive sustainable developments in countries. In 2019, the WHO published a guideline on recommendations of digital interventions for health system strengthening in response to the Seventy-First World Health Assembly, member States resolution (Melh and Tamrat, 2018).

### 5.4 Trends in Digital Health Interventions

The review revealed that despite the diversity of interventions, is most of interventions target specific health areas and focus areas such as maternal and child health, dermatology, ophthalmology, immunization, and pharmaceutical authentication. It was also identified that other interventions are geared towards strengthening the overall health system. This concurs with a systematic review by Villarreal and Berbey-Alvarez (2020) which revealed that mHealth applications were focused on specific health aspects of cardiovascular health including monitoring vital signs, cardiac rehabilitation, heart failure self-management, and cardiovascular disease prevention. Similarly, a study by Mboera *et al.* (2021) mentions that Tanzania adopted the District

Health Information System (DHIS2) to facilitate data access and stimulate usage towards strengthening the health system.

Additionally, this review also highlighted an inclusive geographical distribution of DHIs, with most interventions designed to serve both urban and rural areas, while the remainder are tailored specifically for either urban or rural settings. This finding is similar to a study conducted in Spain by de Garibay *et al.* (2016) The results show that the HeartKeeper app, an mhealth app for self-management and education of cardiac diseases was significantly effective in both the rural and urban areas. Similarly, a systematic review by Mbuthia, Reid and Fichardt (2019) revealed that mHealth interventions were implemented to strengthen postnatal care in rural or semi-rural settings in low and middle-income countries.

### 5.5 Strengths and Limitations of Digital Health Interventions

This review revealed that use of DHIs in Ghana has shown an enhancement in patient care and monitoring through reminder systems that have revolutionized patient adherence to treatment plans and follow-up appointment. This is echoed by Medhanyie *et al.* (2015) who reported that electronic record forms were helpful and useful to health workers for patient follow-up and keeping the patients' appointments in Ethiopia. Similarly, a scoping review by Palacholla *et al.* (2019) revealed that digital health technologies allowed for better monitoring of patients to prevent negative outcomes.

This review revealed ease of use as another strength of existing DHIs. This is consistent with findings from the United States by Cajita *et al.* (2018) emphasizing that most participants would be more likely to adopt mHealth if it were easy to use. This is echoed in findings from a study by Palacholla *et al.* (2019) which revealed that patients often preferred DHTs that were easy to use regardless of technical skills and abilities.

Another strength of DHIs identified in this study is that digital health interventions facilitate better communication between both healthcare professionals and patients, enabling seamless coordination and collaboration. This is similar to findings from a literature analysis by Schreiweis *et al.* (2019) which emphasized that DHIs improve communication among users. Additionally, Palacholla *et al.* (2019) reported in their scoping review that digital health technologies had a positive impact on patient-provider communication enabling direct contact with their providers to share their health data and receive feedback.

Another notable strength of digital health interventions revealed in this review is that they improve access to healthcare by reducing geographical barriers, particularly for patients in remote and underserved areas. This is echoed by Palacholla *et al.* (2019) who reported that digital health technologies reduced office visits and provided the opportunity for patients to potentially avoid having to travel to the physician's office.

This review also reported that digital health systems enable faster access to critical information, and improve the timeliness of care delivery ensuring that patients receive prompt attention they need. This is consistent with findings from a scoping review by Palacholla *et al.* (2019) which revealed that digital health interventions enabled a more timely response to elevated BP levels helping healthcare providers prevent adverse health outcomes in their patients by addressing the changes in BP levels in a timely manner.

Regarding limitations of DHIs, this review identified key technical and infrastructure limitations of DHIs in Ghana including unreliable internet connectivity, inadequate power supply, and limited access to devices. This is consistent with a systematic review by Kaboré *et al.* (2022) which states infrastructure, lack of equipment, unstable internet and electricity supply as barriers associated with DHIs. Additionally, a study by Kaihlanen *et al.* (2022) in Finland highlights that a

considerable portion of the population in LMICs lack access to digital devices including smartphones necessary for utilizing digital health services. This digital divide creates significant barriers to using DHIs effectively.

This review identified complex interfaces and user-unfriendliness as limitations to DHIs as they led to reduced patient engagement. This is consistent with a review by Palacholla *et al.* (2019) which highlights the complexity of technologies as a barrier to the adoption of digital health. Similarly, a study carried out among older adults with heart failure in the United States by Cajita *et al.* (2018) reported poorly designed interface, specifically the size of icons and texts on mobile health apps troublesome.

This review also highlighted digital literacy among healthcare providers and patients as another limitation of DHIs. This is highlighted in a scoping review by Ramachandran *et al.* (2023) which stated that poor digital literacy was the most frequently reported patient-level barrier in utilizing DHIs. Similarly, Ahmed *et al.* (2022) found that low levels of digital literacy among both patients and healthcare providers impeded the effective use of digital health technologies in Ethiopia. The authors added that lack of digital skills often leads to underutilization of available tools and services, reducing the overall impact of DHIs.

Concerns about data privacy and security was another limitation identified in this review. This was echoed in a narrative review by Mumtaz *et al.* (2023) which reported that that the sensitivity of health data can raise privacy concerns when digitized. Similarly, Palacholla *et al.* (2019) reported in their scoping review that patients were concerned about the privacy of data shared via digital health technologies and were uncomfortable with the risk of a third party accessing their data.

This review also pointed out that resistance in adopting the technology among both healthcare providers and patients which stemmed from a lack of familiarity with the technology. This is

consistent with findings from a narrative review by Mumtaz *et al.* (2023) which emphasized resistance to change among healthcare professionals as a limitation to using DHIs.

Findings from this review identified language as barriers hindering the adoption and use of the DHIs. Instructions not available in the local languages, make it difficult for users to understand and operate it. This is consistent with a systematic review by Lestari, Miranda and Fuady (2024) which pointed out that the language used in a product can be a barrier to telemedicine adoption. The authors suggested that telemedicine products should support local languages especially in lower-middle-income countries where there are tens and even hundreds of local languages.

The financial limitations revealed in this review, including high initial costs and ongoing expenses, are consistent with challenges reported in other LMICs. Palacholla *et al.* (2019) reported that the cost of digital health interventions was also cited a barrier to their adoption. Similarly, a systematic review by Kaboré *et al.* (2022) highlighted that financial barriers significantly hinder the scalability and sustainability of digital health projects in resource-limited settings like LMICs.

This review also identified increased workload as a limitation to DHIs. This increased workload often led to longer working hours and added stress for healthcare workers, who were already managing heavy patient loads. This is consistent with findings with a systematic review by Schreiweis *et al.* (2019) which echoed that the implementation of eHealth Services brought in added workload.

# CHAPTER 6

## 6.0 CONCLUSIONS AND RECOMMENDATIONS

### 6.1 Introduction

This chapter presents the overall conclusions drawn from the systematic review and offers recommendations for practice, policy, and future research. It synthesizes the key findings and discusses their broader implications.

### 6.2 Conclusion

This systematic review offers a comprehensive analysis of digital health interventions (DHIs) in Ghana, highlighting their potential to address healthcare challenges while identifying areas for improvement. The findings reveal a diverse range of DHIs, targeting various health conditions and processes, showcasing the versatility of digital health solutions in the country. The predominance of mobile health (mHealth) interventions reflects the widespread adoption of mobile technologies and their potential to reach underserved populations.

This review highlights the positive impact of DHIs on healthcare access and quality in Ghana, with many studies reporting improvements in delivery, patient outcomes, and system efficiency. Telemedicine has been particularly effective in overcoming geographical barriers, while electronic health records have improved data management and decision-making. However, challenges such as unreliable internet connectivity, electricity supply, digital literacy, and data privacy concerns have hindered the effective implementation and scaling of DHIs in Ghana.

The evolution of DHIs in Ghana over the past two decades shows a shift from pilot projects to more sustained, integrated interventions, reflecting growing recognition of digital health's value among policymakers and stakeholders. However, the review emphasizes the need for stronger

evidence on the long-term effectiveness and cost-efficiency of these interventions to better inform policy and guide future implementations.

### 6.2 Recommendations

Based on the findings of this systematic review, the following recommendations are proposed to enhance the effectiveness and sustainability of digital health interventions in Ghana:

i. The Ministry of Health and Ministry of Energy should prioritize investments in improving internet connectivity and electricity supply, particularly in rural and underserved areas.

ii. The Ministry of Health, in collaboration with the Ministry of Education should develop and implement comprehensive digital literacy programs for healthcare providers, patients, and the general population. These programs should focus on building skills in using digital health technologies and raising awareness about their benefits.

iii. The ministry of health should encourage the integration of digital health interventions into existing health systems and workflows rather than implementing them as standalone solutions. This will promote better adoption and sustainability of these interventions.

### 6.3 Implications for Policy and Practice

The findings of this review have important implications for informing evidence-based strategies for leveraging digital health to strengthen health systems, improve healthcare delivery, and ultimately enhance population health outcomes in Ghana and similar settings. It contributes to the growing body of evidence on the efficacy and implementation of digital health solutions in resource-limited settings, with implications that extend beyond Ghana to other low- and middle-income countries (LMICs) facing similar healthcare delivery challenges.

### 6.4 Suggestions for Future Research

Future research on digital health interventions (DHIs) in Ghana should focus on several key areas to enhance understanding and improve implementation. Longitudinal studies assessing the long-term impacts of DHIs on health outcomes and system efficiency are needed, as are comprehensive cost-effectiveness analyses to inform policy decisions. Investigations into user acceptance, adoption, and continued use among diverse population groups would provide valuable insights for improving intervention design. Future studies should also explore capacity building for healthcare professionals, sustainable funding models, and the development of supportive regulatory frameworks.

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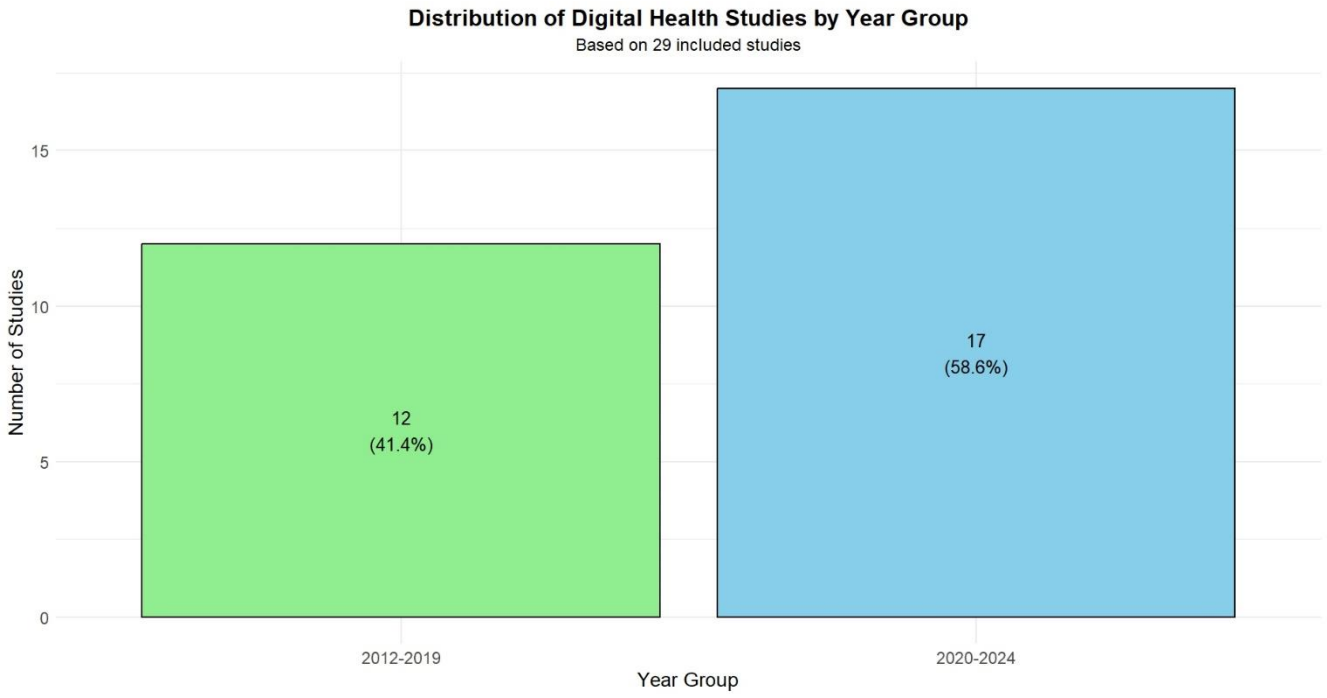
# LIST OF APPENDICES

## Appendix 1 - Results

### Appendix 1.0: Distribution of Included Digital Health Studies in Ghana by Publication Year



**Appendix 1.1: Types & Focus of Digital Health Interventions in Ghana**

| Digital Health Interventions | Type of DHI | Geographic Location | Period of Activity | Target Population | Focus | Type of Setting |
|---|---|---|---|---|---|---|
| SATELLIFE | Hybrid | Accra | 2001 | General | General healthcare | Urban |
| Tele-Ophthalmology | Telemedicine | Accra | 2003 | General | Eye care | Urban |
| Sene PDA Project | mHealth | Sene East and West District, Bono East Region | 2004- Present | Initial levels of care/Community Health Officers (CHO) | Immunization | Rural |
| Pan African eNetwork | Telemedicine | Kumasi | 2007 | Students and medical practitioners | Education and telemedicine | Both |
| OneTouch Medicareline (ML) | mHealth | Accra | 2007-2008 | Physicians and surgeons | Free phone calls, text messages, MMS, data reports | Urban/Rural |
| GCN (ghana consultation network) | Telemedicine | Northern Ghana | 2007-2008 | - | General healthcare consultations | Urban/Rural |
| ReACH (Remote Asynchronous Communication for Healthcare) | Telemedicine | Upper West Region | 2008 | General | General Healthcare (Remote consultations) | Urban/Rural |
| mPEDIGREE | mHealth | Nationwide | 2008 | General | Pharmaceutical drugs | Urban/Rural |

| | | | | | | |
|---|---|---|---|---|---|---|
| SMS for Life | mHealth | Nationwide | 2009 | N/A | Medicine supply chain management | Urban/Rural |
| MOTECH (Mobile Technology for Community Health) | mHealth | Kassena-Nankana, Awutu Senya, Gomoa West, Ada, South Tongu | 2010-2014 | Pregnant women and newborns | Maternal, Prenatal and neonatal care | Urban/Rural |
| DHIS 2 (District Health Information Software 2) | eHealth | Nation-wide | 2011-Present | General | Health data management and reporting | Urban/Rural |
| Vodafone Healthline | Hybrid | Nation-wide | 2011-Present | General | Not specified | Urban/Rural |
| MVHS (Millennium Villages and Mobile Telemedicine) | Telemedicine | Bonsaaso | 2012- 2014 | Pregnant women | Maternal and child health | Rural |
| Sanford | Telemedicine | - | 2012 | Not specified | General Healthcare | Urban |
| eHISS (Electronic Health Information and Surveillance System) | mHealth | Agogo (Asante Akim North) | 2015 | General | General Symptom monitoring | Rural |
| Novartis | Telemedicine | Amansie West District, Ashanti | 2015 | Pregnant women | Pregnant women | Rural |

| | | | | | | |
|---|---|---|---|---|---|---|
| Family Health Hospital telemedicine | Telemedicine | Accra | 2016 | General | Medical Specialist consultations | Urban |
| Lightwave Health Information Management System (LHIMS) | eHealth | Nationwide | 2017- Present | Teaching and Regional Hospitals | Efficient medical record management | Urban |
| Ghana Integrated Logistics Management Information System (GhILMIS) | eHealth | Nationwide | 2020-Present | - | Medicine and supply chain management | Urban/Rural |
| Mobile Teledermatology (africa.telederm.org) | Telemedicine | Accra and Kumasi Ghana | - | General | Dermatology | Urban/Rural |
| EWS (Early Warning System) | Hybrid | Nationwide | - | General | Disease outbreaks, surveillance | Urban/Rural |
| Mahiri | Telemedicine | Tamale, Nsawam | - | General | General Healthcare | Rural |

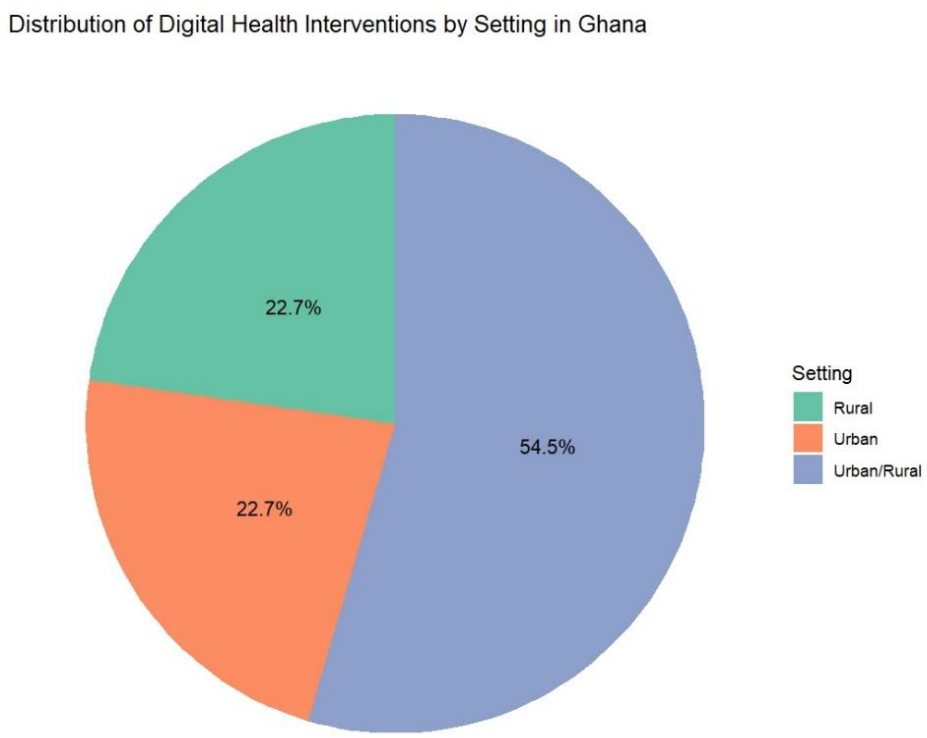
NB: Some entries don't have a specific start year mentioned. These are placed at the end of the table and are ordered alphabetically.

## Appendix 1.2: Glossary of The Types of DHIs

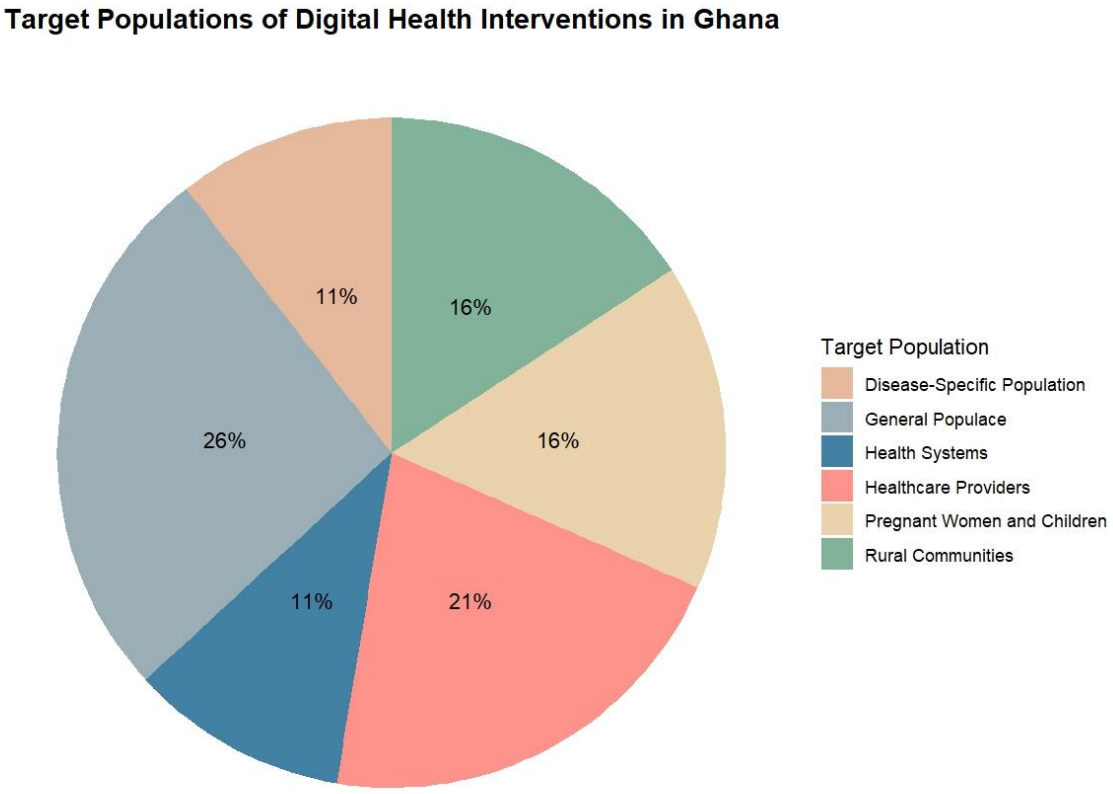
| Type of DHI | Intervention | Description |
|---|---|---|
| **A. mHealth Interventions** | **MOTECH (Mobile Technology for Community Health)** | Aimed at improving prenatal and neonatal care in rural Ghana through mobile phone-based information dissemination and data collection. |
| | **SMS for Life** | A text message-based system for supply chain management in healthcare facilities. |
| | **OneTouch Medicareline (ML)** | A program offering free calls and SMS messages between registered physicians and surgeons in Ghana to facilitate medical consultations. |
| | **mPEDIGREE** | A mobile-based system for authenticating pharmaceutical products to combat counterfeit drugs. |
| | **Sene PDA Project** | One of the earliest mobile health initiatives in Ghana, using Personal Digital Assistants (PDAs) to improve healthcare delivery at the community level. |
| | **eHISS (Electronic Health Information and Surveillance System)** | An automated mobile phone-based system for assessing children's symptoms and providing health advice to caregivers through an interactive voice response system. |
| **B. eHealth and Health Information Systems** | **District Health Information Software 2 (DHIS 2)** | A web-based health information system with a centralized database for generating reports and utilizing health service data from various health centers. |
| | **Lightwave Health Information Management System (LHIMS)** | A system for managing patient records and healthcare data. |
| | **Ghana Integrated Logistics Management Information System (GhILMIS)** | A system focused on improving supply chain management in the health sector. |
| **C. Telemedicine Interventions** | **Pan African eNetwork** | A project providing telemedicine services through online medical consultations between African medical practitioners and Indian medical specialists. |
| | **Mobile Teledermatology** | A system allowing submission of dermatological cases using mobile phones for remote diagnosis. |
| | **ReACH (Remote Asynchronous Communication for Healthcare)** | An online system enabling rural doctors to input case information and forward it to specialists in central hospitals. |
| | **Web-based tele-ophthalmology system** | A platform allowing eye practitioners to share photos and case histories online for consultation with specialists. |
| | **Ghana Consultation Network (GCN)** | A computer-based system providing medical consultation among doctors over a network, both within Ghana and internationally. |

| | | |
|---|---|---|
| | **Millennium Villages and Mobile Telemedicine (MVHS)** | Part of the Millennium Villages Project, using mobile technology to connect community health workers with experienced healthcare professionals. |
| | **Novartis telemedicine project** | An initiative connecting community health workers in remote areas to experienced healthcare professionals via teleconsultation centers. |
| | **Sanford telemedicine** | A comprehensive telemedicine service offering both real-time and store-and-forward capabilities across multiple clinics in Ghana. |
| | **Mahiri Mobile Services telemedicine** | A project equipping healthcare providers in remote areas with tablet devices capable of high-quality live video connections to doctors in urban centers. |
| | **Family Health Hospital telemedicine** | A facility offering video-conferencing systems for patient consultations with international specialists and medical education. |
| **D. Hybrid Digital Health Interventions** | **Early Warning System (EWS)** | A nationwide system for disease outbreak surveillance combining mHealth (data collection through mobile devices) and eHealth (centralized data management and analysis). |
| | **SATELLIFE PDA Project** | This initiative explored the use of PDAs for field surveys and data collection (mHealth) while also establishing a service called Healthnet for medical information access (eHealth). |
| | **Vodafone Healthline** | A health education initiative using television, radio, and a dedicated phone service (Healthline 255) to provide medical advice to the public. |

## Appendix 1.3: Distribution of Digital Health Interventions in Ghana by Setting



## Appendix 1.4: Target Populations of Digital Health Interventions in Ghana



## Appendix 1.5: Coding Frame for Themes & Codes

### Appendix 1.5.1: Themes Related to Strengths of DHIs

| Theme | Corresponding Codes |
|---|---|
| 1. Improved Data Management and Quality | Accuracy, Comprehensiveness of data, Consistency of data, Data Handling, Enhanced Data Scrutiny, Improved Data Accuracy, Improved data quality, Medical records management, Minimizes Loss of Information, Report Generation, Safe & Secure Patient Information, Timely Access to Data |
| 2. Enhanced Patient Care and Monitoring | Automated Reminders, Caregiver Education, Defaulter Tracking, Disease diagnosis, Enhanced Patient Adherence, Enhanced Patient Monitoring, Enhanced Treatment Capability, Ensures Continuity of Care, Ensures Self-Monitoring, Guided Emergency Management, Health Problem Detection, Improved Follow-up, Improved quality of care, Local Management of Cases, Monitoring of Diseases, Patient Education, Patient Tracking, Support for Complicated Cases, Support Treatment Procedures, Treatment and management of diseases |
| 3. Improved Efficiency and Time Management | Completing tasks faster, Cost-Effective, Cost Savings, Efficiency, Faster Access to information, Improved Timeliness, Makes work easier, Perceived Time Savings, Reduced consultation process, Reduced Waiting Time, Reduction in Errors, Reduction in Paperwork, Reduction in Workload, Ease of use, Reliable |
| 4. Enhanced Communication and Coordination | Enhanced Communication with health professionals, Facilitates Communication, Facilitates Departmental Coordination, Improved Communication with patients, Interoperability |
| 5. Improved Access to Healthcare | Easier access to records, Improved Access to Healthcare, Improved Access to Records, Limiting Unnecessary Referrals, Reduction in transportation costs, Reduction in Travel, Specialist Access |
| 6. Enhanced Decision-Making and Professional Development | Effective Protocols and Professional Experience, Encourages Professional Creativity and Innovation, Enhanced User Satisfaction, Improved Decision-Making, Opportunity for Education, Professional Satisfaction, Real-time Skill Development |
| 7. Patient-Centered Benefits | Emotional support to caregivers, Ensures patients' privacy and confidentiality, Helps Assess Client's Environment for Adaptation |

### Appendix 1.5.2: Coding Frame for Themes Related to Limitations of DHIs

| Theme | Corresponding Codes |
|---|---|
| 1. Technical and Infrastructure Challenges | Availability of equipment, Complex interface, Device Management Issues, Inadequate computers/equipment, Inefficient Hardware, Lack of a reliable internet connection, Lack of backup, Lack of fuel, Lack of interoperability, Lack of reliable backup for system, Lack of smartphone/computers, Lack of standardisation of EHR across units, Lack of technical support, Low system performance, System breakdowns, Technical Challenges, Unreliable power supply |
| 2. Human Resource and Training Issues | Inadequate personnel, Inadequate training, Limited Digital Literacy, Limited system understanding, Requires Technical training, User Adaptation issues, Frequent Need for IT Support |

| | |
|---|---|
| 3. Data Quality and Management Issues | Critical Data Omission, Data entry errors, Data Recording Delays, High Volume Data Entry, Incomplete Data Coverage, Incomplete records, Insufficient Client Information, Reduced Data security |
| 4. Usability and Design Issues | Delayed Response Times, Difficult Access, Typing Efficiency, Unfriendly software design, Usability Challenges |
| 5. Workload and Time Management Issues | Increased Workload, Time Delays |
| 6. Financial Constraints | Expensive, Financial Cost, Lack of funding |
| 7. Adoption and Acceptance Challenges | Fear of the unknown, Lack of Awareness, Lack of trust, Low utilization of digital health, Patient Acceptance Challenges, Resistance to change |
| 8. Socio-cultural Barriers | Illiteracy, Language barrier |
| 9. Clinical Concerns | Inaccessible therapeutics following consultation, Inaccurate Information, Interrupted Interaction, Less Patient Engagement, Risk of Misdiagnosis |
| 10. Management and Organizational Issues | Inadequate Compensation, Inadequate logistics, Resource Constraints |

**Source: Review of Literature**

## Appendix 1.6: Quality Appraisal Results

### Appendix 1.6.1: Results of CASP Qualitative Checklist

| Author, Year | Statement of aims | Qualitative methodology appropriate | Research design appropriate | Recruitment strategy appropriate? | Data collection appropriate | Relationship between researcher and participant considered | Ethical issues considered | Data analysis rigorous | Statement of findings | Is research valuable? | Outcome of checklist (Yes/Can't tell/ No) |
|---|---|---|---|---|---|---|---|---|---|---|---|
| (Paul *et al.*, 2024) | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 10/0/0 |
| (Acquah-Swanzy, 2015) | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 10/0/0 |
| (Ginsburg *et al.*, 2016) | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 10/0/0 |
| (Gyamfi *et al.*, 2017) | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 10/0/0 |
| (Rothstein *et al.*, 2016) | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 10/0/0 |
| (Mensah, Boadu, *et al.*, 2023) | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 10/0/0 |
| (Brinkel *et al.*, 2017) | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 10/0/0 |
| (Hammond *et al.*, 2020) | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 10/0/0 |
| (Acquah-Gyan *et al.*, 2022) | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | 9/0/1 |
| (Peprah *et al.*, 2020) | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | 9/0/1 |
| (Nichols *et al.*, 2019) | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 10/0/0 |
| (Opoku, Scott and Quentin, 2015) | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | 9/0/1 |
| (Tchao *et al.*, 2019) | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 10/0/0 |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| (Ibukun-Oluwa Omolade *et al.*, 2018) | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | No | 9/0/1 |
| (Mensah, Adzakpah, *et al.*, 2023) | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 10/0/0 |
| (Afarikumah, 2014) | Yes | Can't Tell | Can't Tell | Can't Tell | Yes | Can't Tell | Yes | Yes | Yes | No | 5/1/4 |
| (Attafuah *et al.*, 2022) | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 10/0/0 |

**Appendix 1.6.2: Results of Standard Quantitative Checklist**

| **Author, Year** | **Question/ Objective** | **Study Design** | **Subject comparison description** | **Subject/comparison group description** | **Random allocation described** | **Blinding of investigators** | **Blinding of subjects** | **Outcome/ exposure measures** | **Sample Size** | **Analytical methods** | **Variance estimate** | **Confounding control** | **Detail reporting** | **Conclusions supported** | **Outcome of checklist Yes/ /No/Partial/NA** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Osei et al., 2021 | Yes | Yes | Yes | Yes | N/A | N/A | N/A | Yes | Yes | Yes | N/A | Yes | Yes | Yes | 10/0/0/4 |
| Mensah, 2022 | Yes | Yes | Yes | Yes | N/A | N/A | N/A | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 11/0/0/3 |
| Okyere Boadu et al., 2024 | Yes | Yes | Yes | Yes | N/A | N/A | N/A | Yes | Yes | Yes | Yes | Partial | Yes | Yes | 10/0/1/3 |
| Essuman et al., 2020 | Yes | Yes | Yes | Yes | N/A | N/A | N/A | Yes | Yes | Yes | No | Partial | Yes | Yes | 9/1/1/3 |
| Adjei et al., 2021 | Yes | Yes | Yes | Yes | N/A | Yes | N/A | Yes | Yes | Yes | Yes | Yes | Yes | Yes | 12/0/0/2 |
| Abotsi, Agbemafle and Ayimey, 2024 | Yes | Yes | Yes | Yes | N/A | N/A | N/A | Yes | Yes | Yes | Yes | Partial | Yes | Yes | 10/0/1/3 |
| Frimpong, 2021 | Yes | Yes | Yes | N/A | Yes | N/A | N/A | Yes | Yes | Yes | Yes | Partial | Yes | Yes | 10/0/1/3 |
| Amoateng and Achampong, 2024 | Yes | Yes | Yes | Yes | N/A | N/A | N/A | Yes | Yes | Yes | Yes | Partial | Yes | Yes | 10/0/1/3 |

**Appendix 1.6.3: Results of CRAAP Checklist**

| Authors | Currency | Relevance | Authority | Accuracy | Purpose | Overall Score (over 5) |
|---|---|---|---|---|---|---|
| (Carney, 2016) | 4 | 5 | 4 | 4 | 4 | 4.2 |
| (Achampong, 2022) | 5 | 4 | 4 | 3 | 3 | 3.8 |
| (Owusu et al., 2023) | 5 | 5 | 4 | 4 | 3 | 4.2 |

**Appendix 1.6.4: Results of Mixed Methods Appraisal Tool (MMAT)**

| Authors | Clear research questions? | Data address research questions? | Appropriate qualitative approach? | Adequate qualitative data collection? | Findings derived from data? | Interpretation substantiated by data? | Coherence in data sources, collection, analysis, interpretation? | Relevant sampling strategy? | Representative sample? | Appropriate measurements? | Low risk of nonresponse bias? | Appropriate statistical analysis? | Adequate mixed-methods rationale? | Effective integration of study components? | Adequate interpretation of integrated outputs? | Addressed divergences and inconsistencies? | Adherence to quality criteria of methods? |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| (Adu et al., 2023) | Yes | Yes | Yes | Yes | Yes | yes | Yes | Yes | Can't Tell | Yes | Can't Tell | Yes | Yes | Yes | Yes | Yes | Yes |

# Appendix 2.0 - PRISMA 2020 Checklist

## PRISMA 2020 Checklist

| Section and Topic | Item # | Checklist item | Location where item is reported |
|---|---|---|---|
| **TITLE** | | | |
| Title | 1 | Identify the report as a systematic review. | |
| **ABSTRACT** | | | |
| Abstract | 2 | See the PRISMA 2020 for Abstracts checklist. | |
| **INTRODUCTION** | | | |
| Rationale | 3 | Describe the rationale for the review in the context of existing knowledge. | |
| Objectives | 4 | Provide an explicit statement of the objective(s) or question(s) the review addresses. | |
| **METHODS** | | | |
| Eligibility criteria | 5 | Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses. | |
| Information sources | 6 | Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted. | |
| Search strategy | 7 | Present the full search strategies for all databases, registers and websites, including any filters and limits used. | |
| Selection process | 8 | Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process. | |
| Data collection process | 9 | Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process. | |
| Data items | 10a | List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect. | |
| | 10b | List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information. | |
| Study risk of bias assessment | 11 | Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process. | |
| Effect measures | 12 | Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results. | |
| Synthesis methods | 13a | Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)). | |
| | 13b | Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions. | |
| | 13c | Describe any methods used to tabulate or visually display results of individual studies and syntheses. | |
| | 13d | Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used. | |
| | 13e | Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression). | |
| | 13f | Describe any sensitivity analyses conducted to assess robustness of the synthesized results. | |
| Reporting bias assessment | 14 | Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases). | |
| Certainty assessment | 15 | Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome. | |

## PRISMA 2020 Checklist

| Section and Topic | Item # | Checklist item | Location where item is reported |
|---|---|---|---|
| **RESULTS** | | | |
| Study selection | 16a | Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram. | |
| | 16b | Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded. | |
| Study characteristics | 17 | Cite each included study and present its characteristics. | |
| Risk of bias in studies | 18 | Present assessments of risk of bias for each included study. | |
| Results of individual studies | 19 | For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots. | |
| Results of syntheses | 20a | For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies. | |
| | 20b | Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect. | |
| | 20c | Present results of all investigations of possible causes of heterogeneity among study results. | |
| | 20d | Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results. | |
| Reporting biases | 21 | Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed. | |
| Certainty of evidence | 22 | Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed. | |
| **DISCUSSION** | | | |
| Discussion | 23a | Provide a general interpretation of the results in the context of other evidence. | |
| | 23b | Discuss any limitations of the evidence included in the review. | |
| | 23c | Discuss any limitations of the review processes used. | |
| | 23d | Discuss implications of the results for practice, policy, and future research. | |
| **OTHER INFORMATION** | | | |
| Registration and protocol | 24a | Provide registration information for the review, including register name and registration number, or state that the review was not registered. | |
| | 24b | Indicate where the review protocol can be accessed, or state that a protocol was not prepared. | |
| | 24c | Describe and explain any amendments to information provided at registration or in the protocol. | |
| Support | 25 | Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review. | |
| Competing interests | 26 | Declare any competing interests of review authors. | |
| Availability of data, code and other materials | 27 | Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review. | |

## Appendix 3.0 – Quality Appraisal Tools

### Appendix 3.1: CASP Qualitative Checklist

| Question | Yes | Can't Tell | No |
|---|---|---|---|
| 1. Was there a clear statement of the aims of the research? | | | |
| 2. Is a qualitative methodology appropriate? | | | |
| 3. Was the research design appropriate to address the aims of the research? | | | |
| 4. Was the recruitment strategy appropriate to the aims of the research? | | | |
| 5. Was the data collected in a way that addressed the research issue? | | | |
| 6. Has the relationship between researcher and participants been adequately considered? | | | |
| 7. Have ethical issues been taken into consideration? | | | |
| 8. Was the data analysis sufficiently rigorous? | | | |
| 9. Is there a clear statement of findings? | | | |
| 10. How valuable is the research? (Comment space) | | | |

## Appendix 3.2: Standard Quality Assessment Checklist for Quantitative Studies

| Criteria | | YES (2) | PARTIAL (1) | NO (0) | N/A |
|---|---|---|---|---|---|
| 1 | Question / objective sufficiently described? | | | | |
| 2 | Study design evident and appropriate? | | | | |
| 3 | Method of subject/comparison group selection *or* source of information/input variables described and appropriate? | | | | |
| 4 | Subject (and comparison group, if applicable) characteristics sufficiently described? | | | | |
| 5 | If interventional and random allocation was possible, was it described? | | | | |
| 6 | If interventional and blinding of investigators was possible, was it reported? | | | | |
| 7 | If interventional and blinding of subjects was possible, was it reported? | | | | |
| 8 | Outcome and (if applicable) exposure measure(s) well defined and robust to measurement / misclassification bias? Means of assessment reported? | | | | |
| 9 | Sample size appropriate? | | | | |
| 10 | Analytic methods described/justified and appropriate? | | | | |
| 11 | Some estimate of variance is reported for the main results? | | | | |
| 12 | Controlled for confounding? | | | | |
| 13 | Results reported in sufficient detail? | | | | |
| 14 | Conclusions supported by the results? | | | | |

**Appendix 3.3: Mixed Methods Appraisal Tool (MMAT), version 2018**

| Category of study designs | Methodological quality criteria | Responses | | | |
|---|---|---|---|---|---|
| Screening questions (for all types) | S1. Are there clear research questions? | Yes | No | Can't Tell | Comments |
| | S2. Do the collected data allow to address the research questions? | | | | |
| | ***Further appraisal may not be feasible or appropriate when the answer is 'No' or 'Can't tell' to one or both screening questions.*** | | | | |
| 1. Qualitative | 1.1. Is the qualitative approach appropriate to answer the research question? | | | | |
| | 1.2. Are the qualitative data collection methods adequate to address the research question? | | | | |
| | 1.3. Are the findings adequately derived from the data? | | | | |
| | 1.4. Is the interpretation of results sufficiently substantiated by data? | | | | |
| | 1.5. Is there coherence between qualitative data sources, collection, analysis and interpretation? | | | | |
| 2. Quantitative randomized controlled trials | 2.1. Is randomization appropriately performed? | | | | |
| | 2.2. Are the groups comparable at baseline? | | | | |
| | 2.3. Are there complete outcome data? | | | | |
| | 2.4. Are outcome assessors blinded to the intervention provided? | | | | |
| | 2.5. Did the participants adhere to the assigned intervention? | | | | |
| 3. Quantitative non-randomized | 3.1. Are the participants representative of the target population? | | | | |
| | 3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)? | | | | |
| | 3.3. Are there complete outcome data? | | | | |
| | 3.4. Are the confounders accounted for in the design and analysis? | | | | |
| | 3.5. During the study period, is the intervention administered (or exposure occurred) as intended? | | | | |
| 4. Quantitative descriptive | 4.1. Is the sampling strategy relevant to address the research question? | | | | |

| | | | | | |
|---|---|---|---|---|---|
| | 4.2. Is the sample representative of the target population? | | | | |
| | 4.3. Are the measurements appropriate? | | | | |
| | 4.4. Is the risk of nonresponse bias low? | | | | |
| | 4.5. Is the statistical analysis appropriate to answer the research question? | | | | |
| 5. Mixed methods | 5.1. Is there an adequate rationale for using a mixed methods design to address the research question? | | | | |
| | 5.2. Are the different components of the study effectively integrated to answer the research question? | | | | |
| | 5.3. Are the outputs of the integration of qualitative and quantitative components adequately interpreted? | | | | |
| | 5.4. Are divergences and inconsistencies between quantitative and qualitative results adequately addressed? | | | | |
| | 5.5. Do the different components of the study adhere to the quality criteria of each tradition of the methods involved? | | | | |

## Appendix 3.4: The CRAAP Test

### The CRAAP Test Worksheet

Use the following list to help you evaluate sources. Answer the questions and then rank each of the 5 parts from 1 to 10 (1 = unreliable, 10 = excellent). Add up the scores to give you an idea of the quality of the resource.

**Currency**: ..... ☐

- When was the information published or posted?
- Has the information been revised or updated?
- Is the information (also links) current or out of date for your topic?

**Relevance**: ..... ☐

- Does the information relate to your topic or answer your question?

**Authority**: ..... ☐

- Who is the author/publisher/source/sponsor?
- Are the author's organizational affiliations given? If yes, are they appropriate? (Does the URL reveal anything about the author or source?)
- What are the author's qualifications to write about the topic?
- Is there contact information, such as a publisher or email address?

**Accuracy**: ..... ☐

- Is the information supported by evidence?
- Has the information been reviewed or refereed?
- Can you verify any of the information in another source?
- Does the language or tone seem unbiased and is it free of emotion?
- Are there spelling or grammar errors, do links work?

**Purpose**: ..... ☐

- What is the purpose of the information?
- Do the authors/sponsors make their intentions or purpose clear?
- Is the information a fact, an opinion or propaganda?
- Are there political, ideological, cultural, religious, institutional, or personal biases?

**Total CRAAP**: ..... ☐

*45 - 50 Excellent | 40 - 44 Good | 35 - 39 Average | 30 - 34 Borderline Acceptable | Below 30 Unacceptable*

## Appendix 4.0: Ethical Clearance

ENSIGN GLOBAL
COLLEGE

OUR REF: ENSIGN/IRB/EL/SN-261/02
YOUR REF:

April 29, 2024.

**INSTITUTIONAL REVIEW BOARD SECRETARIAT**

**Mclord Selasi Azalekor**
**Ensign Global College**
**Kpong.**

Dear Mclord,

**ETHICAL CLEARANCE TO UNDERTAKE POSTGRADUATE RESEARCH**

At the General Research Proposals Review Meeting of the *INSTITUTIONAL REVIEW BOARD (IRB)* of Ensign Global College held on Thursday, April 11, 2024, your research proposal entitled **"A systematic Review on Digital Health Interventions in Ghana"** was considered.

You have been granted Ethical Clearance to collect data for the said research under academic supervision within the IRB's specified frameworks and guidelines.

We wish you all the best.

Sincerely,

Dr. (Mrs.) Rebecca Acquaah-Arhin
**IRB Chairperson**

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