Digital health applications used by community health workers for the management of HIV/AIDS and TB in the Southern African Development Community Region: a scoping review on the factors that influence the success and failure of such applications.

by

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A mini thesis submitted in partial fulfilment of the requirements for the degree of Magister in Public Health at the School of Public Health University of the Western Cape.

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December 2022

Keywords: Scoping Review, Digital Health Applications, Community Health Worker, TB, HIV/AIDS, SADC, scaling digital health applications, Universal Health Coverage, Sustainable Development Goals, WHO Classification of Digital Health Interventions

ABSTRACT

More than three hundred and forty-five million (345 000 000) people live in the South African Development Community region (SADC), which is also the epicentre of the Human Immunodeficiency Virus (HIV) pandemic. In the region, Tuberculosis (TB) remains the leading cause of death among people living with HIV, accounting for around one in three (1/3) Acquired Immune Deficiency Syndrome (AIDS) related deaths, with seven (7) of the sixteen (16) SADC nations among the top thirty (30) TB high burden countries globally. Bringing these diseases under control will contribute to SADC attaining Universal Health Care by 2030 and the health-related Sustainable Development Goals.

An increase in the number of affordable mobile devices and wider mobile network penetration has resulted in the rapid proliferation of digital health interventions (DHIs) of which digital health applications or DHAs form a subset, for the management of HIV/AIDS and TB being implemented in low and middle-income countries (LMICs). Unfortunately, many of these DHAs have failed either at their implementation or when they were brought to scale on a national level. Understanding the reasons for such failure, especially within the SADC region would be the first step towards ensuring further such implementations succeed.

A scoping review was conducted to explore the existing literature to better understand how and why DHAs have failed at implementation or to be brought to a national scale. A comprehensive database search was conducted using Sage Journals, Science Direct, Taylor and Francis, EBSCOhost, and Web of Science. In addition, the thesis repositories of the University of the Western Cape and the University of Cape Town were searched as well as, Google Scholar, the mHealth Compendium online repository and the Digital Square Library. The search strategy included articles published in English between 1 January 2010 to 31 December 2020. 501 articles (full text) were uploaded into COVIDENCE to allow for further screening by the researcher and a co-reviewer. After further review, 150 articles were

selected for full-text review by both reviewers with 123 being identified as irrelevant to the review title, and the remaining 27 articles being selected for inclusion in the review.

To ensure rigour in the study, the researcher firstly followed the five (5) stages recommended when conducting a scoping review and thoroughly documented within the thesis the steps taken in each stage of the study. Furthermore, the researcher used the COVIDENCE tool to identify the articles that were selected for the scoping review, this tool allowed both the researcher and co-reviewer to use COVIDENCE's systematic review process which also produces a detailed report on the progress of the review from stage to stage.

The data extracted from the selected articles was then examined and analysed using a narrative synthesis technique, where the researcher primarily used the content of the data extraction results to examine, explain, and find meaning in the data extracted.

The results of this study demonstrated the pressing need for additional research to be conducted on DHIs, particularly those which are at a national scale particularly around areas like toolkits, health outcomes achieved and legislation to guide DHAs. It also raised the need for transdisciplinary (from the disciplines of digital and health) research methods to be used when researching DHIs to produce research that is both rigorous and beneficial to those investing, implementing, and designing DHIs.

PLAGIARISM DECLARATION:

I declare that *Digital health applications used by community health workers for the management of HIV/AIDS and TB in the Southern African Development Community Region: a scoping review on the factors that influence success and failure of such application i*s my work, that it has not been submitted for any degree or examination in any other university, and that all the sources I have used or quoted have been indicated and acknowledged by complete references.

Full name: Mandy Govender Date: 2 December 2022

Signed 

ACKNOWLEDGEMENTS

I would like to express my gratitude to my supervisor Dr Mathews, for her support and patience as I embarked on this learning journey. Thanks also go to my family, friends and in particular my husband, for their understanding and encouragement over the past months. A final heartfelt thanks to Annie Parsons, who kindly gave up much of her time to COVIDENCE with me.

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LIST OF ABBREVIATIONS

CHW:	Community health worker
DHA:	Digital health application
DHI:	Digital health intervention
GF:	The Global Fund to Fight AIDS, Tuberculosis and Malaria
HCW:	Healthcare worker
HIS:	Health Information systems
HIV/AIDS:	Human immunodeficiency virus / Acquired immune deficiency syndrome)
LMIC:	Low-and-middle income country
MeSH:	Medical Sub-Headings
PLWHA:	Person living with HIV/AIDS
SADC:	Southern African Development Community
SDG:	Sustainable Development Goal
TB:	Tuberculosis
UHC 2030:	Universal Health Care by 2030
UNAIDS:	United Nations Programme on HIV/AIDS
USAID:	The United States Agency for International Development
UWC:	University of the Western Cape
WHO:	The World Health Organisation

CHAPTER ONE: INTRODUCTION

1.1 Layout of the thesis

This thesis is comprised of five chapters. Chapter One provides a background to the study and describes the problem statement. Chapter Two is a review of the literature. Chapter Three provides a detailed report on the methodology of the scoping review with a clear description of the different methodological elements such as the review question, review process and the method of analysis used. Chapter Four is a presentation of the results. Chapter Five discusses these results. The final chapter is a conclusion, which serves to tie the study together and highlights the key findings, the limitations of the study and recommendations for further research.

1.2 Introduction

In this chapter, the researcher provides a background to this thesis as to why the use of digital health applications is important in the management of Human immunodeficiency virus (HIV) / Acquired immune deficiency syndrome (AIDS) and Tuberculosis (TB) in the Southern African Development Community (SADC) region when they are used by Community Health Workers. The chapter also outlines the problem statement and rationale for such a study.

Together, Human immunodeficiency virus (HIV) / Acquired immune deficiency syndrome (AIDS) and Tuberculosis are both continually growing burdens on South African Development Community (SADC) members' healthcare systems, while also impacting the general population's health and socio-economic capacity. This high population level of infections of HIV/AIDS and TB in the member states of the South African Development Community is frustrating the region's efforts to achieve Universal Health Care by 2030 (UHC 2030) and meet multiple Sustainable Development Goals (SDGs) (Southern African Development Community (SADC), 2020).

In the last decade, the potentially significant role that digital health and its related technologies could play in allowing the region to achieve these goals has been noted by the World Health Organisation (Dzenowagis, 2018). This significance has been supported by the global growth in the number of digital health and its related technologies being made available (Sundin, Callan, & Mehta, 2016). The concurrent use of community health care workers (CHWs) in combination with digital health applications (DHAs) as a means with which to accelerate the ability of SADC to reach their Universal Health Coverage (UHC 2030) and Sustainable Development Goals (SDG) has been a widely shared recommendation (Tan, 2022). Unfortunately, despite the proliferation of DHAs being implemented in low-and-middle-income countries (LMICs) most of these have failed in implementation or failed to be brought to the national scale (Swartz, LeFevre, Perera, Kinney, & George, 2021). This failure robs the already beleaguered healthcare systems in LMICs of both valuable resources as well as the chance for the region to achieve its health goals particularly around the HIV/AIDS and TB (Swartz et al., 2021). The next sections help us understand this context in greater detail.

1.2.1 HIV/AIDS and TB Disease Profiles in the Southern African Development Community

The incidence and prevalence of both HIV/AIDS and TB are key public health issues in the SADC region because of their high levels in the region. 34% of the total global HIV/AIDS burden is borne by SADC countries (Southern African Development Community, 2021), and 50% of SADC nations account for the top thirty (30) TB high-burden countries (Lozano et al., 2020). We also found that coinfection with HIV/AIDS and TB is the leading cause of death among people living with HIV/AIDS (PLWHA) in the region (Lozano et al., 2020). By effectively managing these diseases the region can make significant progress in reaching its SDGs goals and achieving UHC 2030 (World Health Organization, 2019).

Leading global health bodies like the WHO, the Global Fund to Fight AIDS, Tuberculosis and Malaria (The Global Fund) and UNAIDS (United Nations Programme on HIV/AIDS) have provided key recommendations to Low and Middle-Income Countries (LMICs) on how to manage these diseases so they reach UHC 2030 and their SGDs (PEPFAR, 2022).

1.2.2 HIV/AIDS and TB Management

This study focuses on three (3) recommendations which are related to the problem statement of this study. These recommendations include co-managing HIV/AIDS with TB, leveraging the use of community health workers (CHWs), and the use of digital interventions in the management of HIV/AIDS and TB. These recommendations are discussed below.

a. Co-management of HIV/AIDS and TB

Both HIV/AIDS and TB are managed at the primary care level of service delivery in the SADC region and are usually offered as parallel services (Southern African Development Community (SADC), 2020). The WHO has identified that by managing these two diseases together as opposed to parallelly, the number of people being diagnosed and treated for both diseases would increase which in turn decreases the mortality rate of PLHWAs (Lessells, Swaminathan, & Godfrey-Faussett, 2015). In other words, a patient who accesses the healthcare system for either disease must then be tested for the other disease at the same time or as part of the care provided, this recognises the increased chance that a person is probably living with both diseases (Lozano et al., 2020). This recommendation for the combined management of these diseases increases the chance of the patient's survival by ensuring both diseases are proactively addressed (Lessells, Swaminathan, & Godfrey-Faussett, 2015).

b. Use of CHWs to manage HIV/AIDS and TB

In the SADC region, only South Africa, Namibia, Seychelles and Mauritius have been able to attain the Health Care Worker (HCW) density of four-point -four- five (4.45) doctors, nurses, and midwives per one thousand (1 000) population that the WHO recommends to reach UHC 2030 and attain the

SDGs, with the other twelve (12) countries are falling far short of this figure (Ahmat et al., 2022). To manage this HCW shortage the WHO advocates that countries tap into the enormous potential that Community Health Care Workers (CHWs) offer in strengthening health and community systems by shifting work where possible from HCWs to CHWs (Leong, Teoh, Fun, & Lee, 2021). A CHW is ideally a community member who is chosen by either the community or localised organizations to provide basic health and medical care within that specific community and is capable of providing preventive, promotional and rehabilitative care (Emmanuel, 2018).

alleviating the shortage of HCWs, CHWs are also recognised as playing a vital role in the delivery of HIV/AIDS and TB services particularly in LMICs, such as in SADC as they support the healthcare system in the management of HIV/AIDS and TB in several ways (World Health Organization., 2020). They can promote disease prevention through the distribution of preventative commodities (e.g., condoms), increase the uptake of HIV and TB testing through community interactions and support, increase treatment initiation for TB and HIV/AIDS, and improve adherence to HIV and TB treatment as well as the retention of patients in care. CHWs can also reduce the costs to patients of travelling to health care facilities by dispensing medication between clinical visits, and can both make and follow up on referrals for further treatment and care. (World Health Organization., 2020).

c. Digital Health Applications for the management of HIV/AIDS and TB

Definition of digital health interventions

Digital health interventions (DHIs) are defined as health services delivered electronically either via formal or informal care and include four (4) broad groupings i.e., *interventions for clients* (health promotion materials, treatment support etc.), *interventions of healthcare providers* including CHWs (disease management information, decision making support etc.), *interventions for a health system or resource managers* (supply chain management, health financing, human resource management etc.) and *interventions for data services* (data management, use and exchange etc.) (World Health Organisation, 2018). These interventions are delivered via multiple numbers of electronic methods that

include digital health applications via mobile devices (DHAs), desktop computers, wearable sensors etc. (Soobiah et al., 2020) For this study, we will be focusing on digital health interventions for healthcare providers which include CHWs, particularly those delivered by digital health applications (DHAs). When the study uses the broader term DHIs the reader can assume this includes DHAs.

DHAs to manage HIV and TB

Both the WHO and UNAIDS recommend DHIs as an efficient and cost-effective way to manage HIV/AIDS and TB as the cost to deliver certain HIV/AIDS and TB services via DHIs is significantly less than providing the same services in a facility (Jongbloed, Parmar, Kop, Lester, & Spittal, 2016). They also recognise the role DHIs can play in the lifelong care required for patients living with HIV/AIDS and TB by supporting the patient's linkage to care and treatment as well as increasing the quality of care provided to them (Jongbloed et al., 2016). Firstly they can ensure the linkage and retention of patients within the healthcare system by connecting the patient to their health facility and care provider, this linkage is proven to improve both HIV/AIDS treatment initiation and adherence by patients and positively impacts their viral suppression of HIV (Jongbloed et al., 2016). Secondly, for CHWs, DHAs can also play a predominant role in helping to retain patients in HIV/AIDS and TB care by providing the CHW with more efficient prevention, treatment and management support tools for both diseases (Devi et al., 2015).

This ability to provide better and cost-effective care is one of the reasons that DHIs have been recommended as a critical part of LMICs health systems in particular those who have heavy burdens of diseases HIV/AIDS and TB like SADC (Swartz et al., 2021).

DHIs in LMICs

The recognition that DHIs can have a dramatic positive impact on LMICs' health systems has resulted in a rapid number of DHAs being created for LMICs in the past twelve (12) years (Swartz et al., 2021). In LMICs this growth has been supported by the increased availability of affordable mobile devices, the growth of mobile network services and the lower cost to access these services (Sundin et al., 2016). However, the promised potential for these tools in LMICs has not been achieved as a large number of these DHAs have failed at implementation or to be implemented at a national scale (Swartz et al., 2021). This phenomenon of an increasing number of stagnant or failed pilots has been termed "pilotitis", i.e., failing to expand beyond the initial pilot (Soobiah et al., 2020). This became a significant enough issue that certain countries in Africa went so far as to place a moratorium on the piloting of new digital health applications to reduce the burden their failure puts on the health services (Sundin et al., 2016).

1.3 Failure of Digital Health Applications

The advent of the COVID-19 pandemic has increased the already large number of new DHAs, with more than ninety thousand (90 000) new DHAs added to mobile app stores in 2020 – an average of more than two-hundred-and- fifty (250) new apps every day (May, 2021). Although the number and diversity of DHAs are increasing, historically the vast majority of these fail to grow beyond their initial pilot stage (Sundin et al., 2016). This continual failure of DHAs to grow and achieve national-scale implementation has both limited the great potential offered to LMICs as well as wasted the LMIC's limited health system resources (Sundin et al., 2016). The reasons why they fail can be grouped into four (4) key categories, which are reasons due to human factors, technical factors and ecosystem factors (healthcare and extrinsic) (Labrique & Wadhwani, et al., 2018). These reasons for failure are discussed in detail in the literature review Chapter.

1.4 Problem Statement

Despite the proliferation of DHAs for the use of CHWs to manage HIV/AIDS and TB in the SADC region, the failure of the majority at either implementation or when being brought to the national scale has reduced the ability of DHAs and CHWs to support the SADC region's progress towards reaching UHC 2030 and SDG3 (Sundin et al., 2016). This failure to scale nationally in LMICs has also wasted valuable and limited healthcare system resources for countries with intrinsic ongoing resource constraints (White, Thomas, Ezeanochie, & Bull, 2016).

The failure of digital solutions to scale has hampered the potential positive impact of DHAs used by CHWs for the SADC region (Swartz et al., 2021). Several reasons have been identified to play a role in the scale-up and failure of DHAs in LMICs, these can be summarised into four groups of factors that include: human factors, technical factors, health system factors and finally extrinsic ecosystem factors (Labrique & Wadhwani, et al., 2018). By examining articles on this subject, the study (a scoping review) will provide insights for further research towards a better understanding of these reasons.

CHAPTER TWO: LITERATURE REVIEW

This chapter summarises the background literature review conducted for this study. With the literature review, the researcher sought to better understand DHAs as they are used by CHWs in SADC to manage patients with HIV/AIDS and TB and the reasons for their failure or success. The chapter will summarise what was discovered by firstly highlighting the current state of HIV/AIDS and TB in SADC, and the health goals being impacted by both diseases, thereafter it will discuss the current recommendation available for managing these diseases, particularly those relating to DHAs and CHWs being used to manage HIV/AIDS and TB. It will then review the reasons identified by the literature as to why DHAs fail or succeed. Finally, it concludes by highlighting why a review such as a scoping review would be the most suitable methodology for this study.

2.1 HIV/AIDS, TB, and the impact of coinfection on SADC's UHC 2030 and SDGs progress

This section reviews the current context of HIV/AIDS and TB within the SADC in specific relation to their impact on the health goals mentioned. The literature shows that both these diseases are the most significant disease burden carried by countries in the SADC. This high burden affects the ability of the region to attain the UHC 2030 and hampers their progress towards the SDGs.

2.1.1 HIV/AIDS in SADC

As of 2020, thirty-eight million and four-hundred thousand (38 400 000) people globally were living with HIV/AIDS (United Nations Programme on HIV/AIDS, 2021a). The SADC region accounted for one-third, with around twelve million eight hundred thousand (12 800 000) people living with HIV/AIDS (Southern African Development Community (SADC), 2020). The HIV/AIDS prevalence in SADC is an average of 3,71% against a global average of 0.2% with prevalence in 70% of the member countries at higher than 10% of their populations. (Jemiluyi & Bank-Ola, 2021). The average

HIV/AIDS incidence in SADC is 5.68 per one thousand (5.68/1000) population versus a global average of 0.3 per one thousand (0.3/1000) (United Nations Programme on HIV/AIDS, 2021a).

2.1.2 TB in the SADC

Eight (8) of the SADC Member States are among those countries with the highest rates of TB (Southern African Development Community (SADC), 2020). Global TB prevalence in 2019 was seven million -and-two-hundred thousand (7,200,000) people, with SADC accounting for approximately one million -and-eight-hundred thousand (1,800,000) cases (United Nations Programme on HIV/AIDS, 2021a). SADC also has the highest average incidence of TB at 314.6 cases per one thousand (314.6/1000), versus the global average of 127 per one thousand (127/1000) (World Health Organisation, 2021).

2.1.3 HIV and TB Comorbidity in SADC

The existence of HIV/AIDS and TB as co-morbidities increases the mortality rate of people who are living with both diseases (World Health Organization, 2022). Approximately two-hundred-and-nineteen thousand (219,000) people died from HIV/AIDS-related causes in SADC in 2021, that is around a third of the six-hundred-and-fifty thousand (650,000) who died globally in the same year from the same disease (World Health Organization, 2022). TB is the leading cause of death among PLWHAs, causing one-third of all global AIDS-related deaths (Naidoo, Gengiah, Singh, Stillo, & Padayatchi, 2019). In the SADC region, it accounts for around one in three AIDS-related deaths or approximately seventy-three thousand (73 000) people every year die due to this comorbidity (Lozano et al., 2020).

2.1.4 HIV/AIDS, TB: SDGs and UHC

There are two global health goals set by the WHO that guide progress towards managing HIV/AIDS and TB, these are the 2030 Sustainable Development Goals (SDGs) and Universal Health Coverage

2030 (UHC 2030) (United Nations, 2015). Universal Health Care (UHC) means everyone can access the health services they need without suffering any financial hardship (World Health Organization, 2019). The 2030 Agenda for Sustainable Development, was adopted by all United Nations Member States in 2015 and shared the global blueprint for peace and prosperity for people and the planet under seventeen (17) goals, known as the Sustainable Development Goals or SDGs (United Nations, 2015). The SGD 3 "Good health and well-being" encompasses the disease burden-specific goals for HIV/AIDS and TB as well as the goal of UHC 2030 (United Nations, 2015).

Due to the region's large HIV/AIDS burden, ten (10) of the seventeen (17) SDGs are negatively impacted, particularly SGD 3 (United Nations Programme on HIV/AIDS, 2021b). TB also negatively impacts five (5) of the SDGs and in particular SDG 3, the same as HIV/AIDS (World Health Organisation, 2017). The impact of both diseases also hinders the region's efforts to attain UHC 2030. Attaining these health goals can only be achieved if SADC manages to either eradicate both diseases or reduces them to significantly lower rates than their current pandemic levels (Southern African Development Community (SADC), 2020).

To achieve these goals leading global health bodies like the WHO, the Global Fund and UNAIDS have guided countries on how to better manage these diseases. The next section looks at these in detail.

2.2 Guidance for HIV/AIDS and TB management

The WHO, the Global Fund and UNAIDS have developed five key guidance documents (Table 1 below) on HIV/AIDS and TB management (PEPFAR, 2022). For this study, we will focus on three (3) reoccurring recommendations for the management of HIV/AIDS as they relate to the problem statement of the study. These are the use of CHWs, the use of DHAs, and the coupled use of CHWs and DHAs.

From the literature reviewed, we found that DHIs can benefit the health system by improving health outcomes, as well as optimisation of processes like patient records and their related admin and resource management including medicine logistics and human resources. We also found that CHWs play multiple essential roles in the delivery of primary health care particularly in LMICs where they help fill the shortage in trained medical personnel.

Table 1: Guidance on HIV/AIDS and TB Management		
Title of document	Organisation	Year
The Global Fund Strategy 2023 to 2028	GF	2021
Global AIDS Strategy 2021 -2026	UNAIDS	2021
WHO guide for optimizing CHW programmes for HIV/AIDS, TB, and malaria services	WHO	2020
Digital Health Strategy 2020-2025	WHO	2020
Digital Health for the END TB strategy	WHO	2015

The first document, the '*WHO guide for optimizing CHW programmes for HIV/AIDS, TB and malaria services'* recognises CHWs as playing a vital role and strongly recommends countries leverage CHWs to reach their UHC 2030 and SGD3 goals (World Health Organization., 2020). CHWs can extend the provision of healthcare services by increasing the manpower required by health systems as well as by the type of services they provide, this will be discussed later (World Health Organization., 2020). This guide also recommends that HIV/AIDS and TB be managed together for countries to efficiently reach the health goals mentioned as co-management has been proven to increase the mortality of people who have both diseases (World Health Organization., 2020).

A second document from the Global Fund. *'The Global Fund Strategy 2023 to 2028'* further emphasises the pivotal role that CHWs can play in managing HI/AIDS and TB in LMICs, in the co-management of HIV/AIDS and TB, as well as describing the potential role of DHAs (The Global Fund, 2021). The third document from UNAIDS *'Global AIDS Strategy 2021 -2026'* also identifies DHIs as a cross-cutting tool that plays a critical role in managing HIV/AIDS and TB (United Nations Programme on HIV/AIDS, 2021b). This recommendation on the use of digital health interventions for the management of HIV/AIDS and TB is re-iterated in the fourth document, the WHO's *'Digital Health for the END TB strategy'* (World Health Organisation, 2015a). The final and fifth document, the WHO's *'Digital Health Strategy 2020-2025'* (World Health Organisation, 2020) adds to the discussion by providing additional guidance on how DHIs can benefit the overall health system as well as support their use by CHWs.

This next section discusses these recommendations in further detail i.e., the use of CHWs to manage HIV/AIDS and TB and the impact DHAs (in their hands) can have on the management of this disease.

2.2.1 Use of CHWs in the healthcare system (management of HIV/AIDS and TB)

CHWs are broadly defined as members of a community, often chosen by the community and working within their community, who are supported by the healthcare system but have no professional training (Leong et al., 2021). They are often the only link to healthcare for millions of people in the developing world and are well-established as major actors in promoting healthy behaviours and extending the reach of healthcare systems in the LMICs (Emmanuel, 2018).

Figure one demonstrates the health services a CHW delivers under key primary health care service areas: Maternal and child health, sexual reproductive health, communicable diseases, non-communicable disease, mental health, public health and global safety and trauma care (World Health Organization., 2018). They support the promotive and preventative health services for these primary health areas by – among other activities – conducting monitoring and evaluation exercises, ensuring

disease surveillance, and providing point-of-care diagnostic support where feasible (Leong et al., 2021; World Health Organization., 2018).

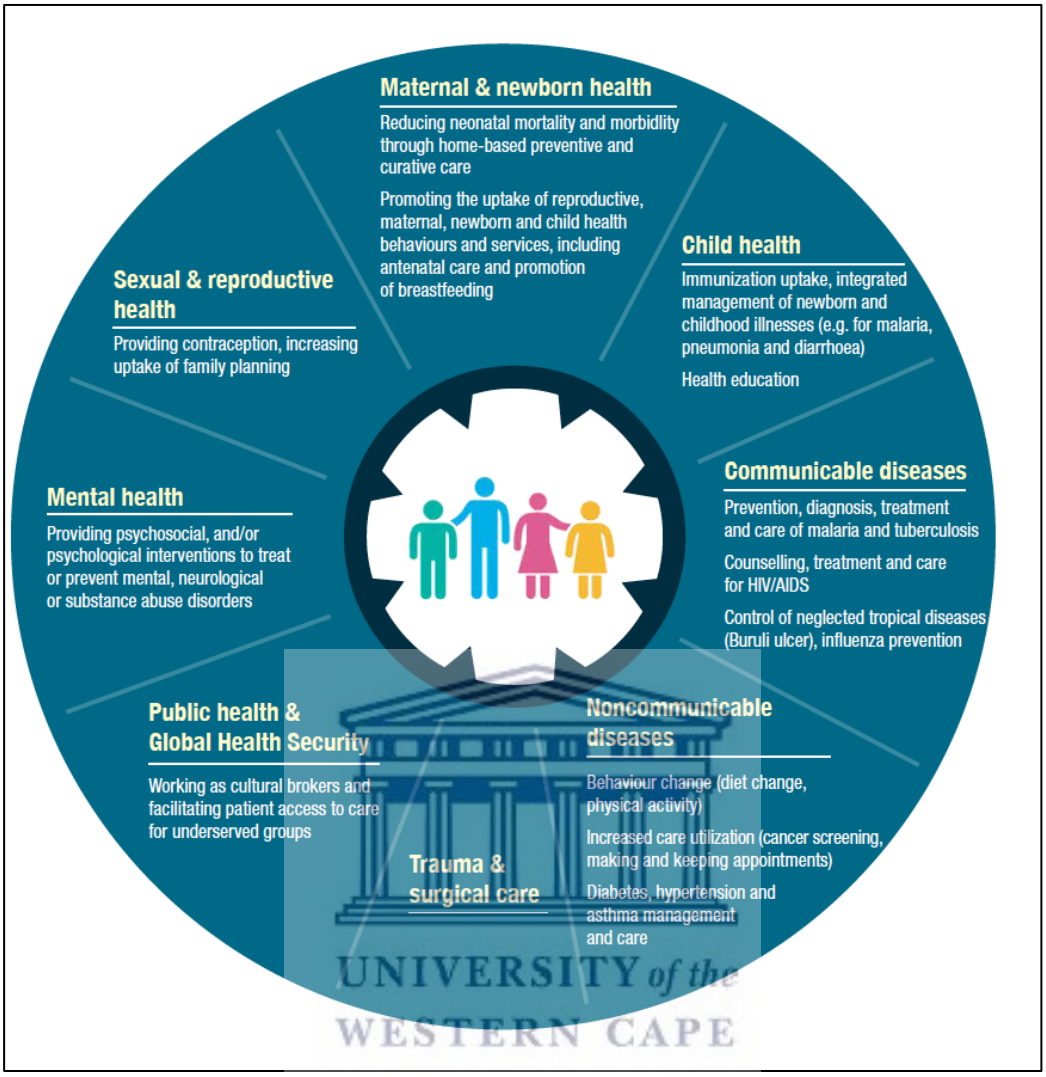


Figure 1: Health services delivered by CHWs (World Health Organization., 2018)

The skills of CHWs are vital in the co-management of HIV/AIDS and TB as they plug the gap in healthcare services (in LMICs) created by an ongoing shortage of qualified medical personnel, they do so by providing additional manpower for the health services mentioned in Figure one (Shapiro, 2018). CHWs have also been found useful in encouraging early testing for both diseases, in improving linkages to care and by providing ongoing support for those who are on medication which increases the suppression/cure of the diseases (Shapiro, 2018). Studies in India (Potty et al., 2021)

and Rwanda (Shapiro, 2018) have shown the use of CHWs for disease co-management can lead to increased rates of testing, referral to care and initiation into treatment.

2.2.2 Benefits of using DHIs for the management of HIV/AIDS and TB

As already mentioned, DHIs can be used in various ways to support and provide benefits to the health system, this next section unpacks how DHIs have been used to manage HIV/AIDS and TB and the benefits they have created. Concerning the management of HIV/AIDS and TB, DHIs have been identified as being most beneficial to the following broad areas: improving health outcomes, optimisation of processes, digitisation health information systems, and digitisation of resource management (Chowdhury & Pick, 2019). In the following section, we will discuss in detail these benefits firstly generally as they occur within the health system and secondly as they occur among CHWs.

2.2.2.1 Health Outcomes

An ongoing challenge in improving the health outcomes of people who are living with HIV/AIDS and TB is firstly testing them , then linking them to care, initiating treatment and finally ensuring their consistent adherence to the usually lifelong or long treatment regimens that come with both diseases both of which can positively impact their overall health outcomes (United Nations Programme on HIV/AIDS, 2021b). A review of digital technologies for the global management of HIV/AIDS found considerable evidence that DHIs including DHAs, can both support the linkage of people living with HIV/AIDS to care, as well as increase enrolment into HIV/AIDS treatment and improve subsequent adherence to treatment (Jongbloed et al., 2016). A review of DHAs used to manage TB programmes found that they are valuable in predicting and avoiding medicine stockouts, while also proving important in the management of patient treatment adherence and treatment support (World Health Organisation, 2015a). Finally, a systematic review with a focus on the long-term management of HIV/AIDS and TB using mobile phones found that DHAs played a predominant role in retention in

care through long-term management and adherence to ART as well as providing more efficient prevention, treatment and management support for both diseases (Devi et al., 2015).

The use of DHAs by CHWs has the potential to improve health behaviours and outcomes, such as increasing the use of primary and preventative health services, health-related data collection, medication adherence, and the timely delivery of disease test results concerning HIV/AIDS and TB (Early, Gonzalez, Gordon-Dseagu, & Robles-Calderon, 2019). A scoping review on the 'evidence of mobile health technologies for disease diagnosis and treatment support by health workers in sub-Saharan Africa' also found that the use of DHAs by CHWs to manage patient's chronic disease conditions like HIV/AIDS, TB, hypertension, and cancer help improve medication adherence and treatment compliance for these conditions (Osei, Kuupiel, Vezi, & Mashamba-Thompson, 2021). A recent global scoping review on the use of DHAs by CHWs found that DHAs can improve service provision by CHWs, in turn, this improved the clinical outcomes of PLWHAs (Early, Gonzalez, Gordon-Dseagu, & Robles-Calderon, 2019).

2.2.2.2 Process Optimisation

LMIC health systems are under duress due to inadequate resources being available to support their needs as well as inadequate management of these resources. DHIs can provide the necessary support which would allow for existing resources to be managed more efficiently by using solutions like the process optimisation (Olu et al., 2019). Process optimisation refers to the digitisation of medical records, staff scheduling, supply chain and logistics so to improve system functions (Chowdhury & Pick, 2019). Process optimisation via digital interventions has allowed for the automation of some human resource-intensive aspects of the system, such as administrative duties and logistics management among others, which allows more time for patient care and better resource management (GSMA Intelligence, 2017).

In the management of HIV/AIDS and TB by CHWs this optimisation increases CHWs' ability to effectively refer clients for further medical care by offering a quicker means of contacting healthcare facilities, as well as access to long-term medical records for ensuring more effective care of HIV/AIDS and TB patients (Swartz et al., 2021). A large portion of the tasks completed by a CHW involves the completion and submission of large amounts of data on the communities that they serve, usually collected and submitted on paper (Chowdhury & Pick, 2019). DHAs allow this analogue and time-consuming task to be converted to one that is digital and less time-consuming for the CHWs, which can increase the time spent with patients and improve job satisfaction (Global Health : Science and Practice, 2014).

2.2.2.3 Digitising Health Information Systems

Health Information systems (HIS) accumulate and use large amounts of data to carry out their functions effectively and efficiently, before DHIs the majority of this data was collected in an analogue manner (Olu et al., 2019). Digitising the HIS means that health systems have digital versions of a patient's paper chart, with the additional capacity to store health data from other electronic sources such as test results from laboratory information systems and dispensing information from pharmaceutical systems which allows for longitudinal and holistic patient care (Stroetmann, 2018). A digitised HIS can also be designed to enable real-time, patient-centred records that make information available instantly and securely to authorized users and can therefore increase the quality of healthcare services by improving access to data for effective management of patient health (Khubone, Tlou, & Mashamba-Thompson, 2020).

Both HIV/AIDS and TB require long-term clinical management, which increases the amount of data collected and required to manage the care of PLWHs by HCWs and CHWs (Shapiro, 2018). The

digitisation of this data can enable CHWs to instantaneously access relevant data on their patients in an accessible format and hence provide better quality comprehensive care to their patients (Jongbloed et al., 2016).

2.2.2.4 Resource management – medicine logistics and human resources

The efficient management of medical and human resources can be a game changer in poorly resourced health systems such as those usually found in LMICs as they can allow the health system to reduce the wastage of these resources (GSMA Intelligence, 2017). In the case of medical stock management, this can ensure that available health resources are used effectively both where and when they are needed (GSMA Intelligence, 2017). DHIs can support efficient stock management by streamlining the logistics needed to manage the demand and supply of medication, in particular being able to predict and better manage supply shortages when they occur (Myrick & Gilbert, 2021). For CHWs providing HIV/AIDS and TB care, DHAs can provide CHWs with the necessary information on what medication stocks and staff expertise are available at different healthcare facilities to ensure better patient referrals (Tambo et al., 2016).

DHIs can also provide human resource support to CHWs in a manner that is accessible and affordable, as it requires little investment in the terms of funds or time for CHWs to access this support on their digital devices (Early et al., 2019). This support can be provided in the forms of ongoing training, facilitation of training and mentoring (Emmanuel, 2018). The poor retention and high attrition of CHWs within the healthcare system is an ongoing challenge which can add strain on the LMIC healthcare systems (World Health Organization., 2018). DHAs have been identified as one of the tools that could reduce this attrition, for example by providing regular, ongoing training and support to CHWs (Emmanuel, 2018). Regular and ongoing access to training can increase job satisfaction and in turn support retention (Global Health : Science and Practice, 2014). The use of DHAs by CHWs was

also seen to increase their status and credibility amongst the communities they work in, which also contributes to the retention of CHWs (Early et al., 2019).

2.2.2.5 Negative consequences of DHIs

The use of DHAs by CHWs does have some unintended negative consequences. For example, process digitisation may result in increased scrutiny of CHWs' performance and efficiency and may also uncover institutional dysfunctions as digitisation can allow for these issues to be easily identified (Labrique & Wadhwani, et al., 2018). This can impact the uptake and use of DHAs by CHWs when such outcomes are used as critiques of CHWs' work performance (Labrique & Wadhwani, et al., 2018). The other issue that also surfaces is data security and confidentiality of patient data. Due to the cost of mobile phones, several CHWs share their phones with other CHWs or with family members (Krah & de Kruijf, 2016). This mobile phone sharing can pose a security risk as these usually have DHAs which contain identifiable patient medical data, that is confidential. (Krah & de Kruijf, 2016).

Overall, the evidence points to the use of DHAs in the healthcare system as a potentially powerful tool for CHWs managing HIV/AIDS and TB, particularly in LMICs. Bringing such DHAs to a national scale would greatly impact LMICs' efforts to manage HIV/AIDS and TB (The Global Fund, 2021).

2.3 Bringing DHAs to scale.

In the past fifteen (15) years, DHIs (including DHAs) have offered LMICs the promise to increase the capacity of their health systems to reach their health goals but this promise has unfortunately fallen short of its expected value due to the high rate at which DHAs fail (Olu et al., 2019). We have seen an explosion of DHAs being implemented, in 2021 there were more than three-hundred-and-fifty-thousand (350,000) health apps available from the various app stores (May, 2021). This escalation in the number of DHAs in combination with their high chance of failure has seen SADC health systems littered with numerous failed DHA attempts (Sundin et al., 2016). This significant number of failures

has come at a loss of resources (time, money, human, materials etc.) in health systems that can ill afford such losses (Sundin et al., 2016). The scale of such loss has resulted in some countries in the region placing a moratorium on DHAs until the reasons behind such failure are adequately addressed (Olu et al., 2019; Sundin et al., 2016).

To reduce such failure and loss of resources, it would therefore be critical for us to understand what are the reasons that cause DHAs to succeed or fail in LMICs. Understanding these reasons and how to overcome them will allow DHAs to attain the promise they provide for health systems. Recent articles have attempted to understand what these reasons might be, the overview of what these reasons are and the role they play can be found in the next section (GSMA Intelligence, 2017; Labrique & Wadhwani, et al., 2018; Sundin et al., 2016; Swartz et al., 2021). We found four (4) reasons why DHAs fail or succeed which are: human, technical, extrinsic ecosystem, and the health care ecosystem related reasons (Agarwal et al., 2016; Labrique & Wadhwani, et al., 2018; Sundin et al., 2016).

2.3.1 Reasons that DHAs fail or succeed.

These four reasons can be further summarised into reasons that can be considered intrinsic to the DHI itself (human and technical) and those that create an enabling and supportive environment for the DHI (extrinsic ecosystem and health care ecosystem).

These reasons consist of several factors. The four (4) reasons and the factors can be found in Table 2 and how they influence DHAs are discussed thereafter.

Table 2: Definition of reasons that influence a DHA's failure or success		
	Reasons	**Areas under these reasons**
Intrinsic to the DHI	*Human*	User training, user support, literacy of user (health, numerical language and technology) (Holeman & Kane, 2020) cost to use the DHA (Labrique & Wadhwani, et al., 2018), appropriateness (location and culture) (Vesel, Hipgrave, Dowden, & Kariuki, 2015)
	Technical	Interoperability (with infrastructure, existing applications), open source software (Labrique & Wadhwani, et al., 2018), complexity DHA (Agarwal et al., 2016), its ability to work offline (Labrique & Wadhwani, et al., 2018), type of phone it requires (Agarwal et al., 2016), the access, and security of data (Agarwal et al., 2016), the integration of the DHA into the existing workflow (Adepoju, Albersen, De Brouwere, van Roosmalen, & Zweekhorst, 2017).
Enabling and supportive environment	*Extrinsic*	Reliability and bandwidth of networks, and availability of electricity (Agarwal et al., 2016; Labrique, Vasudevan, Mehl, Rosskam, & Hyder, 2018; Labrique & Wadhwani, et al., 2018) the inclusion of stakeholders (GSMA Intelligence, 2017; Labrique & Wadhwani, et al., 2018) and the overall cost of DHA implementation (GSMA

		Intelligence, 2017; Labrique & Wadhwani, et al., 2018).
	Health care ecosystem	Standards, regulations, frameworks and governance of the DHAs (Labrique & Wadhwani, et al., 2018; Swartz et al., 2021; Vesel et al., 2015). Financial support for the DHA, long-term and short-term (Agarwal, Perry, Long, & Labrique, 2015; GSMA Intelligence, 2017; Labrique & Wadhwani, et al., 2018).

2.3.1.1 Human factors

Human factors like training, support and the literacy of the users impact the success of DHAs. There is an acknowledged existing technology skills deficit in CHWs, which reduces their ability to use DHAs in the execution of their role (Emmanuel, 2018). These skills deficits can include poor language, computer and health literacy which impact CHWs' comfort and ability to use the DHAs (Labrique & Wadhwani, et al., 2018; Sundin et al., 2016) When the training, experience and skills of CHWs are not adequately matched or modified to those needed to use a DHA, this increases the chances of a DHA failing (Labrique & Wadhwani, et al., 2018). As well as matching their existing skills with initial training, it is also recommended that there should be ongoing training to support the transition of workflows from paper-based to digitised systems, to ensure the continued and efficient use of the DHA (Agarwal et al., 2015).

Other human factors that can impact the failure or success of a DHA is the language it is in and its cultural appropriateness with where it is being implemented and for whom it is being implemented (Olu et al., 2019). By ensuring the social and cultural appropriateness of a DHA, we can increase its

chances of being successful in its implementation or scale as it would be better accepted and used by the CHWs (Vesel et al., 2015).

The inclusion of user-centred design principles in the development of DHAs is noted as a potentially critical success factor for DHAs that can result in sustained levels of uptake and use by ensuring the design of the DHA is acceptable to the user (Labrique & Wadhwani, et al., 2018). The user-centred design puts the user at the centre of the activity and prioritizes their experiences and needs when creating a DHA, by involving them throughout the design and development (Holeman & Kane, 2020). This would mean that CHWs are engaged in the end-to-end process of the development and implementation of DHA's to ensure the end product is acceptable to them (Holeman & Kane, 2020).

2.3.1.2 Technical factors

Technical factors that can contribute to the success of DHA include its interoperability with other digital systems or applications, and its feasibility given the existing infrastructure. Thought-through integration of a DHA into an existing workflow is another factor that can contribute to its successful scaling as it reduces the chances of duplication of efforts and reduces additional tasks that a CHW has to do for the DHA (Adepoju et al., 2017). If a DHA is implemented out of sync with an existing workflow it can create additional work for a CHW, which in turn can result in the tool not being used or being used improperly (Adepoju et al., 2017). By including CHWs from the beginning of the process of development and through to implementation, issues around workflow integration can be easily overcome (Holeman & Kane, 2020).

The ability of a DHA to connect to and communicate with other digital aspects of a healthcare system (its interoperability) is considered critical to the successful implementation and scaling of a DHA (Tran Ngoc et al., 2018). Such a DHA can then 'speak' to other digital technologies and, more importantly,

share information to avoid duplication, reduce the burden on CHWs and clients, and magnify its impact through collaboration via data being shared (Labrique & Wadhwani, et al., 2018). DHAs that are not interoperable increase their chances of failure in both implementation and in going to scale as they are seen as standalone solutions which limit their usefulness to the health system (Tran Ngoc et al., 2018).

Feasibility matching between the DHA's technical requirements and existing infrastructure to ensure that the DHA can be supported is another factor that can positively impact the implementation and scaling of the DHA (Tran Ngoc et al., 2018). This ensures the ability of the DHA to function within the overall system (Vesel et al., 2015). It is also recommended that DHAs are not unnecessarily technically complicated as these can be burdensome to a healthcare system by demanding additional resources to work. Another key suggestion to support this intent is that DHAs repurpose existing infrastructure or technology as much as possible when implementing scaling as this reduces the resources required and increases its interoperability (Labrique & Wadhwani, et al., 2018).

Other technical factors that impact a DHA's success include how data collected by the DHA is managed and stored. There is insufficient consideration by DHA implementers as to how data collected by DHAs is collected, stored, accessed, and managed (Labrique & Wadhwani, et al., 2018). This lack of consideration stems from poor technological literacy and/or skills and the lack of the necessary hardware and software to support these store, manage, and access functions (Agarwal et al., 2015). This results in the data collected by DHAs being poorly managed and the benefits of this data for better medical care not being realised.

2.3.1.3 Extrinsic Ecosystem Factors

Broad extrinsic ecosystem factors that influence the success of DHAs can include its implementation environment and stakeholder involvement. Issues in the extrinsic environment that can impact the

ability of a DHA to be implemented or brought to scale include the infrastructure available in its implementation environment (Labrique & Wadhwani, et al., 2018). For example, the reliability and bandwidth of available mobile networks will impact the ability of a DHA to work as intended in a community setting, and the availability of electricity to charge devices is critical to the functioning of all DHAs (Olu et al., 2019).

2.3.1.4 Health Care Ecosystem

The key players in the healthcare ecosystem that impact the success or failure of a DHA are the government, donors, private sector and non-government organisations (NGOs) (Labrique & Wadhwani, et al., 2018). They impact issues like standards/regulations and financial support (Labrique & Wadhwani, et al., 2018). Wider engagement with key stakeholders (Government and Non-Government Agencies, including bilateral donor agencies, and the private sector, including mobile service providers) from the inception of the project ensures long-term sustainability as they provide the foundational and financial support necessary for the long-term sustainability of a DHA (GSMA Intelligence, 2017). Their inclusion at the inception of such a project ensures issues like long and short-term financial support are considered and supported which increases the DHA's chance of success (Labrique & Wadhwani, et al., 2018).

As a result of the rapid creation and use of DHAs, frameworks, guidance, or policies on these have not been able to be produced at the same rate to keep up with the expansion (Vesel et al., 2015). Providing effective guidance, policy and/or frameworks for developing DHAs, such as for the use of CHWs, can reduce the chances of these DHAs failing and ensure their successful scale, once proven as effective (Lefevre et al., 2021). This lack is attributed as one of the reasons DHAs fail at implementation or scale (Swartz et al., 2021). Countries usually require compliance with national health guidelines and strategies as well as global best practices when it comes to DHA implementation (Labrique &

Wadhwani, et al., 2018). These frameworks, guidance, or policies remain unavailable or at a nominal level in most LMICs (Lefevre et al., 2021). This lack makes it difficult for government officials to approve DHA implementation or their scale as they are hard-pressed to find the relevant guidance, policy and/or frameworks to guide their decisions (Sundin et al., 2016).

Numerous articles can be found on these reasons, their supporting factors and the possible role they could play but articles on how such factors have played a role in the actual implementation of DHAs remain limited (Krah & de Kruijf, 2016; Labrique & Wadhwani, et al., 2018; Sundin et al., 2016; Swartz et al., 2021). It is with this in mind that this scoping review was developed. It aims to look at articles on DHAs (for CHWS managing HIV/AIDS and TB) in SADC to identify and chart what reasons are discussed that have played a role in the implementation and maintenance of DHAs. The next chapter lays out in detail how this was achieved by examining the methodology behind the scoping review conducted.

CHAPTER 3: METHODOLOGY

The study design selected for this thesis is a scoping review. The review will be looking at community health worker digital health applications used for the management of HIV and TB in the South African Development Community from 2010 to 2020. The following chapter will first discuss the choice of methodology (a scoping review) for the study and why such a methodology is the appropriate method to be undertaken for this study. Secondly, the chapter will also outline the research design that was followed in the scoping review process including describing the search strategy, the screening and review process, the data management strategy including the presentation of the results and finally concluding on ethical considerations made when conducting the study.

3.1 Scoping Review Methodology

As discussed in the preceding chapter despite the volume of digital health technologies and their growth as an emerging field there remains a paucity of information or studies on what has resulted in their success or failure. Evidence synthesis was identified as the appropriate overarching methodology that would guide the choice of research design for the study as it would allow the researcher to survey the existing studies to synthesise them to understand what knowledge already exists on the topic and what gaps exist (Kastner et al., 2012). There are two (2) broad types of recognised evidence synthesis techniques that could be used for this purpose: a systematic review or a scoping review (Munn et al., 2018). The next section will detail why a scoping review was the more appropriate method for the study as opposed to a systematic review.

3.1.1 Evidence Synthesis – the systematic and scoping review

Systematic reviews have been part of the evidence synthesis field since the 1970s (Munn et al., 2018), with scoping reviews have appeared more recently in the same field (Arksey & O'Malley, 2005). A

scoping review is used to gain a better understanding of new and emerging areas of interest by providing an overview or map of evidence by mapping key concepts, types of evidence, and gaps in the research related to a defined area or field without making any judgements on the quality of the evidence and usually precedes a systematic review (Munn et al., 2018; Tricco et al., 2016). Systematic reviews are usually conducted by review groups with skills specialized for this purpose with a particular question in mind which they attempt to answer by reviewing the existing studies on the topic of interest, these questions are usually the result of a scoping review (Peters, Godfrey, Khalil, & McInerney, 2015).

When an emerging and new area such as digital health is studied a scoping review study design is recommended as it allowed the researcher to survey, synthesize and analyse the area under study without a particular question in mind (Osei et al., 2021). It also allowed the researcher to examine all the evidence (resulting from the review) in this area irrespective of the quality of the study itself (Munn et al., 2018). The use of this method of study also assisted the researcher to identify key factors related to the areas of interest as well as identify knowledge gaps that exist in the given field which could inform future research efforts (Tricco et al., 2016).

The review followed the framework outlined by Arksey and O'Malley (2005) and recommendations by Tricco et al (2010) and Peters et al (2015), as described below. There is an optional consultation exercise which is recommended as part of Stage 5, this stage entails the discussion of the results with practitioners of DHI, policymakers and other stakeholders Arksey and O'Malley (2005). Due to the time constraints of the study, this stage was not undertaken.

Table 3 Scoping Review Stages (Arksey & O'Malley, 2005; Peters et al., 2015; Tricco et al., 2016)	
Stage 1: Identify the research question, objective. **Stage 2: Identify relevant studies.** **Stage 3: Study Selection** **Stage 4: Charting the data.** **Stage 5: Collating, summarising, and reporting the results**	Stages 1 - 4 are discussed in chapter 3 Stage 5 is discussed in chapters 4 and 5

3.2 Research Design

This section describes in detail the research design, that was followed by the researcher for this scoping review. Before one starts a scoping review, it is recommended that a scoping review protocol (research design) is developed before conducting the actual review (Arksey & O'Malley, 2005). The research protocol of a scoping review follows a pre-determined design, where there are clearly defined steps/stages for the researcher to follow when conducting the research. We do this for a scoping review as it allows us to strengthen the replicability and rigour of such a review, as it should allow any other researcher who follows the same protocol to be able to replicate the same results found using this protocol (Peters et al., 2015). This approach also strengthens the validity of the scoping review findings because of methodological rigour (Arksey & O'Malley, 2005).

STAGE 1: Identify the research question.

A scoping review needs to determine its review question as well as identify two sets of objectives. Firstly, the objectives of the overall review need to be determined. Secondly, it also needs to determine the objectives of the analysis to be conducted on the results produced when answering the review question (Peters et al., 2015). The determination of such objectives allows the researcher to frame the search strategy as well as the analysis strategy to be used on the results of the search (The Johanna

Briggs Institute, 2015). The scoping review objective will be discussed below, the research study objectives will be discussed thereafter.

1.1. Review Question

The determination of the review question and its consequent objectives is critical as it informs the search strategy that the scoping review will undertake, it also provides the researcher with a sense of the breadth with which to construct the search strategy as well as the parameters to manage the same breadth (Peters et al., 2015).

The review question itself should be broad, open and exploratory as it allows the results of the search strategy to produce answers in a narrative and descriptive manner (Thomas, Lubarsky, Varpio, Durning, & Young, 2020). The Population, Concept, and Context (PCC) framework developed by Joanna Briggs Institute (The Johanna Briggs Institute, 2015) allowed the researcher to construct a review title that meets the requirements set out above. The table below illustrates how the PCC Framework was used to identify the population, concept and context for the scoping review which was then used to determine the review question that the study would pose.

Table 4 : PCC Framework (The Johanna Briggs Institute, 2015)

Determinants	Description
Population	*Community Health Workers in SADC:* *Community Health Workers*: As defined by the ILO *SADC*: South African Development Region consisting of 16 member states.
Concept	*HIV and TB Disease Management Support:* Use of digital health applications by the population to manage HIV and TB. *Management support*: Support in diagnosis, treatment and long-term care for HIV and TB.
Context	*Use in the SADC Region:*

	Use: Process of employing DHAs to accomplish a task such as a diagnosis, treatment, control/prevention, and management of diseases

Using the PCC Framework, the following review question was constructed: *Digital health applications used by community health workers for the management of HIV and TB in the Southern African Development Community Region: a scoping review on the factors that influence the success and failure of such applications.* Using this review question, we were able to determine the scoping review and research study objectives below.

1.2. Objective of the scoping review

The objectives of the scoping review were determined by the research question that was constructed using the PCC Framework. Determining the objectives of the scoping review also guided the researcher on the inclusion and exclusion criteria for the scoping review itself (The Johanna Briggs Institute, 2015).

The objectives for the research study were as follows:

- To identify the factors of DHAs that have been brought to scale successfully.
- To identify the factors that contribute to the failure of DHAs to scale.

These research objectives then guided the inclusion and exclusion criteria as well as the search and selection of studies as discussed further.

STAGE 2: Identify relevant studies.

After determining the research question and its objectives, the researcher went on to identify the relevant studies that could answer the question by applying the exclusion and inclusion criteria as discussed below. This was done by following the second stage recommended by Arksey and O'Malley (2005) which entails creating a search strategy for identifying relevant studies.

2.1 Study Eligibility

The exclusion and inclusion criteria guided the search strategy as well as the selection and review process as they determined which studies were included or excluded for analysis. These criteria were determined by the review question and its objective.

2.1.1 Inclusion Criteria

a. Time period

The data sources and collection for the review included any existing literature, e.g., primary research studies, systematic reviews, meta-analyses, letters, secondary research/information, and guidelines for the period from 2010 to 2020. These ten (10) years were chosen as it is within this period when there was a rise in the implementation of digital health applications systems which should yield a rich number of studies (Winters, Langer, & Geniets, 2018).

b. Types of participants

This review only considered articles that included CHWs located in the SADC region which is the focus of the review question.

c. Types of Digital Technologies

The review only considered articles on digital health interventions that were used for the management of HIV and TB via a digital health application which is also the focus of the review question.

d. Location of studies

The geographical focus of the review question is the SADC region. As part of the search strategy, the articles mentioned the SADC member countries which are Angola, Botswana, Comoros, Democratic Republic of Congo, Eswatini, Lesotho, Madagascar, Malawi, Mauritius, Mozambique, Namibia, Seychelles, South Africa, United Republic Tanzania, Zambia, and Zimbabwe.

e. Types of literature/studies/papers

The search strategy accepted English publications and considering the nature of the topic, grey literature was considered because information on DHIs is mostly produced in monitoring and evaluation projects and capacity development projects (which are not published) which will add value by providing valuable insights and contributions to the review (Agarwal et al., 2016; Sundin et al., 2016).

2.1.2 Exclusion Criteria

All studies, papers and reports that fall outside the inclusion criteria were rejected for review. This allowed the study to focus on a specific period of time and within a specific geography which allowed the review results to be specific to the SADC region. At this point, the researcher was able to use the review question, its objectives as well as the inclusion and exclusion criteria for articles to be able to construct the following search strategy.

2.2 Search Strategy

The search strategy for a scoping review is a step-by-step process, the definition required in each step of the search strategy supports the rigour of the study, as the replication of these steps by another researcher should produce the same results (Arksey & O'Malley, 2005) The search strategy involved three (3) steps. The first was the keyword identification to determine the combination of words to be used in the search (search string), the second step was the testing of this search string to determine its ability to produce the desired results, and finally, a comprehensive search of databases mentioned below as well as other databases was done, to identify literature with the identified search string.

2.2.1 Keywords Identification

The following keywords were identified from the review question, its objective, and the inclusion-exclusion criteria for use in the search for articles: digital applications, community health worker, frontline health worker, Southern Africa, Southern African Development Community or SADC, TB, and HIV. These terms were then tested via PubMed to check their MeSH (Medical Subheadings)

suitability, which would make them suitable to use in any database search. The keywords were found to be either MeSH or 'all field' which allowed them to be included in the creation of the search string described below.

These keywords were then developed into Boolean phrases because being able to link several keywords with Boolean operators such as AND, OR and NOT can increase both the efficiency and power of the search (Siddaway, Wood, & Hedges, 2019). Several Boolean variations were then tested as a combined search string on the selected databases to identify the combination that provided the largest return with selected articles. Below can be seen the Boolean phrase that was used in the database search as it produced the greatest number of results. This string would produce articles that would include both HIV and TB within their content.

Table 5: BOOLEAN Keyword's

Digital applications	AND	HIV	AND	TB	AND	Community health worker	AND	Southern Africa

2.2.2 Identifying suitable databases.

To identify the databases that could potentially provide the largest number of hits, the search string was used on Google Scholar, and the results were reviewed to identify the journals producing the greatest number of hits on the string. The databases producing the most promising results were then searched for in the University of the Western Cape's (UWC) library of databases. By using this method, the following databases were selected: *Sage Journals, Science Direct, Taylor and Francis, EBSCOhost and Web of Science* using the pre-defined search criteria and search terms. In addition, other searches using the same search string included searching the thesis repositories of the University of the Western Cape and the University of Cape Town, Google Scholar, the mHealth Compendium online repository and the Digital Square Library, for grey literature. A total number of 38 033 articles were found. The summarised results of these searches can be found in Table 6 below.

Table 6: Summary of Search by Database		
Name of Database	The number of articles found	Eligible articles after applying inclusion and exclusion criteria
Science Direct	**140**	**64**
Taylor and Francis	**117**	**64**
EBSCOHost	**36 484**	**144**
Web of Science	**28**	**19**
Sage Journals	**344**	**163**
UWC Repository	**123**	**2**
UCT Repository	**250**	**7**
mHealth Compendium	**8**	**8**
Digital Square Library	**10**	**6**
Google Scholar	**32**	**32**

STAGE 3: Selection of studies

In this step, a systemized review process was conducted by two (2) reviewers using the software tool called COVIDENCE to review the results of the search strategy. Two (2) reviewers are recommended as this reduces the chance of bias and subjectivity influencing the article selection (The Johanna Briggs Institute, 2015). When executing the review process of the scoping review, if only a single reviewer is carrying out the review there is a chance of bias happening concerning the selection of the articles (Peters et al., 2015). The second reviewer is a consultant in the digital health space for the past 15 years. The third-party providing arbitration is active in the digital health space for the past ten (10) years as well as completing a PhD in recent years. Any conflicts in the selection of articles were settled via a two-step conflict resolution process, the first being a discussion between the two (2) reviewers to agree if this agreement was not achieved the matter was resolved by a third party, who would make the final decision on the article (Peters et al., 2015)

3.1 Choice of review software

All the articles found when executing the search strategy were uploaded into the COVIDENCE online tool to facilitate the review process. COVIDENCE is software that allows the efficient systematic and simultaneous review of a scoping review's search results by organising citations and removing discrepancies (Soobiah et al., 2020). Furthermore, it aids in reducing the biased assessment of articles as all the reviewers are blind to each other's selection until all reviewers have completed their screenings (Cochrane Community, 2022). COVIDENCE also produces a diagram of the review process that maps the various steps as well as the number of articles selected, rejected as well as removed due to discrepancies (Soobiah et al., 2020).

3.2. Study selection

A total of 38 033 articles were found by applying the same search string in the following databases Sage Journals, Science Direct, Taylor and Francis, EBSCOhost, and Web of Science, as well as the following sources for grey literature at the University of the Western Cape's and the University of Cape Town's student thesis database, Google Scholar, the mHealth Compendium online database and the Digital Square Library. After the exclusion criteria were applied to these results 502 articles remained eligible for further screening.

The eligible 501 articles (full text) were uploaded into COVIDENCE to allow for further screening by the researcher and a co-reviewer. At this point, 22 duplicate articles were discovered by COVIDENCE, and the duplicates were removed. The remaining articles 479 were then screened with the co-reviewer over the period 1 October 2022 to 16th October 2022. The review process was a step-by-step process within COVIDENCE which follows the recommended PRISMA-ScR flowchart for the reviewing of scoping review articles (Soobiah et al., 2020). The two (2) reviews screened the suitability of the titles and abstracts with the study objectives as well as the inclusion and exclusion criteria. When both reviewers had completed their screening, COVIDENCE immediately highlighted areas where there

were conflicting selections. There were twenty (20) such conflicts which were settled by discussion between the two (2) reviewers. After this title and abstract review, 150 articles were selected for full-text review by both reviewers with 123 being identified as irrelevant to the review title, the reasons for exclusion are listed in Figure 1 below. Within the selected titles, we also found confirmatory articles which had surfaced as part of the literature review.

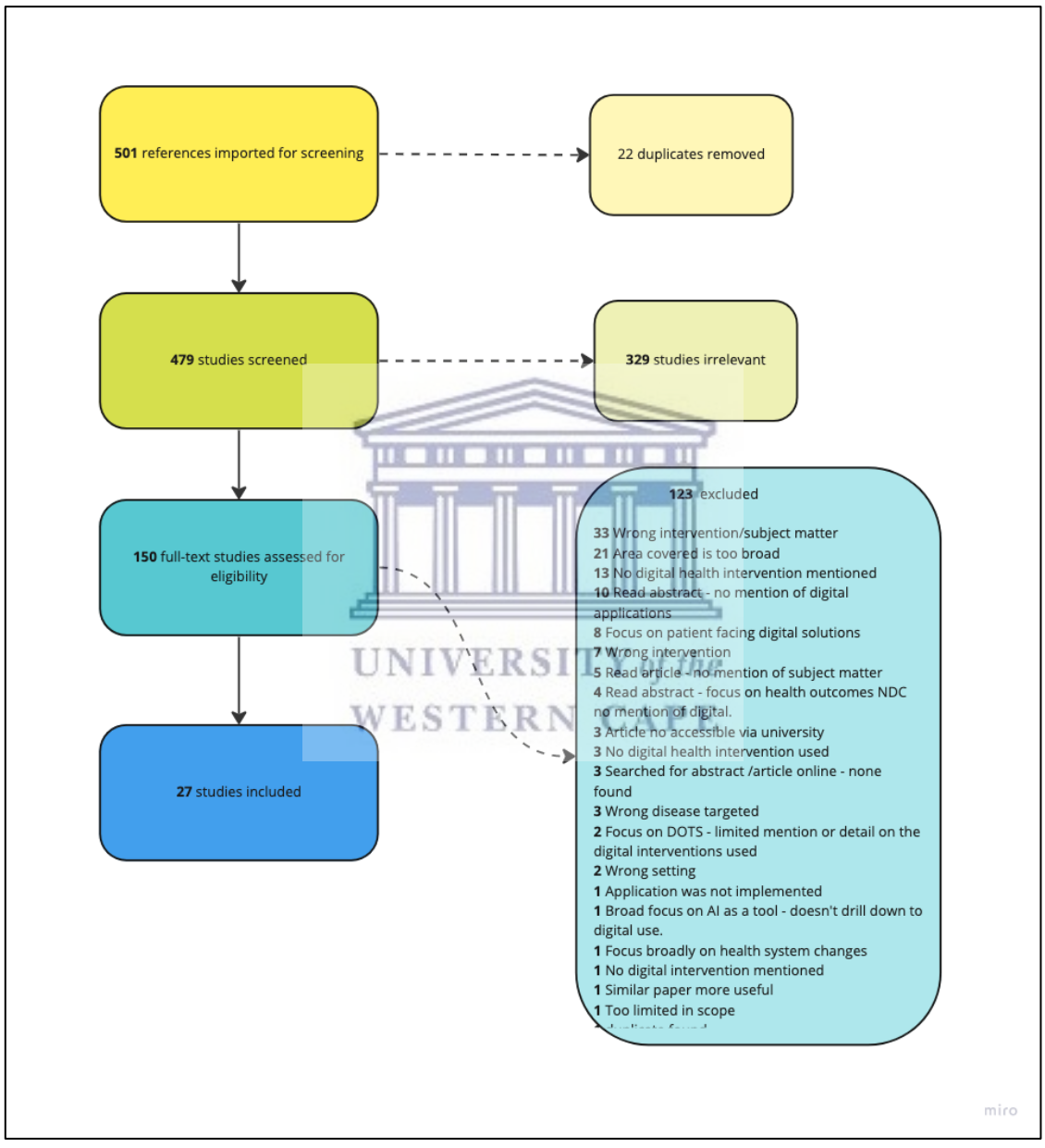


Figure 2 PRISMA – ScR Flowchart as extracted from COVIDENCE

The results of the review were a list of twenty-seven (27) shortlisted articles which were then analysed.

STAGE 4: Charting the data.

The twenty-seven (27) articles that were identified as eligible for the scoping review then underwent data extraction. Table 7 below shows the high-level characteristics of the included studies.

Table 7: General Characteristics of articles

	Title	Author	Year published	Type of article
1	Mobile Technology in Support of Frontline Health Workers	Agarwal	2016	Text and opinion
2	E-health and M-Health in Bangladesh: Opportunities and Challenges	Ahmed	2014	Text and opinion
3	A systematic review of what works, what does not work and why of implementation of mobile health (mHealth) projects in Africa	Aranda-Jan	2014	Systematic review
4	A comparative review of mobile health and electronic health utilization in sub-Saharan African countries	Bervell	2019	Systematic review
5	Building Partnerships that Work: Practical Learning on Partnering in mHealth	Bolton		Text and opinion
6	Community health workers and mobile technology: a systematic review of the literature	Braun	2013	Systematic review
7	mHealth4Afrika Alpha Validation in Rural and Deep Rural Clinics in Ethiopia, Kenya, Malawi, and South Africa	Cunningham	2018	Qualitative research
8	A systematic review of digital health tools used for decision support by frontline health workers (FLHWs) in low- and middle-income countries (LMICs)	DeLeeuw	2019	Systematic review
9	Use of mobile health (mHealth) technologies and interventions among community health workers globally: a scoping review	Early	2019	Scoping Review
10	Peer support in prevention, chronic disease management, and well-being	Fisher	2018	Text and opinion
11	A missing link: HIV-/AIDS-related mHealth interventions for health workers in low-and middle-income countries	Gimbel	2018	Other: Literature Review
12	mHealth Compendium Special Edition 2016: Reaching Scale	Haas	2016	Text and opinion
13	Assessing the impact of mHealth interventions in low- and middle-income countries – what has been shown to work?	Hall	2014	Systematic review
14	Mobile health (mHealth) approaches and lessons for increased performance and retention of community health workers in low- and middle-income countries: a review	Källander	2013	Other: Thematic Review
15	Exploring the ambivalent evidence base of mobile health (mHealth): A systematic literature review on the use of mobile phones for the improvement of community health in Africa	Krah	2016	Systematic review
16	Unpacking the performance of a mobile health information messaging program for mothers (MomConnect) in South Africa: evidence on program reach and messaging exposure	LeFevre	2018	Cohort study
17	How can we help generate the most impact for the least effort?	Lesh	2016	Text and opinion
18	mHEALTH COMPENDIUM VOLUME 5	Levine	2015	Text and opinion
19	Designing with community health workers: feedback-integrated multimedia learning for rural community health	Molapo	2018	Cohort study
20	Digital innovations for global mental health: opportunities for data science, task sharing, and early intervention	Naslund	2019	Text and opinion

21	Crossing the global quality chasm: improving health care worldwide	National Academies of Sciences	2018	Text and opinion
22	Using technology to advance global health: proceedings of a workshop	National Academies of Sciences	2018	Text and opinion
23	Using a mHealth system to recall and refer existing clients and refer community members with health concerns to primary healthcare facilities in South Africa: a feasibility study	Odendaal	2020	Cohort study
24	Strengthening delivery of health services using digital devices	Orton	2018	Systematic review
25	mHealth and MNCH: state of the evidence. Reviewing the evidence on the use of mHealth to improve maternal, new-born and child health: trends, gaps, stakeholder needs, and opportunities for future research	Philbrick	2013	Text and opinion
26	Measuring Frontline Workers' Connectivity While Using Mobile Applications	Stone	2018	Text and opinion
27	mHealth Interventions in South Africa: A Review	Ojo	2018	Systematic review

4.1 Charting the data

The twenty- seven (27) articles collected via the search strategy were then analysed through the process of data extraction also known as data charting, this process allowed the researcher logically analyse and describe the results found concerning the objectives of the research study and the review question (Peters et al., 2015). COVIDENCE was the research software that was used for this process (Cochrane Community, 2022). This process followed each of the steps recommended by Peters et al. (2015) – analysing the data, reporting the results, and applying meaning to the results.

4.1.1. Analysis of the data

An extraction template was constructed to guide the data extraction from the selected articles. It was constructed by the researcher, guided by the recommendations of Peters et al. (2015), the research objectives and finally the factors that impact DHA's success and failure under Chapter 2. The headings under which the data was extracted can be seen below.

1. Article number – a generic non-value determining numbering system that allowed the researcher to keep track of the various articles
2. Article Title
3. Author
4. Year published
5. General Description of the article
6. DHA specific
7. Funding for the DHA
8. The function of the DHA
9. Health Focus of the DHA
10. Name Country of implementation
11. Success or failure of the DHA
12. Factors mentioned for the scale of DHA (the detailed breakdown for each factor can be found in Table 8 below)
13. Other recommendations about the scale of DHA

Table 8: Definition of factors that influence scale of a DHA (Labrique & Wadhwani, et al., 2018)

Factor	**Areas extracted under these factors**
Human	User training, user support, literacy of user (health, numerical language, and technology) cost to use the DHA, appropriateness (location and culture)
Technical	Interoperability (with infrastructure, existing applications), open-source software, the complexity of the DHA, its ability to work offline, the type of phone it requires, management, storage access, and security of data it collects, and the integration of the DHA into the existing workflow.
Extrinsic	Reliability and bandwidth of networks, availability of electricity, the inclusion of stakeholders and overall cost of DHA implementation.
Health care ecosystem	Standards, regulations, frameworks, and governance of the DHAs, the financial support for the DHA, long term and short-term support.

The data extraction template allowed the researcher to begin the process of data extraction systematically and consistently across the selected articles, this was done via the use of COVIDENCE. The headings were loaded into the COVIDENCE extraction tool, which allowed the researcher to

populate the extraction template for each of the articles. The result of this analysis was then consolidated as a data file, once all the articles had been analysed.

4.1.2 Reporting the results.

These results were then downloaded from COVIDENCE and uploaded into two database software processing tools AirTable (a cloud-based spreadsheet/database hybrid) and Google Sheets which allowed the researcher to further analyse and create visualisations of the extracted data which are shared in the next section.

4.1.3 Applying meaning to the results.

This data was then examined and analysed using a narrative synthesis technique, where the researcher primarily used the content of the data extraction results to examine, explain and find meaning in the data extracted (Popay et al., 2006). This technique is considered a suitable technique for scoping reviews as it allowed the researcher to synthesize the different types of data that this scoping review produced i.e. qualitative, quantitative, economic etc. (Barnett-Page & Thomas, 2009).

To allow the data to 'tell a story, the researcher followed three (3) steps: firstly, identifying the number of times each heading was reported across the articles. For data extracted under the four (4) identified reasons for the failure or success of a DHA, to adequately represent this data, the researcher noted not only which reasons were mentioned but also which of the factors under each reason was mentioned. This was done to capture as much as possible data on each reason.

Secondly, the data extracted within each heading were examined to understand the relationship between the data within a heading, finally, the data were examined to identify any relationships between the different headings (Popay et al., 2006). The result of this narrative synthesis is presented in the form of tables and narrative text in the next chapter, as the recommended manner to present the

data found in a scoping review by Arksey & O'Malley (2005) and Popay et al. (2006) and more recently The Johanna Briggs Insitute (2015).

3.3 Ethical considerations

Appendix 1 contains the ethics clearance certificate received for the study. Permission to conduct this scoping review was obtained from the University of the Western Cape's Biomedical Research Ethics Committee (BMREC), with ethics reference number BM 21/4/2 with validity until March 2023.

Unlike primary researchers, scoping reviewers do not collect deeply personal, sensitive, or confidential information from participants. Scoping reviews like this one used previously published studies which are therefore considered publicly accessible documents as evidence for the review (Suri, 2020), which reduced potential ethical issues with the study. It is also focused on published reports and studies and does not involve any patients or primary data collection.

To avoid bias in the study, as mentioned a second reviewer was engaged for the review and selection of articles to be further analysed. This analysis was carried out independently by both reviewers with any discrepancies between the reviewers' choices being referred to a third pre-determined party for the final decision regarding such a discrepancy.

All data collected will be stored on my laptop, which has a password and is for my sole use. Data collected will be stored in a separate folder and destroyed after five years.

3.4 Limitations of the study

The study draws its findings from published data within a specific time frame, as such it is not representative of the entire body of research that possibly exists on the same review title which limits its findings. It was also limited by language with regards to the applications implemented in the

Seychelles and Mauritius, as there was a language limitation in finding applications as these are predominately French-speaking countries with reports/studies being published in French. Due to time constraints the optional consultation exercise (in stage 5 of the review) was not conducted. This exclusion might affect the application of some of the recommendations, as relevant stakeholders were not consulted on these recommendations.

CHAPTER 4: RESULTS

The following section details the results of the data extracted from the twenty-seven (27) selected articles, firstly sharing the general characteristics of the articles, thereafter, discussing the characteristics of the digital health applications reported (for use by CHWs for the management of HIV/AIDS and TB) and finally discussing the data extracted relevant to the factors that support the scaling of digital health interventions.

4.1 Characteristics of included studies.

4.1.1 Location of studies

When looking at the location of the study itself, we need to note that most studies due to them being of review study design included multiple locations in SADC within their articles. To capture this, the researcher extracted data on not only each country mentioned but also collated the number of times a country is mentioned across all articles.

Table 9: Mention of SADC Member State Countries

	Name of Country in SADC	**# times the country is mentioned across all 27 articles**
1	South Africa	52% (n=14)
2	United Republic of Tanzania	41% (n=11)
3	Malawi	37% (n=10)
4	Eswatini	22% (n=6)
5	Zambia	18.5% (n=5)
6	Mozambique	18.5% (n=5)
7	Botswana	15% (n=4)
8	Madagascar	7.5% (n=2)
9	Zimbabwe	7.5% (n=2)

10	Angola	4% (n=1)
11	Lesotho	4% (n=1)
12	Namibia	4% (n=1)

Across all articles mention of a country was made one-hundred and nine (109) times, from this spread we found that studies located in SADC and within other LMIC countries were mentioned the greatest number of times 85% (n=93). When we examined the mentions made of the articles of SADC member states and found that twelve (12) of the sixteen (16) SADC member states (75%) were mentioned.

When looking at the specific mention of SADC countries in the twenty-seven (27) articles, we found South Africa was mentioned the greatest number of times followed by the United Republic of Tanzania and thereafter Malawi (Table 9). We also extracted the data relevant to other LMICs in Africa and found the following: 33% (n=9) in Kenya, 30% (n=8) in Uganda, 22% (n=6) in Rwanda, 18. % (n=5) in Ghana, and Nigeria, and 4 % (n=1) in Mali. Papers that mentioned countries outside SADC were included because with the same studies SADC countries were also mentioned.

4.1.2 Study design of studies

Table 10: Study design employed by articles

No.	Author	Title of Article	Year published	Study design
1	Haas 2016	mHealth Compendium, Special Edition 2016: Reaching Scale	2016	
2	Ahmed 2014	E-health and M-Health in Bangladesh: Opportunities and Challenges	2014	
3	Naslund 2019	Digital Innovations for Global Mental Health: Opportunities for Data Science, Task Sharing, and Early Intervention	2019	
4	Fisher 2018	Principles and Concepts of Behavioural Medicine	2018	
5	National Academies of Sciences 2018	Crossing the Global Quality Chasm: Improving Health Care Worldwide	2018	

6	National Academies of Sciences 2018	Using Technology to Advance Global Health: Proceedings of a Workshop	2018	Text and opinion
7	Bolton 2011	Building Partnerships that Work: Practical Learning on Partnering in mHealth		
8	Agarwal 2016	Mobile Technology in Support of Frontline Health Workers	2016	
9	Levine 2015	mHealth Compendium Volume 5	2015	
10	Philbrick 2012	mHealth and MNCH: the state of Evidence	2013	
11	Lesh 2016	How can we help generate the most impact for the last effort?	2016	
12	Stone 2018	Measuring Frontline Workers' Connectivity While Using Mobile Applications	2018	
13	Bervell 2019	A comparative review of mobile health and electronic health utilization in sub-Saharan African countries	2019	Systematic review
14	Ojo 2018	mHealth Interventions in South Africa: A Review	2018	
15	Aranda-Jan 2014	A systematic review of what works, what does not work and why of implementation of mobile health (mHealth) projects in Africa	2014	
16	Krah 2016	Exploring the ambivalent evidence base of mobile health (mHealth): A systematic literature review on the use of mobile phones for the improvement of community health in Africa.	2016	
17	Orton 2018	Strengthening Delivery of Health Services Using Digital Devices	2018	
18	Braun 2013	Community Health Workers and Mobile Technology: A Systematic Review of the Literature	2013	
19	DeLeeuw 2019	A systematic review of digital health tools used for decision support by frontline health workers (FLHWs) in low-and middle-income countries (LMICs)	2019	
20	Hall 2014	Assessing the impact of mHealth interventions in low- and middle-income countries – what has been shown to work?	2014	
21	LeFevre 2018	Unpacking the performance of a mobile health information messaging program for mothers (MomConnect) in South Africa: evidence on program reach and messaging exposure	2018	Cohort study
22	Molapo 2018	Designing with Community Health Workers: Feedback integrated multimedia learning for rural community health	2018	
23	Odendaal 2020	Using a mHealth system to recall and refer existing clients and refer community members with health concerns to primary healthcare facilities in South Africa: a feasibility study	2020	
24	Early 2019	Use of Mobile Health (mHealth) Technologies and Interventions Among Community Health Workers Globally: A Scoping Review	2019	Scoping Review
25	Källander 2013	Mobile Health (mHealth) Approaches and Lessons for Increased Performance and Retention of	2013	Thematic Review

		Community Health Workers in Low-and Middle-Income Countries: A Review		
26	Cunningham 2017	mHealth4Afrika Beta v1 Validation in Rural and Deep Rural Clinics in Ethiopia, Kenya, Malawi and South Africa	2018	Qualitative research
27	Gimbel 2018	A Missing Link: HIV-/AIDS-Related mHealth Interventions for Health Workers in Low- and Middle-Income Countries	2018	Literature Review

Across the articles we found the following study designs being employed: 45% (n =12) of the articles were text and opinion-based articles with 40% (n=11) being reviews in total 30% (n= 8) of those being systematic reviews. The remaining studies were 4% (n=1) each for literature reviews, scoping reviews, and thematic reviews. There were 11% (n= 3) cohort studies, and 4% (n=1) was a qualitative research study.

4.1.3 Year of publication of studies

Table 11: Year the article was published

No.	Author	Title	Year published
1	Odendaal 2020	Using a mHealth system to recall and refer existing clients and refer community members with health concerns to primary healthcare facilities in South Africa: a feasibility study	2020
2	Naslund 2019	Digital Innovations for Global Mental Health: Opportunities for Data Science, Task Sharing, and Early Intervention	2019
3	Early 2019	Use of Mobile Health (mHealth) Technologies and Interventions Among Community Health Workers Globally: A Scoping Review	
4	Bervell 2019	A comparative review of mobile health and electronic health utilization in sub-Saharan African countries	
5	DeLeeuw 2019	A systematic review of digital health tools used for decision support by frontline health workers (FLHWs) in low-and middle-income countries (LMICs)	
6	National Academies of Sciences 2018	Crossing the Global Quality Chasm: Improving Health Care Worldwide	2018
7	Gimbel 2018	A Missing Link: HIV-/AIDS-Related mHealth Interventions for Health Workers in Low- and Middle-Income Countries	
8	Fisher 2018	Principles and Concepts of Behavioral Medicine	
9	National Academies of Sciences 2018	Using Technology to Advance Global Health: Proceedings of a Workshop	
10	Orton 2018	Strengthening Delivery of Health Services Using Digital Devices	
11	LeFevre 2018	Unpacking the performance of a mobile health information messaging program for mothers (MomConnect) in South Africa: evidence on program reach and messaging exposure	

12	Stone 2018	Measuring Frontline Workers' Connectivity While Using Mobile Applications	
13	Ojo 2018	mHealth Interventions in South Africa: A Review	
14	Cunningham 2017	mHealth4Afrika Beta v1 Validation in Rural and Deep Rural Clinics in Ethiopia, Kenya, Malawi, and South Africa	
15	Molapo 2018	Designing with Community Health Workers: Feedback integrated multimedia learning for rural community health	
16	Haas 2016	mHealth Compendium, Special Edition 2016: Reaching Scale	2016
17	Krah 2016	Exploring the ambivalent evidence base of mobile health (mHealth): A systematic literature review on the use of mobile phones for the improvement of community health in Africa.	
18	Agarwal 2016	Mobile Technology in Support of Frontline Health Workers	
19	Lesh 2016	How can we help generate the most impact for the last effort?	
20	Levine 2015	mHealth Compendium Volume 5	2015
21	Ahmed 2014	E-health and M-Health in Bangladesh: Opportunities and Challenges	2014
22	Aranda-Jan 2014	A systematic review on what works, what does not work and why of implementation of mobile health (mHealth) projects in Africa	
23	Hall 2014	Assessing the impact of mHealth interventions in low- and middle-income countries – what has been shown to work?	
24	Braun 2013	Community Health Workers and Mobile Technology: A Systematic Review of the Literature	2013
25	Källander 2013	Mobile Health (mHealth) Approaches and Lessons for Increased Performance and Retention of Community Health Workers in Low-and Middle-Income Countries: A Review	
26	Philbrick 2012	mHealth and MNCH: the state of Evidence	
27	Bolton 2011	Building Partnerships that Work: Practical Learning on Partnering in mHealth	2011

Most of the articles were published in 2018 i.e., 37% (n=10) with 15% (n=4) published in 2016 and 2019, 11% (n=3) in 2013 and 2014, and 7.5% (n=2) in 2020 and 4% (n=1) in 2015 respectively.

4.1.4 Source of funding in articles

Table 12: Funding sources mentioned by articles	
Government	11
Donor	6
Private and Public Sector	6
Private Sector	3

In the articles which mention who funded the DHA, we found close to half of them mention the Government as a funding source 41% (n=11), while 22% (n=6) mention donors as a funding source,

the same number mention the private and public sector and 11% (n=3) mention the private sector (Table 10). Finally, we also noted that 7.5% (n=2) of the articles shared a model/framework on how to scale a DHA (Agarwal et al., 2016; Aranda-Jan, Mohutsiwa-Dibe, & Loukanova, 2014).

data extracted from the digital health applications themselves.

4.2 DHA Characteristics

4.2.1 Functions of the DHAs

Within the articles, we found that DHAs were being used in five (5) broad ways with the health system. These were for field data collection, communication, education, human resource, and disease management. These uses and how they are reflected and defined in Table 11. Across the articles, we found multiple mentions of different functions within the same article. The researcher analysed the data by looking at each function across all twenty-seven (27) articles.

Using this as a basis for analysis the researcher found that the functions of field-data collection and education were equally mentioned in 70% (n-19) of the articles, communication was mentioned in 75% (n-20) of the articles with, disease management being mentioned by 75% (n-20) of the articles with human resource management being mentioned 30% (n=8) in the least of the articles.

Table 13: Functions of DHA

Function of DHA	**Definition of Uses**	**# Articles it is mentioned in out of a possible 27**
Field-data Collection	Data collected by CHWs while in the field, includes patient data, and medical logistics data e.g. data on the stock of medicines (Braun, Catalani, Wimbush, & Israelski, 2013).	19
Communication	Communication between healthcare providers, and communication between providers and healthcare consumers (appointment reminders	20

	and test-result notification) (Orton, Agarwal, Muhoza, Vasudevan, & Vu, 2018).	
Education	For CHWs and patients with a health focus (Krah & de Kruijf, 2016).	19
Disease Management	Diagnosis and management of diseases (mobile clinical decision support systems and referral coordination) (Orton et al., 2018).	20
Human Resource Management	Management of CHW job performance (Källander et al., 2013)	8

4.2.2 Health Focus of DHA

We found across the articles mention four (4) primary health issues that the DHAs were providing support in, these include HIV/AIDS, TB, Maternal and Child Health (MNCH), and Vector-borne diseases, as depicted in Table 13. Across the articles, we found multiple mentions of DHAs with different health foci within the same article. The researcher reflected data by looking at each health focus across all twenty-seven (27) articles.

We see that MNCH was mentioned in 78% (n=21) of all the articles closely followed by 63%% (n=17) of the article which mentions HIV/AIDS, 48% (n=13) of articles mentioned Vector-borne diseases, 44% (n= 12) of the articles mention of TB. Four (4) or 15% of the articles made no mention of the health focus of the DHI being discussed.

Four (4) or 15% of the articles also stress the importance of disease-specific DHAs like the ones mentioned below being able to be repurposed and or be flexible enough in their design to be receptive to changing health needs, this increases their chances of being brought to scale successfully (Agarwal et al., 2016; Gimbel, Kawakyu, Dau, & Unger, 2018; Haas, 2016; Philbrick, 2012).

Table 14: Health Focus of DHA	
	# Articles it is mentioned in out of a possible 27
MNCH	21
HIV/AIDS	17
Vector-borne diseases	13
TB	12

4.3 Summary of results: reasons for DHA to fail or succeed.

Next, we looked at the reasons that were mentioned in the articles that influenced the scaling of DHAs. These reasons as discussed in Chapter 3 include human, technical, extrinsic, and finally, the healthcare ecosystem.

4.3.1 Human Factors

Table 15: Human Factors influencing the scale of DHAs	
Human Factors	**# Articles it is mentioned in out of a possible 27**
Literacy of user (health, numerical language, and technology) (Agarwal et al., 2016; Bervell & Al-Samarraie, 2019; Braun et al., 2013; Cunningham et al., 2018; Early et al., 2019; Källander et al., 2013; Krah & de Kruijf, 2016; Levine et al., 2015; Molapo, 2018; National Academies of Sciences and Medicine, 2018; Odendaal et al., 2020; Raviola, Naslund, Smith, & Patel, 2019; Taylor & Alper, 2018)	14
User training and support *(Agarwal et al., 2016; Aranda-Jan et al., 2014; Braun et al., 2013; Cunningham et al., 2017; De Leeuw, 2019; Haas, 2016; Källander et al., 2013; Levine et al., 2015; Molapo, 2018; Odendaal et al., 2020)*	10

Cost to use the DHA *(Agarwal et al., 2016; Aranda-Jan et al., 2014; Bervell & Al-Samarraie, 2019; De Leeuw, 2019; Haas, 2016; Källander et al., 2013; Levine et al., 2015; Molapo, 2018)*	8
Appropriateness (location and cultural) (Aranda-Jan et al., 2014; Early et al., 2019; Källander et al., 2013; Molapo, 2018)	4

Across the articles, we found multiple mentions of human factors within the same article. The researcher analysed the data by looking at each factor across all twenty-seven (27) articles

Literacy

As depicted by *Table 15* most studies, over 52% (n=14) of the mentions were on the literacy of the users as a key human factor that influences the ability of a DHA to be brought to scale. In the same vein, we also found articles stating despite the importance of taking into account literacy factors when designing and deploying a DHA, these are still not adequately taken into account when scaling DHAs (Aranda-Jan et al., 2014; Haas, 2016; Levine et al., 2015).

Concerning the literacy factors, 11% (n=3) of the mentions raised a growing concern that government and private-sector leaders have not adequately looked into how current curricula for healthcare workers (including CHWs) can provide HCWs with these skills (Anderson M & Olson, 2016; Early et al., 2019; Philbrick, 2012). This need for further skills development is supported by 37% (n=10) mentions of user support and training factors with the articles as other human factors that support the scale of a DHA.

Cost for CHW

The last factor discussed was the financial cost borne by the CHW when using the DHA, which was mentioned at 30% (n=8). This doesn't underplay the need for this factor to be seriously considered as CHWs (in LMICs) usually earn at or below the breadline and any additional personal financial costs that a DHA adds to a CHW's financial expenses, could result in them not using the DHA, as noted by two (2) of these articles (Aranda-Jan et al., 2014; Källander et al., 2013).

Besides the data extracted on the human factors identified, it is worth mentioning that the studies did raise a few other factors that were not part of the human factors identified but they could play a significant role in the scale of DHAs. These are the digital and gender divide

Digital and Gender Divide

The first factor mentioned in two (2) of the articles was that of the digital divide and as a subset of this, the gender digital divide (referring to the reduced access and use of digital interventions by women and girls due to their gender) (Philbrick, 2012). The digital divide refers to the disproportionally low access and use of digital interventions by financially resource-poor populations, with women and girls as a subset of this population (National Academies of Sciences and Medicine, 2018). This digital divide disadvantages a particular population as it disproportionately (to other populations), reduces their access to the healthcare services that digital interventions can provide (Philbrick, 2012). The articles also mention that addressing this divide would be a critical factor to note in bringing DHAs to scale particularly with CHWs who are usually financially resource-poor and female (Philbrick, 2012).

User Centred design to support the CHW to use a DHA.

A key element to the successful scale of DHA is taking into account the needs of the user, which is in this case a CHW (Agarwal et al., 2016; Aranda-Jan et al., 2014; Källander et al., 2013). Such needs include the CHW's literacy, training, and support needs. Five (5) articles state that the use of the design technique user centred design would allow a better understanding of a CHW's needs (Aranda-Jan et al., 2014; Haas, 2016; Källander et al., 2013; Labrique & Wadhwani, et al., 2018; Levine et al., 2015). A design that is 'user-centred' means that a DHI "designs with the users, and not for them, by building digital tools to better address the specific context, culture, behaviours and expectations of the people who will directly interact with the technology. Designing together means partnering with users throughout the project lifecycle, co-creating solutions, and continuously gathering and incorporating users' feedback" (Digital Principles, 2018).

This design technique allows a better understanding of the literacy needs of the CHW, as well as localisation and contextualisation considerations of the DHA and it allows greater insight into how a DHA could be better integrated into the existing workflow of CHW. All these aspects if properly addressed can drive the success and scale of a DHA (Aranda-Jan et al., 2014; Haas, 2016; Källander et al., 2013; Labrique & Wadhwani, et al., 2018; Levine et al., 2015).

4.3.2 Technical Factors

Across the articles, we found multiple mentions of technical factors. The researcher analysed data by looking at each factor across all twenty-seven (27) articles.

Table 16: Technical Factors influencing scale of DHAs

Technical Factor	**# Articles it is mentioned in out of a possible 27**
Integration of the DHA into the existing workflow (Cunningham & Cunningham, 2018; Early et al., 2019; Gimbel et al., 2018; Haas, 2016; Krah & de Kruijf, 2016; LeFevre et al., 2018; Molapo, 2018; Odendaal et al., 2020; Orton et al., 2018; Philbrick, 2012; Taylor & Alper, 2018)	11
Interoperability (with infrastructure, and existing applications (Braun et al., 2013; Gimbel et al., 2018; Haas, 2016; Källander et al., 2013; Levine et al., 2015; Odendall et al., 2020; Orton et al., 2018; Philbrick, 2012; Taylor & Alper, 2018)	10
Data management, storage, access and security (Aranda-Jan et al., 2014; Bervell & Al-Samarraie, 2019; Haas, 2016; Källander et al., 2013; Krah & de Kruijf, 2016; Molapo, 2018; Orton et al., 2018; Taylor & Alper, 2018)	8

The simplicity of DHA (Gimbel et al., 2018; Krah & de Kruijf, 2016; LeFevre et al., 2018; Molapo, 2018)	4
Open-source software (Braun et al., 2013; Levine et al., 2015; Taylor & Alper, 2018)	3
DHA offline capability (Early et al., 2019; Levine et al., 2015; Stone, 2020)	3
Type of phone required by DHA *(Levine et al., 2015; Molapo, 2018)*	2

Integration and Interoperability

The ability of a DHA to integrate (into existing infrastructure, existing digital applications, and workflow) was mentioned across the articles, 78% (n=21) of them. These three (3) factors were represented across 37% (n=10) of articles as the biggest technical factor as to why DHAs have failed to scale. The articles proposed the adequate assessment of such integration and interoperability of the DHA can contribute significantly towards a DHA being brought to scale (Braun et al., 2013; Haas, 2016; Källander et al., 2013; Odendaal et al., 2020).

Engaging with design principles like the user-centred design could help overcome some of the workflow integration issues that DHAs seem to keep missing in their design process, the reason postulated for this could be cost related, as this design process can be a cost-heavy exercise (Braun, Catalani, Wimbush, & Israelski, 2013; Krah & de Kruijf, 2016; Swartz, LeFevre, Perera, Kinney, & George, 2021). The inability of DHAs to operate within the existing infrastructure and existing digital applications is also cited by these articles as a key driver of DHA failure, as this inability not only adds additional costs (to ensure alignment) to the implementer of the DHA but also places an additional burden of time on CHWs as they might need to use multiple devices and replicate processes (for the same patient) on different DHAs due to this lack of interoperability (Braun et al., 2013; Gimbel et al., 2018; Haas, 2016; Källander et al., 2013).

Some articles also stated that successful interoperability and integration could support the creation of a dashboard where data from multiple data sources to be viewed (Agarwal et al., 2016; Bervell & Al-Samarraie, 2019; Haas, 2016). This was seen as supporting CHWs by allowing them to view multiple data sources on a single platform to enhance the service they provide. (Agarwal et al., 2016; Bervell & Al-Samarraie, 2019; Haas, 2016).

Data

Data, its collection, its storage, how its accessed and how it is managed played a large role across both the human and technical factors. Increasing the amount of data collected, its quality and frequency allows the HIS to be better able to monitor the population's health status and health service delivery, identify health inequalities, and allocate health finances to achieve universal health care (Greenwell & Salentine, 2018). DHAs used by CHWs offer the HIS an opportunity to do just that – collect large amounts of good quality data frequently (Agarwal et al., 2016) Being able to incorporate this data collection aspect into the design of DHA would increase its chances of being successful and increase its usefulness to the health system (Agarwal et al., 2016; Bervell & Al-Samarraie, 2019; Haas, 2016).

The management of data collected by the DHA was mentioned by 30% (n= 8) of the articles, by this we mean the ability of a CHW to access the data gathered by the DHA as well the DHA's ability to keep the data confidential and its ability to store the same data. Data and its role in DHAs become more important when we take into account that most CHWs don't have access to a computer (with which to access such data) and remain dependent on their mobile devices to provide them with this data, which usually guides the content of their patient visits (Bervell & Al-Samarraie, 2019; Källander et al., 2013).

In the articles, we find that the majority of the DHAs were being used by CHWs not only for data collection but also to better manage their patients via the same data (Agarwal et al., 2016; Bervell & Al-Samarraie, 2019; Haas, 2016). This illustrated the two-way engagement potential of the DHA to not only collect data but also support the work of the CHWs which is why consideration of the data-related issues becomes crucial in the design of a DHA.

Simplicity

15% (n=4) of articles mention the simplicity of the DHA itself. By simplicity we mean the reported use of the DHA is simple and uncomplicated with a single function, which seems to heavily influence its ability to scale (Aranda-Jan et al., 2014; Haas, 2016; Krah & de Kruijf, 2016; LeFevre et al., 2018; Levine et al., 2015). The Agarwal et al (2016) article support this as they found that the 16% (n=11) of the CHW DHA's they identified as being brought to scale were used for a single function with the remaining 84% n= (55), with multiple functions, remaining as pilot implementations.

Other factors

The final factors identified were the ability of the DHA to be used offline and the use of open-source software to run the DHA mentioned in a total of just under 10% of the articles. Two (2) articles mention the type of phone used by a DHA and supported the notion that DHAs should be able to be used on simple phones that are easy to use and affordable to a CHW *(Levine et al., 2015; Molapo, 2018).*

Three (3) articles recommended the use of open-source software did so as they believed such software would cost less over time and increase the probability of a DHA being interoperable with existing DHIs (Braun et al., 2013; Levine et al., 2015; Taylor & Alper, 2018). By open-source software, we mean software that anyone can inspect, modify, and enhance the software that 'runs'

the DHI, this allows programmers to edit the software to allow it to be more interoperable when its needs to be linked to new DHIs (Stahl, Roth, & Mellor, 2015)

Finally, the three (3) articles supported the addition of an offline functionality in DHAs as DHAs are being used by LMICs, LMICs which have both intermittent and poor mobile network coverage (Early et al., 2019; Levine et al., 2015; Stone, 2020). The same three (3) articles reflected that such capability would allow the DHA to still be used in areas with poor network connectivity, allowing the data collected to be uploaded once connectivity is restored (Early et al., 2019; Levine et al., 2015; Stone, 2020).

4.3.3 Extrinsic Factors

Across the articles, we found multiple mentions of extrinsic factors. The researcher reflected data by looking at each factor across all twenty-seven (27) articles.

Infrastructure

The reliability and bandwidth of networks were mentioned an equal number of times as the availability of electricity, which was 82% (n=22) times each, as displayed in Table 16 below. As discussed previously the majority of the articles mention the DHA being located in LMICs where such reliability and availability might not be as consistent as in higher-income countries, which explains the greater emphasis on these factors (Agarwal et al., 2016; Aranda-Jan et al., 2014; Bervell & Al-Samarraie, 2019; Early et al., 2019; Källander et al., 2013; Krah & de Kruijf, 2016; Levine et al., 2015; Molapo, 2018; Odendall et al., 2020; Stone, 2020; Taylor & Alper, 2018).

Table 17: Extrinsic factors influencing the DHA scale

Extrinsic Factor	# Articles it is mentioned in out of a possible 27
Inclusion of stakeholders (Agarwal et al., 2016; Ahmed, Bloom, Iqbal, Lucas, & Rasheed, 2014; Aranda-Jan et al., 2014; Bolton, Hausman, & Keisling, 2011; Cunningham et al., 2018; Gimbel et al., 2018; Haas, 2016; Krah & de Kruijf, 2016; LeFevre et al., 2018; Levine et al., 2015; Naslund et al., 2019; National Academies of Sciences and Medicine, 2018; Odendaal et al., 2020; Ojo, 2018; Philbrick, 2012; Taylor & Alper, 2018)	16
Reliability and bandwidth of networks (Agarwal et al., 2016; Aranda-Jan et al., 2014; Bervell & Al-Samarraie, 2019; Early et al., 2019; Källander et al., 2013; Krah & de Kruijf, 2016; Levine et al., 2015; Molapo, 2018; Odendall et al., 2020; Stone, 2020; Taylor & Alper, 2018)	11
The availability of electricity (Agarwal et al., 2016; Aranda-Jan et al., 2014; Bervell & Al-Samarraie, 2019; Early et al., 2019; Källander et al., 2013; Krah & de Kruijf, 2016; Levine et al., 2015; Molapo, 2018; Odendall et al., 2020; Stone, 2020; Taylor & Alper, 2018)	11
The overall cost of DHA implementation (Ahmed et al., 2014; Aranda-Jan et al., 2014; Haas, 2016; Lesh, 2016; Molapo, 2018; Odendall et al., 2020; Orton et al., 2018; Philbrick, 2012)	7

Inclusion of stakeholders

We found 60% (n=16) of the articles discussed the importance of stakeholder involvement. The article by Philbrick et al (2012) illustrated what they would define as stakeholders as bodies that support the scale of DHAs, they do this under four areas that included stakeholders under health, finance, technology, and government, as illustrated in Figure 2 below. Multi-stakeholder partnerships (government, private sector, and civil society) are recommended not only for scaling a DHA but the

role it plays in supporting the longer-term sustainability of the DHA, particularly around the financing of the DHA (Agarwal et al., 2016; Haas, 2016; Källander et al., 2013).

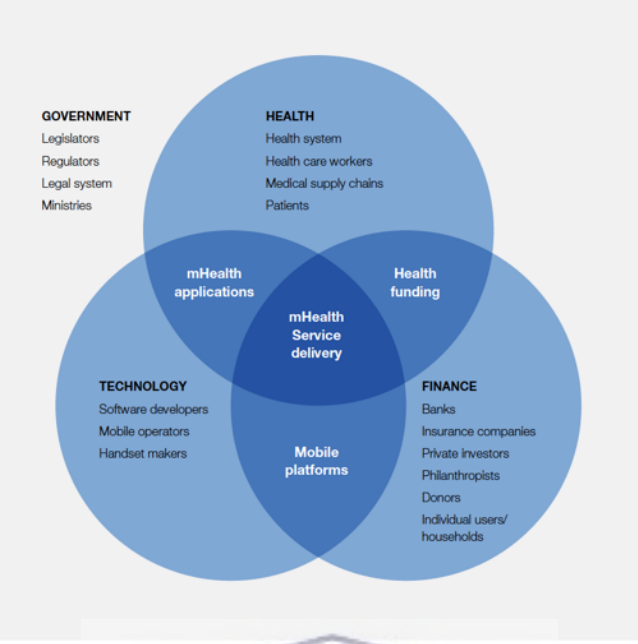


Figure 3: List of mHealth Stakeholders (Philbrick, 2012)

This level of partnership provides ingredients for long-term success like political leadership and buy-in, long-term financial support, and the ability to harness the skills of partners, especially from the private sector and government ownership (for long-term sustainability, maintenance and support) (Bolton et al., 2011; Gimbel et al., 2018; Haas, 2016; Källander et al., 2013; Levine et al., 2015; Taylor & Alper, 2018).

Cost of implementation

In 26% (n=7) articles the cost of implementing DHA is also discussed mainly in the context of there being very little research or articles being published on how these costs are calculated particularly when it comes to the maintenance of the DHA as well as the cost to bring it to scale, this information would be important in guiding the success of a DHA being brought to scale (Braun et al., 2013; Early et al., 2019; LeFevre et al., 2018; Naslund et al., 2019; Orton et al., 2018). These articles also

recommend further such research be conducted and published as a matter of priority on the cost of implementing and scaling DHIs.

The article by Agarwal et al (2016) provides an untested framework (Figure 3 below) that allows one to be able to not only demonstrate the cost of the DHA but also the savings it could earn for the health system. This type of framework could be an important tool as it allows governments to calculate the cost-benefit in health outcomes of DHAS about financial resources before investing in a DHA (Agarwal et al., 2016). Across all twenty-seven (27) we found no mention of any research conducted on the use of this tool in the 'real-world' design, development, implementation, and maintenance of DHAs.

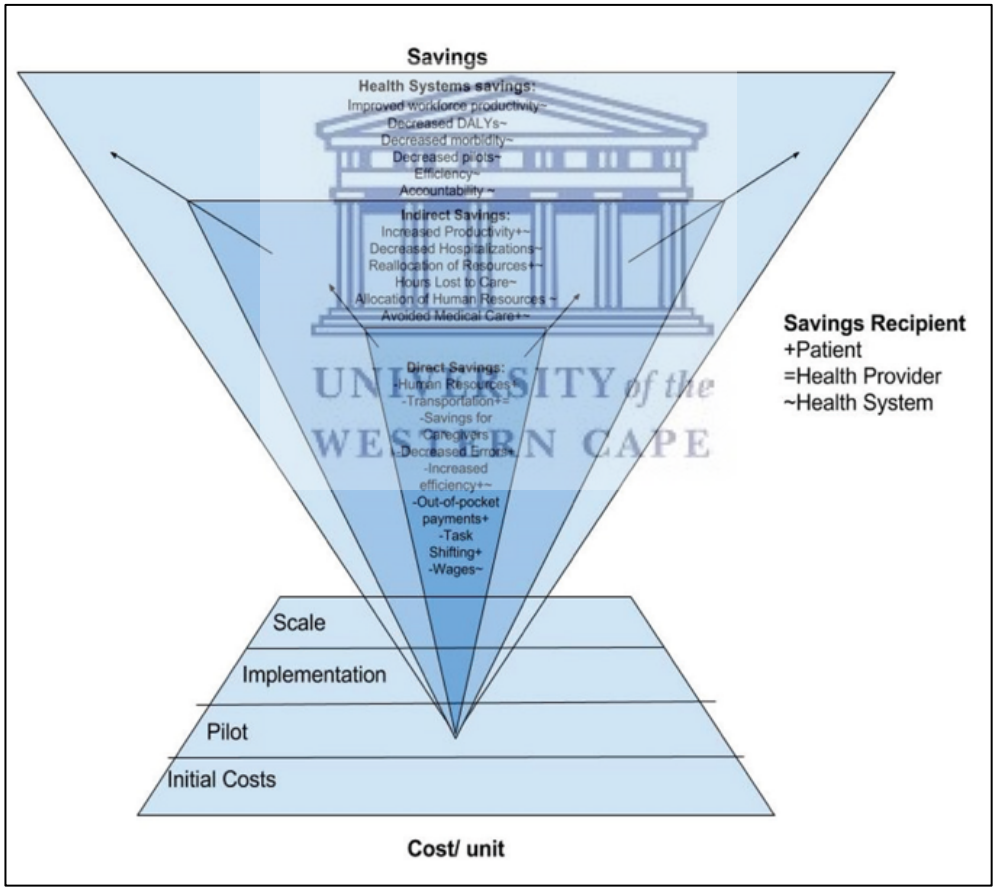


Figure 3: Cost vs Savings for DHAs (Agarwal et al., 2016)

4.3.4 Healthcare ecosystem factors

Table 18: Healthcare Ecosystem Factors influencing DHA scale	
Healthcare Ecosystem Factors	**The number of articles factor is referred to in**
Standards and regulations (Agarwal et al., 2016; Ahmed et al., 2014; Aranda-Jan et al., 2014; Braun et al., 2013; Early et al., 2019; Källander et al., 2013; National Academies of Sciences and Medicine, 2018; Orton et al., 2018; Philbrick, 2012; Taylor & Alper, 2018)	10
Financial support for the DHA, long-term and short-term support (Agarwal et al., 2016; Ahmed et al., 2014; Aranda-Jan et al., 2014; Early et al., 2019; Källander et al., 2013; Krah & de Kruijf, 2016; Molapo, 2018; Odendaal et al., 2020; Philbrick, 2012; Taylor & Alper, 2018)	10
Frameworks (Agarwal et al., 2016; Ahmed et al., 2014; Aranda-Jan et al., 2014; Braun et al., 2013; Källander et al., 2013; National Academies of Sciences and Medicine, 2018; Orton et al., 2018; Philbrick, 2012; Taylor & Alper, 2018)	9
Governance (Agarwal et al., 2016; Ahmed et al., 2014; Aranda-Jan et al., 2014; Early et al., 2019; Källander et al., 2013; National Academies of Sciences and Medicine, 2018; Philbrick, 2012).	7

a. Standards, Frameworks and Regulations

The need for standards and regulations to guide the design and implementation of a DHA so it can be brought to scale was reflected in 37% (n=10) of articles with the same number of articles mentioning the role of short- and long-term funding to support the same scale. The use of frameworks as further guidance was mentioned in 33% (n=9) of articles and the role of how DHAs are governed was found in 26% (n=7) of the articles.

Concerning the guidance, frameworks, standards and regulations, it is also worth noting that several articles recommended the use of the following documents as possible tools for the implementation and scale of DHAs i.e. *the Principles of Digital Development and the WHO classification of digital interventions* (Agarwal et al., 2016; Haas, 2016; Källander et al., 2013; Levine et al., 2015; Odendall et al., 2020). Within Haas (2016) we find mention of *The mHealth Assessment and Planning for Scale (MAPS) Toolkit: mHealth Assessment and Planning for Scale*.

Across all twenty-seven (27) we found no mention of any research conducted on the use of these tools in the 'real-world' design, development, implementation, and maintenance of DHAs.

WHO classification of digital interventions

The WHO classification of digital interventions was produced for the WHO members who requested the WHO to them with normative guidance to inform the adoption of evidence-based digital health interventions and has been accepted by the member states of the WHO (Källander et al., 2013). Targeted primarily at public health audiences, this classification framework aims to promote an accessible and bridging language for health program planners to articulate the functionalities of digital health implementations (Källander et al., 2013). This document allows members states to not only analyse the nature of digital health solutions within their health systems but also identify gaps and duplication of effort; synthesise evidence and research; developing guidance resources to inform planning and articulating required digital functionality based on identified health system challenges and needs (Agarwal et al., 2016). All of which support bringing a DHA to scale.

Principles of digital development

Launched in 2017 The Principles for Digital Development outlines nine (9) items to consider in designing digital health programs to mitigate predictable and preventable factors contributing to program failure (Lefevre et al., 2021). They are designed to help integrate best practices into

technology-enabled programs and are intended to be updated and refined over time and include guidance for every phase of the DHA project life cycle (Haas, 2016; Levine et al., 2015). They are endorsed by over 500 organisations, donors, governments etc. (Haas, 2016). These principles have recently been supplemented by the creation of a maturity matrix that allows DHI stakeholders to review their DHI projects to produce an assessment that would strengthen the DHI's success and potential to be brought to scale (Principles of Digital Development, 2022).

The MAPS Toolkit: mHealth Assessment and Planning for Scale

This toolkit published in 2015 by WHO is a self-assessment and planning guide to help DHI implementers successfully and sustainably scale up their innovations (World Health Organisation, 2015b). It assists DHI project teams in critically assessing their DHI project as they move from piloting to planning their next steps for overcoming the challenges inherent in scaling up (Haas, 2016). The Toolkit covers six major areas (referred to as the "axes of scale") that influence the scaling up of DHIs: groundwork, partnerships, financial health, technology and its architecture, operations, and monitoring with evaluation (World Health Organisation, 2015b).

b. National digital health strategies

20% (n=5) articles commented that several LMICs either don't have a digital health strategy or have one that is outdated (Aranda-Jan et al., 2014; Haas, 2016; Levine et al., 2015; National Academies of Sciences and Medicine, 2018). The lack of a national digital health strategy or an outdated one can compromise a DHA's success, as such a strategy should provide overall guidance to the DHI space in the country.

c. Funding of DHA

When it comes to funding of the DHA, 37% (n=10) of the articles mention long-term and short-term funding of the DHA as a factor determining the success of the DHA to scale.

d. Contingency Planning

Finally, it is worth mentioning that only one (1) of the articles mentioned the ability of the DHA to be used in contingency planning for emergencies i.e. the ability of a DHA to be adapted to the sometimes rapidly evolving needs of the health system under emergencies e.g. discovery of an infectious disease with high mortality like the Ebola Virus or COVID-19 (Levine et al., 2015). We assume this would have been a more common recommendation if the study period included 2021 and 2022 when health issues like COVID-19 and Ebola played a more dominant role in the DHI space (Benis, Tamburis, Chronaki, & Moen, 2021; Crawford & Serhal, 2020).

4.4 Discussion of scale within articles

Nineteen (19) of the articles also discussed how one can successfully scale DHAs, this section shares unique insights, which have not already been discussed as part of the four (4) factors above.

4.4.1 Frameworks

Two of the articles provide frameworks which guide the scale of DHA's (Agarwal et al., 2016; Aranda-Jan et al., 2014). These are displayed below.

Design of DHI in the African context

The first model by Aranda et al (2014) provided four key areas that would need to be assessed and addressed when designing and implementing a DHI, particularly in the African context. The guidance provided was generic for all DHIs and not particularly for those used by CHWs.

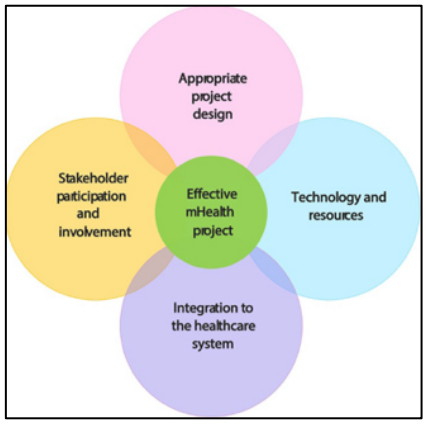


Figure 5 Main considerations for effective DHI projects in the African context (Aranda-Jan et al., 2014)

These were: firstly, good project design (adapted to the local context, promotion, education and awareness of the project, etc.), secondly identifying technology and resources (use local resources, capacity building, availability and maintenance), thirdly the involvement of stakeholders (strong public-private partnership, multidisciplinary teams, Ministry of Health, political leadership, local champion) and finally the involvement of Government eHealth/m-health department (program monitoring and evaluation, research, etc.). (Aranda-Jan et al., 2014).

Considerations for scaling DHIs

The second model provided guidance particular to the scale of DHI programmes and provided a matrix of different aspects that one would need to consider in combination as well as how they interact with each other when implementing for scale (Agarwal et al., 2016). These factors are the type of platform and phone being assessed in conjunction with its functionality as well infrastructural/environmental considerations, and cost considerations of both the platform and phone. All of these would also need to be considered together with the number of users that the DHA would have as well as the skills of these users, where why and how the DHA was going to be used (Agarwal et al., 2016). This model evolves the more simplistic guidance provided by the previous model as well as the guidance used to construct the data extraction table by showing how these different factors impact and influence each other when scaling a DHA.

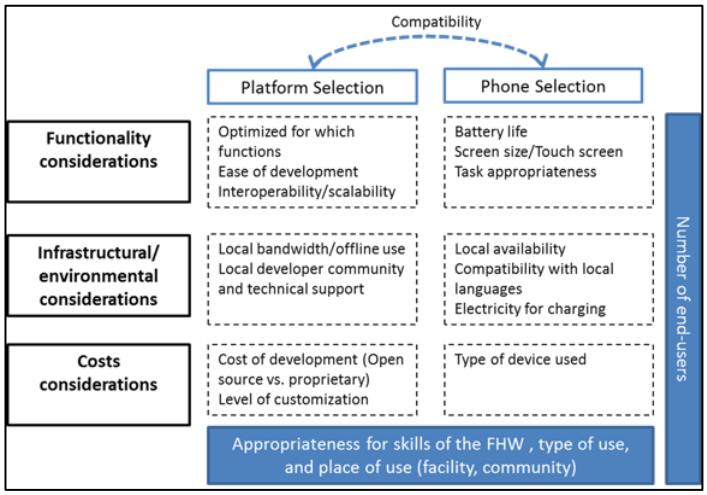


Figure 6: Considerations for scaling DHIs for FHW including CHW (Agarwal et al., 2016)

Across all twenty-seven (27) we found no mention of any research conducted on the use of these tools in the 'real-world' design, development, implementation, and maintenance of DHAs.

4.5 Other findings noted, outside the extraction table

The researcher noted one (1) thematic area that surfaced repeatedly across the articles, which was not initially part of the data identified for extraction within the extraction table. This thematic area was on the research and its subsequent knowledge generation on DHIs, this was framed in three (3) areas, lack of research on large-scale DHIs, lack of recent research on DHIs, lack of research on the health outcomes because of a DHI and finally the scarcity of country representative research on DHIs in SADC member states.

4.5.1 Lack of research

33% (n=9) of articles reflected on the deficiency of research on DHAs' impact on health outcomes, on large-scale successful DHAs and their cost effectiveness (Agarwal et al., 2016; Aranda-Jan et al., 2014; Braun et al., 2013; Gimbel et al., 2018; Ojo, 2018; Orton et al., 2018; Philbrick, 2012). The studies that have been published on DHAs have focused predominately on small and pilot-type DHIs which provide inadequate evidence to support the scale of such interventions (Gimbel et al., 2018;

Haas, 2016; Källander et al., 2013; Ojo, 2018; Orton et al., 2018). Table 20 highlights direct quotes from the reviewed articles on research and the lack thereof.

Table 19: Lack of research- examples from reviewed articles
"…to bridge this gap from piloting to scale-up, research priorities need to pivot to be more implementation-oriented and bring together academia and industry…" (Gimbel et al., 2018)
"… the current body of evidence is still quite limited in 3 main areas: the effectiveness of interventions on health outcomes, improvement in health system efficiencies for service delivery, and the human capacity required to implement and support digital health strategies at scale…" (Orton et al., 2018)
"…additional research is urgently needed to inform the effectiveness of interventions on health outcomes, improvement in health system efficiencies, and cost-effectiveness of service delivery. In particular, more documentation and research on ways to standardize and engage health workers in digital referral and clinical decision support systems can provide the foundation needed to scale these promising approaches in low- and middle-income settings" (Orton et al., 2018)
"There is a need for more intervention studies to ascertain the effect mHealth interventions on health outcomes and health care delivery processes.."(Ojo, 2018)
"… LMICs there remains a strong focus on mHealth pilot studies, which have rarely been followed up with more rigorous evaluation studies and have generally not been taken to scale. … it is imperative to undertake more rigorous evaluations. mHealth interventions need to be proven to be effective and cost-effective …" (Hall, Fottrell, Wilkinson, & Byass, 2014)

This lack of research has reduced the body of knowledge about DHAs, which would guide practice around DHA. This practice includes the production of frameworks, guidelines etc. (Agarwal et al., 2016; Aranda-Jan et al., 2014; Levine et al., 2015; National Academies of Sciences and Medicine, 2018).

Recent research

This is not only a lack of research but also a lack of recent research. We also note that most of the articles published were before 2019, with a minority being published thereafter. The DHI space is a fast-evolving space and the lack of more recent studies reduces the ability to gather learning that could be more current for the scaling of the DHAs (Gimbel et al., 2018; Haas, 2016; Källander et al., 2013; Ojo, 2018; Orton et al., 2018). We found this statement supported by the fact that the minority of the articles reviewed (14%) were based on research studies themselves and within these, the majority were focused on pilot DHIs.

Lack of research on the impact of DHIs on health outcomes

26% (n=7) of the articles note that despite the plethora of DHI the evidence and knowledge body around their impact on health outcomes themselves remains scarce (Aranda-Jan et al., 2014; Braun et al., 2013; Gimbel et al., 2018; Källander et al., 2013; Krah & de Kruijf, 2016; Ojo, 2018; Orton et al., 2018; Philbrick, 2012). This lack of research and knowledge body reduces the basis on which investors in DHIs like governments, donors and the private sector can make evidence-based decisions on which DHIs to support particularly when bringing these to scale (Krah & de Kruijf, 2016; Philbrick, 2012).

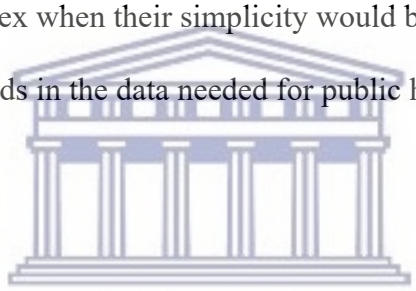
Lack of location-specific research in SADC

Overall, we found that the location of the DHA's discussed by the articles was predominately within three (3) SADC countries which were South Africa, Malawi, and the United Republic of Tanzania, with the other thirteen (13) countries being mentioned far fewer times. This disproportionate number of articles being produced by only certain member states prevents us from knowing if the guidance/recommendations produced would have the same significance in the under-represented member states as well as insight into the evidence body for these countries.

CHAPTER 5: DISCUSSION

This chapter discusses the challenges which hinder efforts to successfully implement and bring the DHIs to scale, with a particular focus on the challenges faced by those who design and implement DHIs in LMICs like those within SADC. The challenges are framed in two broad thematic areas i.e., those intrinsic to the DHI itself (human and technical) and those that create an enabling and supportive environment for the DHI (extrinsic ecosystem and health care ecosystem).

Under the intrinsic factors, this chapter provide insight and information on aspects of DHI design which impact its success and scale if not given due consideration i.e., why 'user-centred' design approaches despite being recognised as crucial to a DHI are not widely used, why the DHIs are becoming increasingly more complex when their simplicity would be key to their success and finally how the design of the DHI that builds in the data needed for public health decision making ensures its success and scale.



The aspects discussed under the enabling and supportive environment theme will cover three (3) areas, firstly the chapter will discuss why there is a lack of guidance to support DHIs, including why there is a lack of research available on validated DHI guidance documents like toolkits and models and general research on efficacy and effectiveness of a DHI. Secondly, it will discuss the rigidity of current legislation, its impact on the scale and success of DHIs and what can be done to address this rigidity. This section concludes with the theme of enabling and supporting the environment by unpacking why those who design and implement DHIs need to be aware of the 'digital divide that exists in certain populations and how that reduces their access and benefit from DHIs.

5.1 DHI Intrinsic Factors

Besides ensuring that a DHI is implemented in enabling environment, those who design, implement and support DHIs need to also ensure the DHI itself is designed for optimal efficacy and efficiency for its health outcome benefits to be felt. Attention to such design aspects as designing with the user and their context in mind, the simplicity of the DHI itself and a design that supports data collection, all go a long way in ensuring the success and scale of the DHI.

5.1.1 Design of the DHI: Users

A DHI being able to meet the needs of CHWs by supporting them to do their job efficiently and effectively increases the chances for success and being brought to scale (Labrique & Wadhwani, et al., 2018). Five (5) articles within the review recommend the use of the design technique called *'user-centred design'* which allows a better understanding of these needs, these needs could include literacy needs, training needs as well as the integration of the DHA in their existing workflow (Aranda-Jan et al., 2014; Haas, 2016; Källander et al., 2013; Labrique & Wadhwani, et al., 2018; Levine et al., 2015). Several such design approaches already exist, for example, user-centred design, person-based design, human-centred design, patient-centred design, and patient-led design (Duffy, Christie, & Moreno, 2022).

Despite the number of DHI design approaches that do exist, which place the user in the centre of the design of a DHI, the practice of such design approaches is either not widely used or partially used when designing DHIs (Duffy et al., 2022; Mathews et al., 2019).

One of the reasons postulated for this technique not being widely used is the dichotomy created by using a design approach created by and for the fast pace of the digital industry in a slower more rigorous environment like health care, which makes it seem incompatible with the more traditional

health care space (Mathews et al., 2019). This perceived incompatibility has resulted in a slower uptake of the principle especially if the DHI is spear-headed by healthcare professionals as opposed to digital professionals (Murray et al., 2016). A recommendation on how to overcome this would be consideration about the composition of a DHI team, the inclusion of professionals from both health care and digital spaces in the team as well as negotiation between them as to how to best use such techniques would go long way towards supporting the use of such techniques (Duffy et al., 2022).

Another reason why this design technique is used infrequently relates to its costs in terms of time and financial costs. This technique does take time and would need further financial resources, being able to demonstrate the value of such an investment via research increases the chances that donors, designers and implementers would support such an investment (Mathews et al., 2019).

5.1.2 Design of DHI: The relevance of its software

Across the articles reviewed, we saw numerous references to multiple factors that should be considered when designing the actual software that would be used to 'run' the DHI because the software itself not only 'runs' the DHI but also shapes how the DHI interacts with the user (as mentioned above) and how the DHI functions in the health system context within which it is implemented (Labrique & Wadhwani, et al., 2018). Several contextual aspects need to be considered when creating the software, these should include whether it runs on open-sourced software, whether the software allows the DHI to be reused for other health functions, whether it can be interoperable with existing systems, whether it creates an easy-to-use DHA and most importantly for LMICs with poor network connectivity, whether it has an 'off-line' functionality (Labrique & Vasudevan, et al., 2018). From the articles, we note that many DHIs take into consideration some but not always all software aspects that must be considered when designing a DHI which affects its ability to be successful and brought to scale. The reason for this inconsistent application could be the lack of a

standardised globally accepted list, adherence to which would allow a DHI to be able to ensure it incorporates these recommendations (Principles of Digital Development, 2022).

5.1.3 Design of DHI: Data collection, management, and use

DHIs as mentioned in Chapter 2, play a crucial role in digitising data that is collected by the health system. This finding was supported by the review itself where 30% (n= 8) of the articles noted this crucial role. The reviewed articles go beyond identifying the most simplistic way a DHI can be beneficial to data collection for the health system i.e., it collects electronic data, which is sent to a central point for consolidation, to expanding its role in data collection and management. They do this by recommending that the design and implementation of DHIs should consider the DHI's wider potential in the health data space for the benefit of the health system. Such potential includes how the data collected can be collated in an accessible and user-friendly manner. Expanding on such potential increases the DHIs scale and success as discussed further.

The usefulness of merging Data – HIS and Dashboards

This ability of data to be merged from different sources was a prominent recommendation by the articles. This was identified as the second biggest factor that determines a DHA's ability to scale. This recommendation relies heavily on another major recommendation under the technical factors i.e., the ability of a DHA to be interoperable with the existing infrastructure, workflow, and applications which allows data from these sources to be collated together. Merging multiple data sources like health, medical supplies availability, cost of treatment etc., allows the HIS to be able to produce a holistic picture of a person/region/country level health needs and how these needs are being met which ensures increased precision in decision making around investment in the health system and decreased wastage of resources (Greenwell & Salentine, 2018).

Another recommendation was that the design of DHAs must include a 'dashboard' function (Agarwal et al., 2015; Haas, 2016). By 'dashboard' we mean : a user interface that organizes and presents information and data in a way that is easy to read is user-friendly and can facilitate real-time system tracking and decision-making (World Health Organisation, 2015b). Such a dashboard-type tool would allow a CHW to review multiple data points (collected by different DHAs) at a glance which increases the CHW's efficiency and quality of care (Agarwal et al., 2016; Bervell & Al-Samarraie, 2019; Haas, 2016). This also reduces the CHW's time as they would not need to waste time referring to different data sources (analogue and or digital) to provide holistic care to their patients (Agarwal et al., 2016; Bervell & Al-Samarraie, 2019; Haas, 2016).

Furthermore, functionality is often overlooked by DHI designers, as those who invest in DHIs usually have a silo view of the data i.e., they are only interested in investing in software that collects data on their health focus and is not willing to invest in additional functionality like a dashboard, which includes other health foci (Agarwal et al., 2016; Bervell & Al-Samarraie, 2019; Haas, 2016).

5.2. DHI Enabling Environment

Understanding the factors intrinsic to the DHI itself is part of ensuring its success and scale, this understanding needs to be combined with understanding the environment within which it is implemented. Several studies from the review mentions of the lack of guidance and research on DHIs, such lack increases the chances of a DHI failing as designers and investors have a limited body of evidence and knowledge on which to base their decisions.

5.2.1 Guidance for DHIs to support scale

As found by the review, there remains a gap in the body of evidence for guidance/frameworks etc. that have been supported by research, the existence of which would strengthen their justification and

use by those who design and implement DHIs (Agarwal et al., 2016; Aranda-Jan et al., 2014; Levine et al., 2015; Murray et al., 2016; Taylor & Alper, 2018). The use of these guidance documents remains low despite the positive impact they could make on DHI's success and scale. One of the reasons postulated for this is the rigid nature of these guidance documents and their inability to be used in conjunction with DHIs that require guidance that can be agile and flexible. The section below discusses the reasons for the lack of evidenced-based toolkits and models, which were uncovered by the review.

5.2.1.1 Lack of well-researched guidance documentation and rigid nature

Lack of researched documentation and use thereof

There is a deficiency of well-researched guidance (standards, regulations, frameworks and governance) across the digital health intervention space (Agarwal et al., 2016; Aranda-Jan et al., 2014; Levine et al., 2015; Murray et al., 2016; Taylor & Alper, 2018). Under the healthcare ecosystem factors, the need for guidance was dominant in the form of recommendations for the need for frameworks, policies, and governance. This lack of frameworks, policies and governance compromises the chances of a DHA being scaled successfully as such guidance reduces the chances of a DHA failing when adhered to (Agarwal et al., 2016; Aranda-Jan et al., 2014; Levine et al., 2015; National Academies of Sciences and Medicine, 2018).

The same articles also noted that when such guidance documents do exist, a substantial number of DHIs don't consider or even consider such guidance in their design and implementation mainly due to the rigid nature of the guidance, the extra effort it requires and the changes in design and planning that such documents would require. Such lack of consideration ensures that the DHI, when implemented will face obstacles from government officials as well as citizens themselves, as improper consideration of guidance, particularly of the legislative kind will bring the DHI in direct conflict with the legal system of the country it is implemented in.

Rigid nature of guidance documentation

The rigid nature of frameworks, policies, guidelines and standards means that they are sometimes unable to support the fluid nature of the DHI space (Tait & Banda, 2016). For example, when a regulatory system is imposed in the early stages of the development of DHI, the regulatory system usually requires subsequent adaptation to meet the evolution of the DHI, but this proves difficult due to its rigid nature (Tait & Banda, 2016). This means that DHIs either ignore such guidance to ensure the DHI is successfully implemented as such guidance slows down the development and implementation of a DHI or includes such guidance which finds themselves at odds with their investors due to the rather large amount of time added to the delivery date for the DHI to ensure its compliance with such guidance.

5.2.1.2 Toolkits and models- lack of testing

Within the study review, we found nine (9) toolkits and five (models) with which to guide DHIs. Toolkits can be defined as "a collection of related information, resources, or tools that together can guide users to develop a plan or organise efforts to follow evidence-based recommendations or meet evidence-based specific practice standards" (Godinho, Ansari, Guo, & Liaw, 2021:pagenumber?). Models (like the ones we found in the study review) can be used to inform toolkits (Yamada, Shorkey, Barwick, Widger, & Stevens, 2015).

None of the toolkits or models the review found has been either field tested or evaluated or the findings of such testing have not been published (Godinho et al., 2021). A reason for this could be that the development of these toolkits is inconsistent which could be a result of the inconsistent methodology being used when creating these toolkits which make researching and comparing across toolkits and models difficult (Godinho et al., 2021).

5.2.2 Research on DHIs – the reduced body of evidence

The lack of research on DHIs impact, outcomes and their large-scale implementations hinders the generation of new knowledge with which to guide practice around DHAs especially their 'real-world' practice of DHI implementation (Duffy et al., 2022; Tambo et al., 2016). One reason for the poor evidence body could be that good research in this area requires fertile multidisciplinary collaborations that draw on insights and experience from multiple fields, including clinical medicine, health services research, behavioural science, education, engineering, and computer science, which the field lacks (Murray et al., 2016). The lack of such collaboration could be the numerous challenges that it brings which include marrying varying and sometimes competing and contrasting methodologies and ideologies for each discipline for the same DHI research (Murray et al., 2016).

Digital and health bring together digital and health professionals who have different methodologies on how to design a solution, with health professionals' research on a solution centred on rigour, transparency and systematicity, using the gold standard for health intervention evaluation i.e. the randomised control trial (Duffy et al., 2022). In contrast within the digital industry, research is conducted in a rapid, iterative manner not always with rigour etc. this rapidity allows the industry to keep pace with the often fast developmental nature of DHIs (Duffy et al., 2022; Tait & Banda, 2016). These different paces and methodologies, often create an environment within which the research needs (by either party) are not compatible which results in the research either not being taken up or done in a manner that satisfies one but not the other discipline's needs (Murray et al., 2016).

5.2.3 The digital divide and scale

Understanding the role, the digital divide plays in the DHI and mitigating that role by its design and implementation would go a long way in not only reducing the divide but also supporting the scale and success of a DHI. Only two (2) of the articles mentioned the role the digital divide plays in the

successful implementation and scale of a DHI. The number of times the digital divide should have mentioned should have been significantly higher when one looks at its potential impact on the scale and success of a DHI particularly in LMICs.

By 2021 3.5 billion people were still unable to access the internet, a lack which also affects their ability to use DHIs, usage of which is dependent on internet access (European Union, 2021). Within this group, we find an overrepresentation of marginalised groups like women, elderly people and those living in remote and rural areas, particularly in LMICs like SADC (Makri, 2019). This inequitable access decreases the ability of these populations to benefit from the DHIs and will have a more and more negative impact on their health status, especially as the use of DHIs accelerates (Chowdhury & Pick, 2019). The ability to access the internet is one contributing factor to the digital divide, others include the literacy of the user, access to the hardware and software necessary to use a DHI, digital skills of the user to allow them to effectively use the technology as well as their motivation to use the DHI (which is influence by their confidence, trust in the DHI and its relevance) (Bloom, 2022).

Understanding what factors create and maintain this divide, is an important first step as it allows the designers and implementors of DHIs to institute measures that counter and overcomes such factors as they design and implement the DHI. Being able to generate more evidence on the downsides of exclusion and the overall cost to society as well as designing data collection that highlights such exclusions could be used to advocate for greater investment in aspects like rural infrastructure, digital literacy and up-skilling programmes etc. (Makri, 2019). The International Technology Union also recommends that countries, sector members and academia support the formulation and implementation of policies and strategies on digital inclusion, as well as awareness raising and advocacy, sharing good practices and knowledge, building capacity and the development of

products/services as ways to reduce this digital divide (UN Secretary-General's High-level Panel on Digital Cooperation, 2019).

CHAPTER 6: CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusion

Bringing a DHI to scale in an LMIC has numerous challenges, which have stymied the efforts of governments, donors, and investors from achieving significant scale to harness the benefits of DHIs as a population-wide benefit. This scoping review identified the factors under the four (4) areas that influence these challenges, these four (4) areas being human, technical, extrinsic environmental and healthcare ecosystem factors.

Firstly, the understanding of the user of the DHI in its design and implementation was identified as the key recommendation identified under the human factors to be considered in the design of a DHI. Challenges which included the literacy of the user, financial means of the user as well as their mobile network connectivity could be managed better with better user understanding of user-centred design techniques. The review found that insufficient time and money have been invested in such user centred design techniques, which has resulted in their minimal use in the design and implementation of DHIs. An investment in the recommended user centred design techniques could significantly reduce the failure of DHIs by addressing these user related challenges.

Under the technical area, it is noted that a better understanding of the usage and usability of a DHI its design and implementation i.e., the type of software used its interoperability, its simplicity, its ability to manage and collate data and whether it was open-source software influence the relevance of a DHI to the health system. This understanding in turn influences its success and its subsequent ability to be brought to scale and reduces its chances of failure.

The study noted that the extrinsic factors, the inclusion of stakeholders in the DHI design and implementation, investment in the infrastructure supporting a DHI and a good understanding of what it costs to scale and maintain a DHI, all contribute to the success of a DHI to be brought to scale. Unfortunately, these aspects are either never used or when used, they are used sparingly in the design and implementation of a DHI, which reduces its chances of being brought to scale successfully. Careful thought around the inclusion of stakeholders by those implementing DHIs before implementation, would significantly increase the chances of a DHI succeeding particularly in LMICs.

Within the final area the study on the healthcare ecosystem itself, it discovered the factors that carry the most influence on a DHI is those around guidance documents. What has been a challenge is the availability, applicability, evidence-based research, and usability of such guidance documents like policies, regulations, frameworks, toolkits, and models for DHIs. Global health related bodies like the WHO and UNAIDS and bilateral like USAID should be more cognisant of each other's contribution to the DHI field, in the form of guidance documentation. This awareness could reduce duplications and fill the gap in missing guidance. This would in turn support the successful implementation and scale of DHIs.

The study revealed there is insufficient understanding and therefore incorporation of the drivers of the 'digital divide by the designers and implementors of DHIs. Such inclusion would by intentional incorporation of design and implementation means, alleviate this divide that reduces the number of people who can access the benefits of DHIs, which would increase it success and longevity.

6.2 Recommendations

To overcome some of the challenges identified in bringing a DHI to scale will require a framework for evidence generation, a critical appraisal checklist for toolkit generation and implementation as well as the use of the Principles of Digital Development matrix to guide investment in DHIs.

6.2.1 Evidence generation for DHIs

6.2.1.1 Framework for research generation

To plug the gap that exists in the quantity of good quality research and evidence-informed guidance available with which to guide DHIs, it would be critical for research bodies like universities and global bodies like the WHO and large-scale bilateral donors in digital health like The United States Agency for International Development (USAID) to identify, invest in and implement a framework that would guide the production of such research. This framework should take a more transdisciplinary approach to research, which binds together healthcare outcomes, with clinical data and digital design which would allow both health professionals and digital professionals to produce research that would be useful not only to each discipline but also research that would be more holistic and added value to DHIs implementation and scale (Duffy et al., 2022). An example of how such a suggestion could be put into practice is shown by the *Framework for evidence generation*, which shares nine (9) levels at which a DHI can generate research, as part of its development process as well as the type of evidence it can generate by taking into account the multi-disciplinary aspects of DHI design and implementation (Hughes, Lennon, Rogerson, & Crooks, 2021). These levels are: Demand/Needs assessment and vision; Current state mapping; Landscape review/Horizon scanning; Future state options co-designed; Future state preferred and simulated; Real-world testing; Evaluation and evidence gathering; Case for scale developed and Service implemented and scaled (Hughes et al., 2021).

6.2.1.2 Evidence-informed toolkits – appraisal checklist

As evidenced, the toolkits and models presented across the articles, lack evidence which informs their creation or even evidence of their impact on 'real-world' usage in DHIs. A reason for this is the

lack of rigour that exists in the creation of toolkits and their implementation (Godinho et al., 2021). The adoption of a critical appraisal checklist by the creators and implementors of toolkits will increase toolkit quality and would also support building the knowledge and evidence base on toolkits for DHIs. Such an appraisal checklist as supported by Godinho et al. (2021) should have a framework with a scoring system that supports the quality and rigour in the development and implementation of a toolkit and allows external parties to use such an appraisal to guide their decision on which toolkits to use (Godinho et al., 2021).

6.2.1.3 Designing with Principles of Digital Development matrix.

To better manage the challenges in the successful scale implementation of a DHI, the use of the Digital Principles Maturity Matrix tool (launched in 2022) would go a long way in understanding and better management of such challenges that stem from human factors like literacy etc. that contribute to widening the 'digital-divide' (Principles of Digital Development, 2022). The matrix is an interactive tool with which to better align proposal evaluation with the Principles for Digital Development throughout all phases of the DHI project lifecycle. Such alignment increases the chance of a DHI being successful at scale (Principles of Digital Development, 2022). Investors in DHIs should use such a matrix to guide their investment decisions on DHIs and invest in DHIs which have a closer alignment as this pre-empts a successful and scalable DHI.

6.2.2 Landscape analysis of prevailing legislation, regulation, and policies impacting on DHIs

To allow DHIs to be guided by legislation, regulation, and policies, so that their design, production, implementation, and maintenance are in line with the rules that govern the land within which they exist, these guidance pieces need to be sufficiently flexible to support the iterative nature of DHIs while still protecting the country's citizens. Tait & Banda (2016) from the British Standards Institution proposed an innovative approach to the British Government on how this can be resolved, where the frameworks, policies, guidelines, and standards could be adopted in different ways at different stages of creating a DHI as opposed to the current 'one-size' fits all approach. This

approach suggests that at the early stages of DHI development ‘soft laws’ like frameworks, guidelines and standards be used to guide DHIs with these laws becoming ‘hard laws’ like regulations as the DHI progresses towards later development and for large-scale deployment (Tait & Banda, 2016). A landscape analysis of prevailing legislation that could impact the DHI should be conducted before the implementation of a DHI, this would allow those that design, invest, and implement a DHI to negotiate the amendments within such legislation as well as any new legislation with relevant government bodies to support the scale and success of the DHI.

References

Adepoju, I.-O. O., Albersen, B. J. A., De Brouwere, V., van Roosmalen, J., & Zweekhorst, M. (2017). mHealth for Clinical Decision-Making in Sub-Saharan Africa: A Scoping Review. *Journal of Medical Internet ResearchmHealth and UHealth*, *5*(3), e38. https://doi.org/10.2196/mhealth.7185

Agarwal, S., Perry, H. B., Long, L. A., & Labrique, A. B. (2015). Evidence on feasibility and effective use of mHealth strategies by frontline health workers in developing countries: Systematic review. *Tropical Medicine and International Health*, *20*(8), 1003–1014. https://doi.org/10.1111/tmi.12525

Agarwal, S., Rosenblum, L., Goldschmidt, T., Carras, M., Goal, N., & Labrique, A. B. (2016). Mobile Technology in Support of Frontline Health Workers. *John Hopkins University Global MHealth Initiative 2016*, 86.

Ahmat, A., Okoroafor, S. C., Kazanga, I., Asamani, J. A., Millogo, J. J. S., Illou, M. M. A., … Nyoni, J. (2022). The health workforce status in the WHO African Region: findings of a cross-sectional study. *British Medical Journal Global Health*, *7*(Suppl 1), e008317. https://doi.org/10.1136/bmjgh-2021-008317

Ahmed, T., Bloom, G., Iqbal, M., Lucas, H., & Rasheed, S. (2014). E-health and M-Health in Bangladesh: Opportunities and Challenges. *Research Gate*, 24.

Anderson M, K., & Olson, S. (2016). The Promises and Perils of Digital Strategies in Achieving Health Equity. In K. M. Anderson & S. Olson (Eds.) (p. 82). Washington, D.C.: National Academies Press. https://doi.org/10.17226/23439

Aranda-Jan, C. B., Mohutsiwa-Dibe, N., & Loukanova, S. (2014). Systematic review on what works, what does not work and why of implementation of mobile health (mHealth) projects in Africa. *BioMed Central Public Health*, *14*(1). https://doi.org/10.1186/1471-2458-14-188

Arksey, H., & O'Malley, L. (2005). Scoping studies: Towards a methodological framework.

International Journal of Social Research Methodology: Theory and Practice, *8*(1), 19–32. https://doi.org/10.1080/1364557032000119616

Barnett-Page, E., & Thomas, J. (2009). Methods for the synthesis of qualitative research: A critical review. *BiodMed Central Medical Research Methodology*, *9*(1). https://doi.org/10.1186/1471-2288-9-59

Benis, A., Tamburis, O., Chronaki, C., & Moen, A. (2021). One digital health: A unified framework for future health ecosystems. *Journal of Medical Internet Research*, *23*(2). https://doi.org/10.2196/22189

Bervell, B., & Al-Samarraie, H. (2019). A comparative review of mobile health and electronic health utilization in sub-Saharan African countries. *Social Science & Medicine*, *232*, 1–16. https://doi.org/https://doi.org/10.1016/j.socscimed.2019.04.024

Bloom, S. (2022). *The Impact of Digital Health Technologies on Health Inequities; to improve understanding on causation and mitigation strategies*. London.

Bolton, P., Hausman, V., & Keisling, K. (2011). *Building Partnerships that Work: Practical Learning on Partnering in mHealth*. New York. Retrieved from www.gbchealth.org

Braun, R., Catalani, C., Wimbush, J., & Israelski, D. (2013). Community health workers and mobile technology: a systematic review of the literature. *Public Library of Science One*, *8*(6), e65772.

Chowdhury, A., & Pick, A. (2019). Digital Health in LLMICs: Current and future technological developments with the potential to improve health outcomes in low-and lower-middle-income countries. *Pathways for Prosperity Commission Background Paper Series*. Retrieved from www.pathwayscommission.bsg.ox.ac.uk

Cochrane Community. (2022). The Future of Evidence Synthesis in Cochrane- Covidence. Retrieved 12 October 2022, from https://community.cochrane.org/organizational-info/plans/future-evidence-synthesis-cochrane

Crawford, A., & Serhal, E. (2020). Digital health equity and COVID-19: The innovation curve

cannot reinforce the social gradient of health. *Journal of Medical Internet Research*, *22*(6), 1–5. https://doi.org/10.2196/19361

Cunningham, M., & Cunningham, P. (2018). mHealth4Afrika-Supporting Primary Healthcare Delivery in Resource Constrained Environments. *International Conference on Sustainable Development (ICSD)*, (September 2018).

Cunningham, M., Cunningham, P. M., van Greunen, D., Kanjo, C., Kweyu, E., & Tilahun, B. (2018). mHealth4Afrika Beta v1 Validation in Rural and Deep Rural Clinics in Ethiopia, Kenya, Malawi and South Africa. In *2018 IEEE Global Humanitarian Technology Conference(GHTC)*.

Cunningham, M., Cunningham, P. M., van Greunen, D., Veldsman, A., Kanjo, C., Kweyu, E., & Tilahun, B. (2017). mHealth4Afrika Alpha Validation in Rural and Deep Rural Clinics in Ethiopia, Kenya, Malawi and South Africa. In *2017 IEEE Global Humanitarian Technology Conference(GHTC)* (pp. 268–276).

De Leeuw, K. (2019). *A systematic review of digital health tools used for decision support by frontline health workers (FLHWs) in low- and middle- income countries (LMICs)*. University of Cape Town. Retrieved from http://hdl.handle.net/11427/31402

Devi, B. R., Syed-Abdul, S., Kumar, A., Iqbal, U., Nguyen, P. A., Li, Y. C. J., & Jian, W. S. (2015). MHealth: An updated systematic review with a focus on HIV/AIDS and tuberculosis long term management using mobile phones. *Computer Methods and Programs in Biomedicine*, *122*(2), 257–265. https://doi.org/10.1016/j.cmpb.2015.08.003

Digital Principles. (2018). Principle : Design with the User Principle 1. Retrieved 15 September 2022, from https://digitalprinciples.org/wp-content/uploads/PDD_Principle-DesignWithUser_v31.pdf

Duffy, A., Christie, G. J., & Moreno, S. (2022). The Challenges Toward Real-world Implementation of Digital Health Design Approaches: Narrative Review. *Journal of Medical Internet Research Human Factors*, *9*(3). https://doi.org/10.2196/35693

Dzenowagis, J. (2018). *Digital technologies: shaping the future of primary health care*. Geneva.

Early, J., Gonzalez, C., Gordon-Dseagu, V., & Robles-Calderon, L. (2019). Use of Mobile Health (mHealth) Technologies and Interventions Among Community Health Workers Globally: A Scoping Review. *Health Promotion Practice*, *20*(6), 805–817. https://doi.org/10.1177/1524839919855391

Emmanuel, G. (2018). A Mobile Application System for Community Health Workers: A Review. *Global Journal of Research and Review*, *05*(02), 1–7. https://doi.org/10.21767/2393-8854.100040

European Union. (2021). The rise of digital health technologies during the pandemic, (April).

Gimbel, S., Kawakyu, N., Dau, H., & Unger, J. A. (2018). A missing link: HIV-/AIDS-related mHealth interventions for health workers in low-and middle-income countries. *Current HIV/AIDS Reports*, *15*(6), 414–422.

Global Health : Science and Practice. (2014). Cell phones and CHWs: A transformational marriage? *Global Health Science and Practice*. https://doi.org/10.9745/GHSP-D-14-00007

Godinho, M. A., Ansari, S., Guo, G. N., & Liaw, S. T. (2021). Toolkits for implementing and evaluating digital health: A systematic review of rigor and reporting. *Journal of the American Medical Informatics Association*, *28*(6), 1298–1307. https://doi.org/10.1093/jamia/ocab010

Greenwell, F., & Salentine, S. (2018). *Health Information System Strengthening: Standards and Best Practices for Data Sources — MEASURE Evaluation*. *Measure Evaluation*. Retrieved from https://www.measureevaluation.org/resources/publications/tr-17-225

GSMA Intelligence. (2017). *Scaling digital health in developing markets*. Retrieved from https://www.gsmaintelligence.com/research/?file=c581aa43bdb7b7d236bb937698c2d6fd&download

Haas, S. (2016). mHealth Compendium Special Edition 2016: Reaching Scale, (May), 92 pp. Retrieved from http://21028-presscdn.pagely.netdna-cdn.com/wp-

content/uploads/2016/08/mHealth-Compendium-Special-Edition-2016-Reaching-Scale-.pdf

Hall, C. S., Fottrell, E., Wilkinson, S., & Byass, P. (2014). Assessing the impact of mHealth interventions in low- and middle-income countries – what has been shown to work? *Global Health Action*, *7*(1), 25606. https://doi.org/10.3402/gha.v7.25606

Holeman, I., & Kane, D. (2020). Human-centered design for global health equity. *Information Technology for Development*, *26*(3), 477–505. https://doi.org/10.1080/02681102.2019.1667289

Hughes, J., Lennon, M., Rogerson, R. J., & Crooks, G. (2021). Scaling digital health innovation: Developing a new 'service readiness level' framework of evidence. *International Journal of Environmental Research and Public Health*, *18*(23). https://doi.org/10.3390/ijerph182312575

Jemiluyi, O. O., & Bank-Ola, R. F. (2021). The Burden of Infectious Diseases: A Trend Appraisal in Sub-Saharan Africa Regional Trade Blocs. *Journal of Scientific Research in Medical and Biological Sciences*, *2*(3), 104–122. https://doi.org/10.47631/jsrmbs.v2i3.331

Jongbloed, K., Parmar, S., Kop, M. van der, Lester, R. T., & Spittal, P. M. (2016). Recent Evidence for Emerging Digital Technologies to Support Global HIV Engagement in Care. *Physiology & Behavior*, *176*(12), 139–148. https://doi.org/10.1007/s11904-015-0291-7.Recent

Källander, K., Tibenderana, J. K., Akpogheneta, O. J., Strachan, D. L., Hill, Z., ten Asbroek, A. H. A., … Meek, S. R. (2013). Mobile health (mHealth) approaches and lessons for increased performance and retention of community health workers in low-and middle-income countries: a review. *Journal of Medical Internet Research*, *15*(1), e2130.

Kastner, M., Tricco, A. C., Soobiah, C., Lillie, E., Perrier, L., Horsley, T., … Straus, S. E. (2012). What is the most appropriate knowledge synthesis method to conduct a review? Protocol for a scoping review. *Bio Medical Central Research Methodology*, *12*, 1–10. https://doi.org/10.1186/1471-2288-12-114

Khubone, T., Tlou, B., & Mashamba-Thompson, T. P. (2020). Electronic health information systems to improve disease diagnosis and management at point-of-care in low and middle income

countries: A narrative review. *Diagnostics*, *10*(5). https://doi.org/10.3390/diagnostics10050327

Krah, E. F., & de Kruijf, J. G. (2016). Exploring the ambivalent evidence base of mobile health (mHealth): A systematic literature review on the use of mobile phones for the improvement of community health in Africa. *Digital Health*, *2*, 205520761667926. https://doi.org/10.1177/2055207616679264

Labrique, A., Vasudevan, L., Mehl, G., Rosskam, E., & Hyder, A. A. (2018). Digital health and health systems of the future. *Global Health Science and Practice*, *6*, S1–S4. https://doi.org/10.9745/GHSP-D-18-00342

Labrique, A., Wadhwani, C., Williams, K. A., Lamptey, P., Hesp, C., Luk, R., & Aerts, A. (2018). Best practices in scaling digital health in low and middle income countries. *Globalization and Health*, *14*(1), 1–8. https://doi.org/10.1186/s12992-018-0424-z

Lefevre, A. E., Chamberlain, S., Singh, N. S., Scott, K., Menon, P., Barron, P., … George, A. (2021). Avoiding the Road to Nowhere: Policy Insights on Scaling up and Sustaining Digital Health. *Global Policy*, *12*(S6), 110–114. https://doi.org/10.1111/1758-5899.12909

LeFevre, A. E., Dane, P., Copley, C. J., Pienaar, C., Parsons, A. N., Engelhard, M., … Pillay, Y. (2018). Unpacking the performance of a mobile health information messaging program for mothers (MomConnect) in South Africa: evidence on program reach and messaging exposure. *British Medical Journal Global Health*, *3*(Suppl 2), e000583.

Leong, S. L., Teoh, S. L., Fun, W. H., & Lee, S. W. H. (2021). Task shifting in primary care to tackle healthcare worker shortages: An umbrella review. *European Journal of General Practice*, *27*(1), 198–210. https://doi.org/10.1080/13814788.2021.1954616

Lesh, N. (2016). How can we help generate the most impact for the least effort? In *Global Digital Health Forum* (p. 13). Retrieved from https://lib.digitalsquare.io/handle/123456789/77293

Lessells, R. J., Swaminathan, S., & Godfrey-Faussett, P. (2015). HIV treatment cascade in tuberculosis patients. *Current Opinion in HIV and AIDS*. Lippincott Williams and Wilkins.

https://doi.org/10.1097/COH.0000000000000197

Levine, R., Corbacio, A., Konopka, S., Saya, U., Gilmartin, C., Paradis, J., & Haas, S. (2015). mHEALTH COMPENDIUM VOLUME 5, *5*(June).

Lozano, R., Fullman, N., Mumford, J. E., Knight, M., Barthelemy, C. M., Abbafati, C., … Murray, C. J. L. (2020). Measuring universal health coverage based on an index of effective coverage of health services in 204 countries and territories, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. *The Lancet*, *396*(10258), 1250–1284. https://doi.org/10.1016/S0140-6736(20)30750-9

Makri, A. (2019). Bridging the digital divide in health care. *The Lancet Digital Health*, *1*(5), e204–e205. https://doi.org/10.1016/s2589-7500(19)30111-6

Mathews, S. C., McShea, M. J., Hanley, C. L., Ravitz, A., Labrique, A. B., & Cohen, A. B. (2019). Digital health: a path to validation. *Nature Partner Journal Digital Medicine*, *2*(1), 1–9. https://doi.org/10.1038/s41746-019-0111-3

May, E. (2021). How digital health apps are empowering patients. *Deloitte*, 1–11. Retrieved from https://www2.deloitte.com/us/en/blog/health-care-blog/2021/how-digital-health-apps-are-empowering-patients.html

Molapo, M. (2018). *Designing with community health workers: feedback-integrated multimedia learning for rural community health*. University of Cape Town. Retrieved from http://hdl.handle.net/11427/27977

Munn, Z., Peters, M. D. J., Stern, C., Tufanaru, C., McArthur, A., & Aromataris, E. (2018). Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. *Bio Medical Central Medical Research Methodology*, *18*(1), 1–7. https://doi.org/10.1186/s12874-018-0611-x

Murray, E., Hekler, E. B., Andersson, G., Collins, L. M., Doherty, A., Hollis, C., … Wyatt, J. C. (2016). Evaluating Digital Health Interventions: Key Questions and Approaches. *American*

Journal of Preventive Medicine, *51*(5), 843–851. https://doi.org/10.1016/j.amepre.2016.06.008

Myrick, N., & Gilbert, S. (2021). How digital technologies can address 5 sources of health inequity. Retrieved 10 September 2022, from https://www.weforum.org/agenda/2021/09/how-digital-technologies-can-address-5-sources-of-health-inequity/

Naidoo, K., Gengiah, S., Singh, S., Stillo, J., & Padayatchi, N. (2019). Quality of TB care among people living with HIV: Gaps and solutions. *Journal of Clinical Tuberculosis and Other Mycobacterial Diseases*, *17*, 100122. https://doi.org/10.1016/j.jctube.2019.100122

Naslund, J. A., Gonsalves, P. P., Gruebner, O., Pendse, S. R., Smith, S. L., Sharma, A., & Raviola, G. (2019). Digital innovations for global mental health: opportunities for data science, task sharing, and early intervention. *Current Treatment Options in Psychiatry*, *6*(4), 337–351.

National Academies of Sciences and Medicine, E. (2018). *Crossing the global quality chasm: improving health care worldwide*. National Academies Press. https://doi.org/https://doi.org/10.17226/25152

Odendaal, W., Lewin, S., McKinstry, B., Tomlinson, M., Jordaan, E., Mazinu, M., … Atkins, S. (2020). Using a mHealth system to recall and refer existing clients and refer community members with health concerns to primary healthcare facilities in South Africa: a feasibility study. *Global Health Action*, *13*(1). https://doi.org/10.1080/16549716.2020.1717410

Odendall, W., Anstey Watkins, J., Goudge, J., Leon, N., Griffiths, F., Tomlinson, M., & Daniels, K. (2020). Health workers' perceptions and experiences of using mHealth technologies to deliver primary healthcare services: a qualitative evidence synthesis. *Cochrane Database of Systematic Reviews*, (3). https://doi.org/10.1002/14651858.CD011942.pub2.www.cochranelibrary.com

Ojo, A. I. (2018). mHealth Interventions in South Africa: A Review. *Sarah and George (SAGE) Open*, *8*(1), 2158244018767223. https://doi.org/10.1177/2158244018767223

Olu, O., Muneene, D., Bataringaya, J. E., Nahimana, M. R., Ba, H., Turgeon, Y., … Dovlo, D. (2019). How Can Digital Health Technologies Contribute to Sustainable Attainment of

Universal Health Coverage in Africa? A Perspective. *Frontiers in Public Health*, *7*(November), 1–7. https://doi.org/10.3389/fpubh.2019.00341

Orton, M., Agarwal, S., Muhoza, P., Vasudevan, L., & Vu, A. (2018). Strengthening delivery of health services using digital devices. *Global Health: Science and Practice*, *6*(Supplement 1), S61–S71.

Osei, E., Kuupiel, D., Vezi, P. N., & Mashamba-Thompson, T. P. (2021). Mapping evidence of mobile health technologies for disease diagnosis and treatment support by health workers in sub-Saharan Africa: a scoping review. *Bio Medical Central Medical Informatics and Decision Making*, *21*(1), 1–18. https://doi.org/10.1186/s12911-020-01381-x

PEPFAR. (2022). Global HIV / AIDS Organizations. Retrieved from https://www.hiv.gov/federal-response/pepfar-global-aids/global-hiv-aids-organizations

Peters, M., Godfrey, C., Khalil, H., & McInerney, P. (2015). Guidance for conducting systematic scoping reviews. *International Journal of Evidence-Based Healthcare*, *13*(3), 141–146. https://doi.org/10.1097/XEB.0000000000000050

Philbrick, W. (2012). *mHealth and MNCH: state of the evidence*.

Popay, J., Roberts, H., Sowden, A., Petticrew, M., Arai, L., Rodgers, M., … Duffy, S. (2006). Guidance on the Conduct of Narrative Synthesis in Systematic Reviews. *Economic and Social Research Council Methods Programme*. https://doi.org/10.1001/archderm.1985.01660090059014

Potty, R. S., Kumarasamy, K., Adepu, R., Reddy, R. C., Singarajipura, A., Siddappa, P. B., … Washington, R. (2021). Community health workers augment the cascade of TB detection to care in urban slums of two metro cities in India. *Journal of Global Health*, *11*, 1–15. https://doi.org/10.7189/JOGH.11.04042

Principles of Digital Development. (2022). Digital Principles Maturity Matrix for Program Design and Proposal Evaluation. Retrieved 20 October 2022, from https://digitalprinciples.org/wp-

content/uploads/dial -principles_maturity-matrix- user-guide_v1 .0-.pdf

Raviola, G., Naslund, J. A., Smith, S. L., & Patel, V. (2019). Innovative models in mental health delivery systems: task sharing care with non-specialist providers to close the mental health treatment gap. *Current Psychiatry Reports*, *21*(6), 1–13.

Shapiro, A. E. (2018). Extending the reach of integrated TB-HIV services with community health workers. *Public Health Action*, *8*(2), 32–33. https://doi.org/10.5588/pha.18.0036

Siddaway, A. P., Wood, A. M., & Hedges, L. V. (2019). *How to Do a Systematic Review: A Best Practice Guide for Conducting and Reporting Narrative Reviews, Meta-Analyses, and Meta-Syntheses*. *Annual Review of Psychology* (Vol. 70). https://doi.org/10.1146/annurev-psych-010418-102803

Soobiah, C., Cooper, M., Kishimoto, V., Bhatia, R. S., Scott, T., Maloney, S., … Desveaux, L. (2020). Identifying optimal frameworks to implement or evaluate digital health interventions: a scoping review protocol. *British Medical Journal*, *10*(8), e037643. https://doi.org/10.1136/bmjopen-2020-037643

Southern African Development Community. (2021). Southern African Development Community: SADC Facts & Figures. Retrieved from http://www.sadc.int/about-sadc/overview/sadc-facts-figures/

Southern African Development Community (SADC). (2020). Southern African Communicable Diseases 2020. Retrieved 15 September 2022, from https://www.sadc.int/pillars/communicable-diseases

Stahl, M., Roth, S., & Mellor, S. (2015). Digital health Terminology Guide. *Requirements Engineering for Digital Health*, 1–23. https://doi.org/10.1007/978-3-319-09798-5_1

Stone, A. (2020). Measuring Frontline Workers' Connectivity While Using Mobile Applications. Retrieved from https://lib.digitalsquare.io/handle/123456789/77226

Stroetmann, K. (2018). *Digital Health Ecosystem for African countries*. Berlin.

Sundin, P., Callan, J., & Mehta, K. (2016). Why do entrepreneurial mHealth ventures in the developing world fail to scale? *Journal of Medical Engineering and Technology*, *40*(7–8), 444–457. https://doi.org/10.1080/03091902.2016.1213901

Suri, H. (2020). *Systematic Reviews in Educational Research*. *Systematic Reviews in Educational Research*. Springer Fachmedien Wiesbaden. https://doi.org/10.1007/978-3-658-27602-7

Swartz, A., LeFevre, A. E., Perera, S., Kinney, M. V., & George, A. S. (2021). Multiple pathways to scaling up and sustainability: an exploration of digital health solutions in South Africa. *Globalization and Health*, *17*(1), 1–13. https://doi.org/10.1186/s12992-021-00716-1

Tait, J., & Banda, G. (2016). Proportionate and Adaptive Governance of Innovative Technologies: the Role of Regulations, Guidelines and Standards. *British Standards Institution*, 11.

Tambo, E., Madjou, G., Mbous, Y., Olalubi, O. A., Yah, C., & Adedeji, A. A. (2016). Digital health implications in health systems in Africa. *European Journal of Pharmaceutical and Medical Research*, *91*(1), 91–93.

Tan, G. (2022). The role of technology in improving health system resiliency. Retrieved 28 September 2022, from https://blogs.oracle.com/healthcare/post/the-role-of-technology-in-improving-health-system-resiliency

Taylor, R., & Alper, J. (2018). *Using technology to advance global health: proceedings of a workshop*. (T. N. A. Press, Ed.). Washington, DC: National Academies Press. https://doi.org/https://doi.org/10.17226/24882.

The Global Fund. (2021). Global Fund Strategy 2023-2028, 1–71. Retrieved from https://www.theglobalfund.org/media/11612/strategy_globalfund2023-2028_narrative_en.pdf

The Johanna Briggs Institute. (2015). The Joanna Briggs Institute Reviewers' Manual 2015: Methodology for JBI scoping reviews. *Joanna Briggs Institute*. Adelaide. https://doi.org/10.1017/CBO9781107415324.004

Thomas, A., Lubarsky, S., Varpio, L., Durning, S. J., & Young, M. E. (2020). Scoping reviews in

health professions education : challenges , considerations and lessons learned about epistemology and methodology. *Advances in Health Sciences Education*, *25*(4), 989–1002. https://doi.org/10.1007/s10459-019-09932-2

Tran Ngoc, C., Bigirimana, N., Muneene, D., Bataringaya, J. E., Barango, P., Eskandar, H., … Olu, O. (2018). Conclusions of the digital health hub of the Transform Africa Summit (2018): Strong government leadership and public-private-partnerships are key prerequisites for sustainable scale up of digital health in Africa. *Bio Medical Central Proceedings*, *12*(Suppl 11), 1–7. https://doi.org/10.1186/s12919-018-0156-3

Tricco, A. C., Lillie, E., Zarin, W., Brien, K. O., Colquhoun, H., Kastner, M., … Straus, S. E. (2016). A scoping review on the conduct and reporting of scoping reviews. *Bio Medical Central Medical Research Methodology*, 1–10. https://doi.org/10.1186/s12874-016-0116-4

UN Secretary-General's High-level Panel on Digital Cooperation. (2019). The Age of Digital Interdependence. *Digital Cooperation*, (June), 60. Retrieved from https://digitalcooperation.org/panel-launches-report-recommendations/

United Nations. (2015). 2030 Agenda for sustainable development. *Arsenic Research and Global Sustainability - Proceedings of the 6th International Congress on Arsenic in the Environment, AS 2016*, 12–14. https://doi.org/10.1201/b20466-7

United Nations Programme on HIV/AIDS. (2021a). *UNAIDS Data 2021*. Geneva. Retrieved from https://www.unaids.org/sites/default/files/media_asset/JC3032_AIDS_Data_book_2021_En.pdf

United Nations Programme on HIV/AIDS. (2021b). *UNAIDS Global AIDS strategy 2021-2026*. Geneva. Retrieved from https://www.unaids.org/sites/default/files/media_asset/global-AIDS-strategy-2021-2026_en.pdf

Vesel, L., Hipgrave, D., Dowden, J., & Kariuki, W. (2015). Application of mHealth to improve service delivery and health outcomes: Opportunities and challenges. *Etude de La Population Africaine*, *29*(1), 1683–1698. https://doi.org/10.11564/29-1-718

White, A., Thomas, S. . D., Ezeanochie, N., & Bull, S. (2016). Health Worker mHealth Utilization: A Systematic Review. *Physiology & Behavior*, *176*(1), 100–106. https://doi.org/10.1097/CIN.0000000000000231.Health

Winters, N., Langer, L., & Geniets, A. (2018). Scoping review assessing the evidence used to support the adoption of mobile health (mHealth) technologies for the education and training of community health workers (CHWs) in low-income and middle-income countries. *British Medical Journal Open*, *8*(7), 1–10. https://doi.org/10.1136/bmjopen-2017-019827

World Health Organisation. (2015a). *Digital Health for the End TB Strategy: an Agenda for Action*. *World Health Organization*. Retrieved from https://www.who.int/cancer/en/

World Health Organisation. (2015b). *The MAPS Toolkit*. Geneva. Retrieved from http://www.mobilemamaalliance.org/sites/default/files/9789241509510_eng.pdf

World Health Organisation. (2017). *Fact sheet on Sustainable Development Goals (SDGs): Health Targets (TB)*. *Lancet (London, England)* (Vol. 381). Copenhagen. Retrieved from http://www.ncbi.nlm.nih.gov/pubmed/23683634

World Health Organisation. (2018). *WHO classification of digital health interventions (DHIs)*. *Research for Impact* (Vol. 1). Retrieved from https://apps.who.int/iris/bitstream/handle/10665/260480/WHO-RHR-18.06-eng.pdf

World Health Organisation. (2020). *Global Strategy on Digital Health 2020 -2025* (Vol. 57). https://doi.org/10.1007/s13312-020-1789-7

World Health Organisation. (2021). Global Tuberculosis profile. Retrieved 27 September 2022, from https://worldhealthorg.shinyapps.io/tb_profiles/?_inputs_&lan=%22EN%22&entity_type=%22group%22&group_code=%22global

World Health Organization. (2018). WHO guideline on health policy and system support to optimize community health worker programmes. Geneva: World Health Organisation. Retrieved from https://www.who.int/publications/i/item/9789241550369

World Health Organization. (2020). *Health policy and system support to optimize community health worker programmes for HIV , TB and malaria services : an evidence guide*. Geneva. Retrieved from https://apps.who.int/iris/bitstream/handle/10665/340078/9789240018082-eng.pdf?sequence=1&isAllowed=y

World Health Organization. (2019). Universal health coverage (UHC) Key Facts. *World Health Organization*, 1–5. Retrieved from https://www.who.int/news-room/fact-sheets/detail/universal-health-coverage-(uhc)

World Health Organization. (2022). HIV Mortality SADC 2021, 2022. Retrieved from https://www.who.int/data/gho/data/indicators/indicator-details/GHO/number-of-deaths-due-to-hiv-aids

Yamada, J., Shorkey, A., Barwick, M., Widger, K., & Stevens, B. J. (2015). The effectiveness of toolkits as knowledge translation strategies for integrating evidence into clinical care: A systematic review. *British Medical Journal Open*, *5*(4). https://doi.org/10.1136/bmjopen-2014-006808

Appendix

1. Ethics Approval from UWC

UNIVERSITY of the WESTERN CAPE

60 YEARS of hope, action & knowledge

08 June 2021

Ms M Govender
School of Public Health
Faculty of Community and Health Sciences

Ethics Reference Number: BM21/4/2

Project Title: Digital health applications used by community health workers for the management of the Human Immunodeficiency virus and tuberculosis in the Southern African Development region: A scoping review on the factors that influence success and failure.

Approval Period: 14 May 2021 –14 May 2024

I hereby certify that the Biomedical Science Research Ethics Committee of the University of the Western Cape approved the scientific methodology and ethics of the above mentioned research project.

Any amendments, extension or other modifications to the protocol must be submitted to the Ethics Committee for approval.

Please remember to submit a progress report annually by 30 November for the duration of the project.

Permission to conduct the study must be submitted to BMREC for record-keeping.

The Committee must be informed of any serious adverse event and/or termination of the study.

Ms Patricia Josias
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