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UNIVERSITY OF THE
WITWATERSRAND,
JOHANNESBURG

Implementation of a mobile health application used by community health workers in Ekurhuleni Health District

Dr Yarumia Ndombi

Supervisors: Professor Leena Thomas, Dr Harsha Somaroo

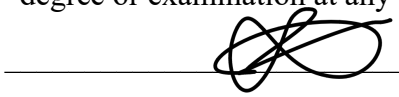
A Research Report submitted to the Faculty of Health Sciences, University of the Witwatersrand,

in partial fulfilment of the requirements for the Degree of Master of Medicine in Community Health.

August 2024

Declaration

I, Yarumia Ndombi declare that this Thesis/Dissertation/Research Report is my own, unaided work. It is being submitted for the Degree of Master of Medicine in Community Health.at the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at any other University.



(Signature of candidate)

7th day of February 2025 in Pretoria

Dedication

In loving memory of my mother,

Dana Masta

1957 – 2021

Presentations arising from this research report

1. Ekurhuleni Health District Research Conference, November 2024.

Abstract

Background: The introduction of digital technology into the health sector began globally in the early 2000s, revolutionizing healthcare delivery and management. In 2017, the Ekurhuleni Health District was chosen as a national pilot site for the CommCare mobile health application, intended for Community Health Workers (CHWs) and Outreach Team Leaders (OTLs) within ward-based primary healthcare outreach teams. Despite the promise of digital health interventions, challenges in scaling and sustainability persist globally and nationally. This study assesses the experiences of end-users and key stakeholders in implementing CommCare over a five-year period in Ekurhuleni.

Methods: A mixed methods cross-sectional descriptive study was conducted in the Ekurhuleni Health District. Data were collected through semi-structured interviews with seven key informants and an online self-administered questionnaire distributed to 1,197 CHWs and OTLs. Quantitative data were analysed descriptively, while qualitative data underwent thematic analysis using Atlas.ti.

Results: Out of 1,197 end-users, 39% (n=464) participated in the study. Most participants (83%) reported that CommCare met their expectations, with 85% expressing overall satisfaction, and 95% recommended its adoption in other districts. However, 35% encountered challenges including connectivity issues, difficulties with data management, and technological problems like app freezing or hardware malfunctions. Key informants identified logistical challenges in training, particularly in sourcing suitable venues. The diverse ages and educational backgrounds of the CHWs created challenges but pairing them helped bridge learning gaps. Asset management was a significant issue, with frequent device losses prompting the enforcement of a provincial policy to hold CHWs accountable. The cascade model of training was successful and highlighted as a best practice. They also emphasized the need for dedicated technical teams, multi-stakeholder engagement, improved ICT infrastructure, long-term planning, and ongoing technical support.

Conclusions: The implementation of the CommCare app in Ekurhuleni was generally successful, with high end-user satisfaction. Stakeholder feedback highlighted the importance of robust planning, investment in ICT infrastructure, and multi-stakeholder engagement for future digital health interventions. Evaluating existing programs and understanding the factors that contribute to their success will be essential for guiding the scale-up and sustainability of future digital health initiatives.

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1.1 Introduction

The Digital Health Global Strategy, 2020-2025 of the World Health Organization (WHO) defines digital health as "the field of knowledge and practice associated with any aspect of adopting digital technologies to improve health, from inception to operation (1)." Digital health is rooted and builds on the previous WHO concept of eHealth which was defined as, "the use of Information and Communication Technologies (ICT) for health to treat patients, pursue research, educate students, track disease and monitor public health (2)."

Mobile health (mHealth) is an area of eHealth that is defined by the WHO, as the use of portable electronic devices with software applications to provide health services and manage patient information (3).

The following sections will provide a background for digital health and mHealth within the global and national contexts, that are pertinent to this study.

1.1.1 Global context of digital health

The introduction of digital technology into the health sector began globally in the early 2000s (4). An increased emphasis accompanied this on investment in digital health interventions in lower- and middle-income countries. This investment intended to improve health system outcomes, as findings from short-term evaluations of digital health interventions have proven to have positive impacts on health (4,5).

The Digital Health Global Strategy, 2020-2025 emphasizes the importance of the role of digital technologies in the advancement of the Sustainable Developmental Goals. Digital technologies have the potential to support health systems through health promotion, disease prevention as well as access and storage of data (1).

During the seventy-first World Health Assembly in 2018 where the report Resolution on Digital Health was drafted, mHealth was emphasised as an important avenue for health service delivery and public health (5). According to the International Telecommunication Union, in 2023, 78% of the global population over the age of ten own a mobile phone. (6). Through the increased use of digital technology mHealth has been identified as having the potential to: (i) increase access to quality health services; (ii) increase access to sexual and reproductive health services; (iii) reduce mortality from noncommunicable diseases and noncommunicable disease comorbidities; (iv) increase global health security; and lastly (v) increase safety and quality of care (5).

1.1.2 National context of digital health

In 2018, during his first State of the Nation address, President Cyril Ramaphosa incorporated the phrase the 'Fourth Industrial Revolution' (4IR) into his economic policy statement, stating that our prosperity as a nation would be dependent on our ability to take full advantage of rapid technological change (7). 4IR is a term that was popularized in 2015 by Professor Klaus Schwab, Founder and Executive Chairman of the World Economic Forum who explained that one of the characteristics of the range of new technologies is that they will impact all disciplines (8). It consists of a fusion of interconnected technologies whose systems are interdependent (9)

In response to the report Seventy-First World Health Assembly Resolution on Digital Health that was adopted in 2018 by the WHO, South Africa formulated the National Digital Health

Strategy for South Africa, 2019 – 2024 (2,10). The overarching vision of this strategy is to enhance the well-being of all South Africans through a person-centric approach to digital health. This means prioritizing individuals such as patients, healthcare professionals and members of management by addressing their diverse needs. Its mission is to construct a unified digital health ecosystem that harmonizes people, processes, and technology for the eventual realisation of Universal Health Coverage within the context of the National Health Insurance Fund (NHIF) (2).

1.1.3 Digital Health Implementation Challenges

Numerous challenges have been identified globally and nationally that hinder the success of digital health interventions. In South Africa, these include a lack of collaboration between government departments and private sectors such as the Department of Health and ICT or mobile service providers. A multitude of pilot projects in existence lack well-defined plans or processes for scaling up. There is also a lack of standards and tools to assess the functionality, value and scalability of digital health interventions (5).

Nationally there have been numerous obstacles such as insufficient investment in digital health and failure to obtain value for money on systems procured and implemented. Broadband connectivity, network infrastructure and cybersecurity have led to high market-driven costs. Additionally, there is also the concern of inadequate ICT infrastructure and lack of interoperability (2).

These difficulties have been identified in the National Digital Health Strategy for South Africa, 2019-2024. The strategy explicitly underscores its commitment to addressing these issues by giving priority to strengthening governance structures and formulating relevant national legislation and policies, developing leadership and technical capacity, establishing integrated platforms, and collaborating with other government departments to set up broadband network infrastructure (2).

In response to the issue of insufficient interoperability among current health information systems and digital health applications, the National Health Normative Standards Framework for Interoperability in eHealth in South Africa, spanning from 2012 to 2016, was formulated. Its objective is to establish a foundation for the prospective integration of digital health interventions, particularly envisioning a unified health information system post the implementation of the NHIF (11).

1.1.4 Existing digital health interventions within the South African context

Despite these difficulties, there are digital health interventions that have reached national scale such as MomConnect; a direct-to-consumer maternal messaging and feedback service. The Perinatal Problem Identification Programme (PPIP) and Child Healthcare Problem Identification Programme (Child PIP) are mortality audit reporting and visualisation tools (12). A further review of digital health interventions that have been implemented within South Africa and the African continent will be explored within the literature review.

1.1.5 The use of digital health interventions during the Covid-19 global pandemic

The Covid-19 pandemic which started in December 2019 further cemented the position of digital health globally. During this time various countries implemented a variety of digital health interventions to curb the transmission of Covid-19 (13). In countries with a high prevalence of Covid-19 such as China and the USA, the predominant digital health interventions included telemedicine consultations, followed by geographic information systems and mobile systems for self-care and patient tracking (13).

During this time in South Africa, COVID-19 related information was disseminated through various channels, including the Covid-19 Connect WhatsApp helpline and multiple social media platforms. Disease surveillance, particularly contact tracing, was conducted using an application called Covi-ID. Comprehensive databases like DatCov and the Electronic Vaccination Data System (EVDS) provided information regarding daily hospital admissions, deaths, and monitoring the uptake of COVID-19 vaccinations respectively (14,15).

1.2 Background

The Ekurhuleni Health District, which is divided into three sub-districts, is positioned along the eastern borders of Gauteng province. It is one of the three metropolitan districts within the economic hub of South Africa (16,17). Similar to the rest of South Africa Ekurhuleni has a quadruple burden of disease and is made up of a population of approximately four million people (17,18).

Ward Based Primary Health Care Outreach Teams (WBPHCOT) were introduced as part of the national Primary Health Care Re-engineering strategy between 2010 and 2011 to reprioritize and reorganize primary health care and district health services. The multifaceted strategy also includes Integrated School Health Services and District Clinical Specialist Teams (18).

1.2.1 The introduction of CommCare

In 2017 the Ekurhuleni Health District was identified as a national pilot site to test a mobile health application to be used by the Community Health Workers (CHWs) in the ward-based primary health care outreach teams. This digital health technology was called CommCare. The district support partner at the time of the introduction of CommCare was Aurum, a not-for-profit health research organization founded in 2005 by Anglo Ashanti Gold (19). Aurum was contracted by the National Department of Health (NDOH) to support the Ekurhuleni Health District in developing the CommCare application for use by the WBPHCOTs. Aurum subcontracted a social enterprise and software development company called Dimagi to assist in the software development process. CommCare is an open-source, cloud-based platform developed by Dimagi (20). Organizations can customize CommCare so it can be used to support data collection, track activity and behavior change and provide diagnostic support tools. It is currently being used in over 2000 projects and 80 countries worldwide (21).

The use of CommCare was initially proposed by the National Department of Health as a pilot project for WBPHCOTs to be run over one year with a long-term goal of national scale-up. However, through an agreement with the Ekurhuleni Health District and its district support partner Aurum, this project was extended to five years, from 2017 to 2022. Aurum also

subcontracted another IT services company called CosmoNet over this period to maintain internet connectivity and hardware of all the mobile gadgets used in Ekurhuleni (Motshele P, 2022, personal communication, September 27).

A cascade model of work integrated learning and training was used to teach the WBPHCOTs on how to use the CommCare application as part of the mHealth project rollout. (Ramabale T, 2023, personal communication, November 23). It involves a stepwise learning approach (22), where master trainers, consisting of sub-district coordinators and a few OTLs, are trained first. These master trainers then train the rest of the OTLs who go on to train smaller groups of CHWs and facility users. This cascaded model of training is also referred to as a train the trainer approach(23) .

Before 2017, collection of data by the CHWs was mainly paper based (Motshele P, 2022, personal communication, September 27). The CommCare app was developed as a data capture and decision-support application to be utilized by CHWs during their community and household visits (12). The stored data was later aggregated and fed into the District Health Information System (DHIS). Through digital tracking of patients, CHWs follow up on the health status and services received by clients (Motshele P, 2022, personal communication, September 27).

1.2.2 Roles and Responsibilities within the WBPHCOT and District Support Partners for the Implementation of CommCare

WBPHCOT

As outlined in the Policy Framework and Strategy for WBPHCOT, 2018/19 – 2023/24, each team, linked to a health facility or clinic, ideally should be composed of six to ten CHWs, one Outreach Team Leader (OTL) who is an enrolled nurse, and a data capturer (24). These teams are tasked with overseeing about 6000 individuals or 1500 - 2000 households each within a clinic catchment area. This implies that each community health worker is responsible for approximately 250 households (18,24). Within these households they conduct screening and referrals for pregnancy and diseases such as TB, HIV and diabetes. They also provide health education, psycho-social support and conduct tracing of people who have missed their appointments for collecting treatment. (25). In 2022, at the time of the study, the Ekurhuleni Health District had 178 WBPHCOTs consisting of only 170 OTLs who were supervising a total of 1027 CHWs. Each of the three sub-districts in Ekurhuleni had a coordinator who supervised the WBPHCOTs, and they were based at district level (Motshele P, 2022, personal communication, September 27).

The role of the WBPHCOT sub-district coordinators

At the beginning of the implementation of CommCare, the role of the WBPHCOT sub-district coordinators in Ekurhuleni was focused on training and support. They were trained as master trainers with the responsibility of facilitating the training of OTLs, CHWs and facility users. Facility users, who were identified clinic staff, had the responsibility of uploading information of clients that needed to be traced. Facility managers were also orientated on the activities and roles of the WBPHCOT for ease of collaboration. The WBPHCOT sub-district coordinators were also responsible for the mapping of CHWs for the mHealth app implementation. This activity entails documenting which OTL each CHW falls under and the facilities they are attached to. The WBPHCOT sub-district coordinators were later trained to take on the additional role of mHealth coordinators. This involved mentoring OTLs and providing ongoing

support at facilities by addressing challenges experienced by the WBPHCOTs, including technical difficulties.

The role of Ekurhuleni Health District ICT helpdesk technicians

Following the implementation of the CommCare app, two ICT helpdesk technicians at the district were trained by the developers on the CommCare application. Their role was to facilitate the installation of the app on the devices, to ensure its functionality and to make sure that the CHW or OTL could log in. They also provided technical support for malfunctioning devices and oversaw the process of booking faulty devices with the relevant manufacturers. The technicians followed up on this process by engaging with the manufacturers to update the OTLs and sub-district coordinators about whether the issue pertains to the sim card or the gadget, and whether it will be repaired or replaced. The process of updating is done via the app though a ticket logging system. Should a gadget be reported lost or stolen, they assist in obtaining sim cards provided by the provincial office and facilitate the sim swap on a new device.

The role of the district support partner: Aurum

The task of Aurum was to oversee the implementation of an mHealth application for use mainly by OTLs and CHWs in the Ekurhuleni district. This was done by subcontracting a software development company called Dimagi. The process of implementing the mobile health application involved engagements with stakeholders, endorsement, and procurement of mobile phones and data. Following continuous facilitation of meetings between the software developers, the National Department of Health and the district, they facilitated training to use the app. Monitoring the app's usage and mentoring the WBPHCOTs continued throughout the project. Aurum was also responsible for later introducing mHealth coordinators, who were trained and reimbursed by the district partner. MHealth coordinators provided technical support to users at facilities and were employed by the district support partner. When Aurum left the district, this role was taken on by the WBPHCOT sub-district coordinators. WBPHCOT sub-district coordinators already had the role of mentoring teams and could provide ongoing technical support to the WBPHCOT teams.

The role of the district support partner: Dimagi

Dimagi is a software development company that was subcontracted by Aurum to develop a mobile health application for a few pilot districts such as Ekurhuleni. Although, at the time of the pilot it was only being implemented in a few districts nationally the eventual aim was to scale up the use of CommCare app across the country. The role of Dimagi was multi-pronged as they were involved in designing the custom application as well as setting up a training program, a technical support system and procuring devices.

A brief timeline of the implementation of the CommCare mHealth project in Ekurhuleni over the 5 years is illustrated in Figure 1 below.

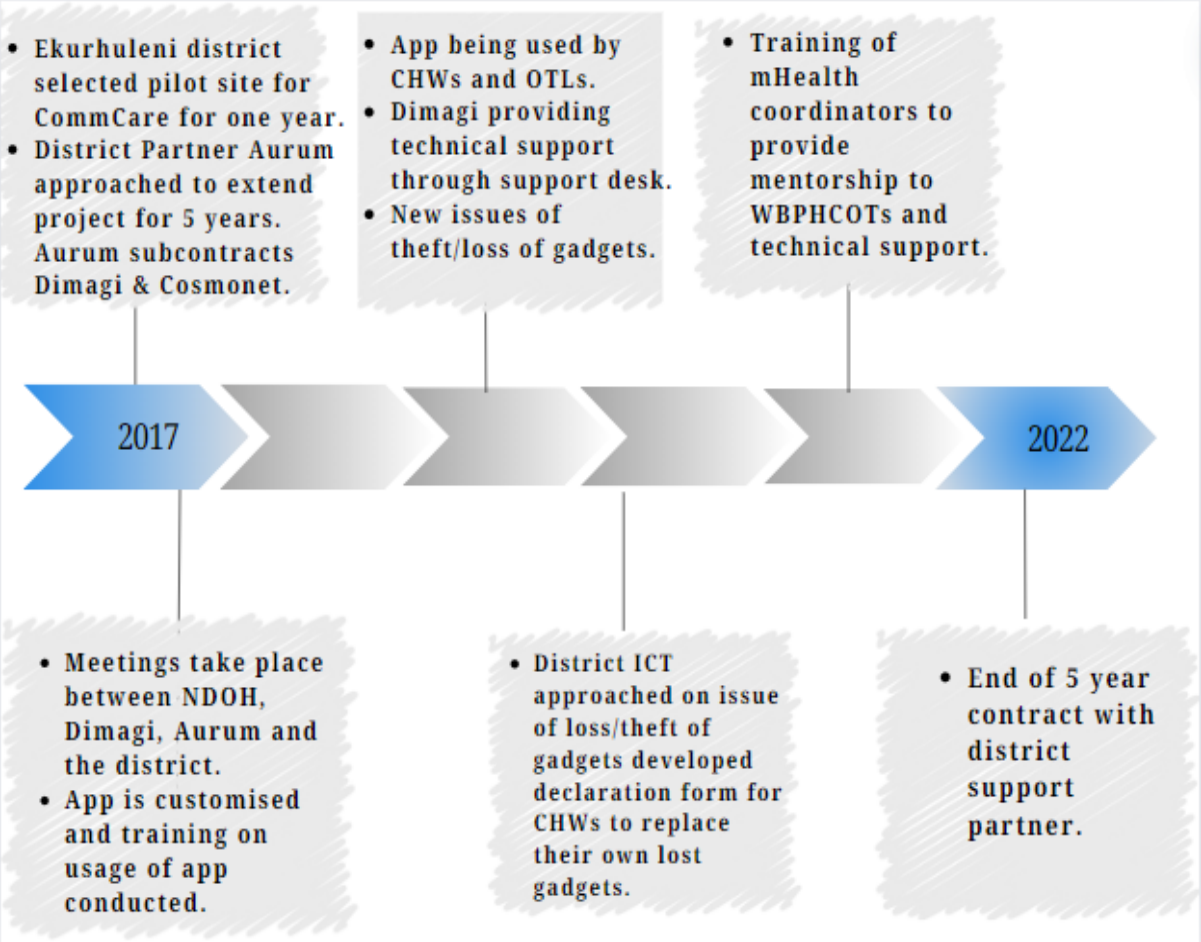

Figure 1 Timeline of implementation of CommCare mHealth project in Ekurhuleni from 2017 - 2022

With the increased use of digital health interventions nationally and sub-nationally, it's important to evaluate existing interventions and analyse the facilitating factors that have sustained them to guide the implementation of new ones. This will help strengthen positive factors that contribute to scaling up and sustainability, while also enabling better resolution or workaround of potential barriers to implementation (12).

1.3 Literature review

The selected published peer-reviewed journal articles that will be reviewed were searched for on PubMed and Google Scholar electronic databases. Literature searching was based on the following search terms, “Digital health intervention” OR “Digital health solutions” OR “mHealth” OR “Implementation” OR “Lessons learned” OR “Community health workers” OR “CommCare” OR “District” OR “Sub-Saharan Africa” OR “South Africa.” The readings were then selected based on relevant titles, abstracts, full text and having been conducted within the last 10 years. This timeframe was selected due to an evolving technological landscape which may lead to outdated older articles regarding the topic. Relevant guidelines and strategic frameworks were sourced from the World Health Organization (WHO) websites.

The literature review is organized to examine established global guidelines and strategic frameworks, as well as the conceptual frameworks employed in implementing digital health interventions. This was done for the purpose of the informing the study design and methodology. It also explores existing mHealth applications in Sub-Saharan Africa, with a specific focus on literature surrounding CommCare.

1.3.1 Conceptual Frameworks

Developing a complex health intervention involves gaining a thorough understanding of the environment and considering the perspectives of various stakeholders (26). It's important to keep in mind that the complexity of a digital health intervention may not be due to the technology being introduced, but rather due to the health system it is being implemented in. (27).

The Technological-Organizational-Environmental Framework (TOE) is an organizational-level theory that explains three critical elements within an institution’s context that influence its adoption of new interventions. It has been used in multiple sectors including healthcare. The first pillar is the technological context of the organization. This is an analysis of the existing technologies within the organization and their capabilities and whether the intervention in question is a completely new innovation or an extension of the existing infrastructure and what changes need to be made to adopt the new technology. The second pillar is the Organizational context, which is a description of the organizational structure and culture, its size and the resources available. The last pillar is the environmental context which looks at factors external to the organization such as legislative frameworks, the outside market and socio-cultural influence. It is a versatile framework in that one can manipulate the factors looked at under each heading as per the sector one is researching (28).

The Technology Acceptance Model (TAM) is a conceptual framework that aims to explain and predict how users accept and use technology. Developed by Fred Davis in 1985, TAM is rooted in the theories of reasoned action and planned behaviour but introduces key modifications to better fit the context of technology acceptance. The conceptual model is based on three main pillars: the system's features and capabilities, the user's motivation and a measurable outcome of system use. The user's motivation can be explained by three factors: (i) Perceived usefulness: This refers to the user's belief that using a particular technology will enhance their performance or make their tasks easier. The perceived usefulness of a technology significantly influences the user's attitude towards using it. (ii) Perceived ease of use: This component reflects the user's perception of how easy or difficult it is to use the technology. A technology that is perceived as

easy to use is more likely to be accepted and adopted by users. (iii) Behavioural intention: This component represents the user's intention to use a technology based on their attitudes and perceptions of usefulness and ease of use. Behavioural intention is a key determinant of actual technology usage. The Technology Acceptance Model provides a structured approach to understanding the factors that influence users' acceptance and adoption of technology. By focusing on perceived usefulness, perceived ease of use, attitudes, intentions, and actual use, TAM helps researchers and practitioners predict and explain user behaviour towards technology (29)

The Expectation-Confirmation Theory is a marketing theory to measure the perceived usefulness and satisfaction of the end user following the use of the product. It measures whether the product met their pre-conceived expectations and whether they were satisfied with it during its consumption by measuring its performance and it lastly measures the consumers repurchase intention (28).

The Non-adoption, Abandonment, Scale-up, Spread, and Sustainability (NASSS) framework developed in 2019 at the university of Sydney, Australia for studying the non-adoption and abandonment of digital health solutions by individuals and the challenges to scale-up, spread and sustain can be used to map out possible areas of complexity in the planning, analysing and implementation of a digital health solutions. It analyses seven different domains, the disease/condition, technology, value proposition, adopters, organisation, wider system, and environment such as the political context as well as the scope of adaptation of the digital solution and its ability to be embedded within the health system. The authors relay that the complexity of these domains should be assessed using quantitative and qualitative data to provide a richly described case study and that programs with domains that can be classified as simple have a higher probability of being successful and vice versa. Because complexity tends to be inherent in healthcare systems the key recommendations should be in developing ways to work within complexity rather than seeking to eliminate it. While published studies on the application of the NASSS Framework are limited it provides a comprehensive analysis of digital health solutions implemented within the public health sector (27).

For the purposes of this report elements of each of these conceptual frameworks will be used to analyse components of the system such as the organization and environment giving context to the setting in which the application will be introduced. Next, determining the application itself and technological readiness in terms of the infrastructure and support already in place. Lastly, looking at the end-users regarding their perceived usefulness and satisfaction with the digital health intervention. To attain this information various stakeholders will have to be identified at district, sub-district and facility level.

1.3.2 Global Guidelines and Strategic Frameworks on Digital Interventions

In 2019, the World Health Organization (WHO) released a comprehensive guideline titled "Guideline on Recommendations on Digital Interventions for Health System Strengthening." This guideline delves into the crucial role that digital health interventions can play in the strengthening of healthcare systems and achieving universal health coverage. According to the guideline, it is imperative to have a realistic understanding of the extent to which digital interventions can address healthcare system challenges. Additionally, it emphasizes the

importance of considering the environment in which the intervention is being introduced to ensure its sustainability. It recommends the use of an app that provides healthcare worker decision support and digital tracking of clients' health status and services if accessed via a mobile device for community and facility-based health workers. However, it stresses that the health system must support the implementation of the digital health solution in an integrated manner for optimal results (30).

The Guideline on Recommendations for Digital Interventions for Health System Strengthening was designed to be used along with the Digital Implementation Investment Guide (DIIG), which was published by WHO in 2020. This guidebook outlines the process from building a relevant stakeholder team, to conducting a situational analysis, identifying challenges in the healthcare system, and choosing suitable digital interventions. During the situational analysis, the guideline references the WHO Digital Health Atlas, a global directory of digital health interventions. The guidelines then explain how to implement a digital health intervention. It emphasizes creating a monitoring and evaluation plan, testing with sustainability in mind, and assessing the technological ecosystem's capability (31).

To assess whether a digital health intervention can be scaled up, in 2015 the WHO developed an mHealth Assessment and Planning for Scale (MAPS) Toolkit which is designed specifically for project managers and project teams to conduct a comprehensive self-assessment. It allows the users to track the progress of the digital health intervention as it evolves increasing its potential for scaling up and achieving sustainability. The Toolkit covers six areas: Groundwork, Partnerships, Financial health, Technology & architecture, Operations, and Monitoring & evaluation. The toolkit consists of point-based checklists, and while it is a useful technical tool, it may not account for varying opinions. There is also a limitation of which stakeholders can be involved in the assessment. It is also limited to aspects of scaling up and sustainability and does not cover the psychological and sociological aspects of the proposed end-users (4).

1.3.3 Research on CommCare

In India in 2015 a study was conducted among CHWs assessing whether a mobile health application, CommCare, affected the quality and experience of maternal and new-born care provided by CHWs, depending on their level of technology adoption and the individual characteristics of the CHW. The level of technology adoption was determined by their age, literacy and education. The cross-sectional study involved 15 CHWs and involved the use of three quantitative data collection tools assessing the quality of the consultation, demographics of the CHW and lastly a checklist to document the proficiency of use of CommCare. Three CHWs did not use the mobile application as comparators. The results showed that mobile health applications positively affect the quality and experience of care. The CHWs who were literate and more educated had increased proficiency in using the mobile health application. Age was found to affect app proficiency negatively. There were multiple limitations to the study with it having a small sample size and even smaller comparator group and a major conflict of interest being that the researchers were employed by Dimagi who developed CommCare (32).

Over the past 25 years Senegal has experienced a very high national maternal mortality ratio at 315 deaths per 100 000 live births. CommCare was introduced among CHWs in 2014 to reduce maternal mortality. CHWs registered pregnant women, stored their health and contact information, reminded them about appointments, and provided health education. A qualitative

study was conducted between January 2016 and May 2018 to identify the key social and cultural contextual factors that contribute to the uptake of the application. The study involved 62 participants, including Non-Governmental Organization (NGO) field staff, physicians, nurses, midwives, CHWs, and women who participated in the maternal community support groups. It consisted of focus group discussions, semi-structured interviews and open-ended interviews. The key findings that contributed to the successful use of the application were the long-standing history of women's associations in the country which had a positive impact on attendance and participation in care groups. Early disclosure of pregnancy which is traditionally frowned upon was enabled through The Care Group intervention through women discreetly signalling their pregnancy status. This mechanism facilitates timely access to maternal health services and support. Harnessing the power of older women within the society instead of treating them as carriers of misinformation, was done by involving them in the maternal health support system. The CommCare application served as a valuable tool for offering guidance on maternal health protocols, tracking pregnancies, providing reminders for antenatal care visits, and facilitating data collection for monitoring and evaluation. It enhanced communication between CHWs and pregnant women by enabling timely and accurate information sharing. The CHWs were able to monitor the progress of pregnant women more effectively, ensuring that they receive appropriate care throughout their pregnancy, during childbirth, and in the postpartum period. By utilizing the CommCare application, the professional status and credibility of the CHWs within the community was enhanced. And overall, it had a positive impact on how CHWs were perceived. Mobile phone usage is widespread in Senegal, including rural areas, where a majority of the population owns or can use a mobile phone. They also benefit from extensive Wi-Fi coverage which was reported as a positive contextual factor. Another point raised in the study is the underreporting in literature of the social and cultural factors that shape the context in which digital health interventions are being implemented. As the perceptions and cultures of different communities in the form of gender, age and experiences of women can also play a role in the uptake and successful scale-up of digital health interventions, as seen in this study (33).

CommCare can also be used by health researchers for electronic data collection as fieldworkers prefer electronic data collection applications over paper-based systems. In a qualitative, cross-sectional study conducted in Mchinji district in Malawi, researchers who were using four different data collection applications amongst four different research projects compared three other apps with CommCare which was being used in two out of four of the projects. Data was gathered from project managers and developers who responded to open semi-structured questionnaires. The results indicated that certain features of the CommCare application, such as built-in skip features, user-friendly web interface for form development, and technical support, were positively received. However, it was noted that the application's limitations included the requirement for internet access to complete certain actions. (34).

In 2014 a cross-sectional study using mixed methods was conducted in South Africa looking at cardiovascular disease (CVD) risk assessment that is carried out by CHWs during home visits. The aim of the study was to compare the impact on CHW training and duration of screening for CVD screening by CHWs when using an mHealth application (CommCare) versus a paper-based system. The study included 24 Community Health Workers (CHWs) who were randomly assigned to either use the app or the paper-based system. Training times and screening times were recorded and focus group discussions were conducted to compare both

systems. Out of the 537 people screened, it took 14 minutes less when using the mHealth application. The training time for using the application was 3 hours, compared to the 12 hours it took to train the CHWs on the paper-based tool.

Further studies performed in various developing countries such as Guatemala and Peru all looked at CommCare for a specific health intervention and disease, yielding positive results such as improved data quality and the appropriate management of chronic disease (35,36).

Research on CommCare shows how it can optimize the performance of community health workers (CHWs), increase data quality, and improve healthcare delivery. The identified elements influencing adoption and effectiveness include technological literacy, education levels, social and cultural contexts, and internet connectivity.

Limited local studies have been conducted in South Africa regarding the implementation of CommCare, with little to no focus on the utilization of the mobile application in all of the reviewed literature.

1.3.4 Implementation of Digital Solutions/Mobile Health Applications in Africa

In 2020, a study was conducted in South Africa's North-West Province to understand users' views and experiences of using a mHealth application called Mobenzi. The study focused on Community Health Workers (CHWs) and Operational Team Leaders (OTLs) within a selected sub-district. The research involved semi-structured interviews and two focus group discussions with twenty-four CHWs and four OTLs. The findings revealed that CHWs found the mHealth application useful and easy to use, supporting their workflow. However, they faced challenges with technical support and expressed dissatisfaction with reverting to a paper-based system after the application was terminated. OTLs were concerned about the quality of data collected through the paper-based system and emphasized the critical support provided by the application in monitoring CHWs' activities. The study concluded that community-based healthcare programs using mobile health applications are crucial for strengthening the healthcare system (37).

A study published in 2021 in Uganda using semi-structured interviews with three health facility administrators and focus group discussions with twenty-eight health care workers (doctors and nurses) was conducted to assess health workers' perceptions of the acceptability, usability and feasibility of a novel mHealth application called ALRITE, that would help frontline health workers diagnose, treat and provide education about Acute Lower Respiratory Infection in children <5 years. It grouped the findings impacting the potential implementation of the application into Individual-level determinants, Clinic-level determinants, and health system-level determinants. Individual level determinants included factors such as acceptability, perceived benefit and usability. The health workers appreciated the app for its ability to remind them of essential medical questions and procedures, making it easier to follow guidelines and provide accurate dosages. Those familiar with smartphones found the app easier to use but provided suggestions such as using larger fonts and age groups instead of dates of birth for better usability. At clinic-level and health system level there is a challenge of limited training of staff members, high patient volumes and limited resources with frequent medicine stock-outs leading to inconsistency within the supply chain. Early engagement with stakeholders, including the Ministry of Health and local district health officials, was deemed crucial for the

app's approval and widespread adoption. Because most interviews were conducted in focus group discussions a limitation of the study is that a full scope of the views of the participants may not have been captured due to group dynamics (38).

A feasibility assessment was conducted in 2015 in Ethiopia involving 14 health workers selected from 12 different primary health care facilities to assess the user's perception and experience in using a newly installed customized data collection application and electronic maternal health care form for six months. Through qualitative methods consisting of in-depth interviews, it was found that there was high acceptability and demand for the mobile health application despite it being introduced fairly recently and the users had no previous experience with mHealth applications. One of the findings was that younger participants were more accepting of using the application than older participants and there was considerable difficulty in getting around this in comparison to solving technical challenges such as low battery life or malfunctioning devices. The limitations of this study were the small sample size as well as the absence of a control group (39).

The MomConnect mobile health app has obtained the highest population coverage in South Africa and globally of pregnant women reaching more than 60% with 1.7 million subscribers since its launch in 2014. Its success can be linked to several facilitating factors such as high-level government buy-in and leadership, with it being championed by the Minister of Health at the time and currently being overseen by the deputy director general at the NDOH. It has multistakeholder partnerships with more than twenty different partnerships contributing to its day-to-day operations. Clients have access to a helpdesk for health-related queries. This is useful for creating a demand for health services and collecting health service experience data. Following South Africa's Health Normative Standards Framework, it is interoperable with data on antenatal care attendance feeding directly into the District Health Information System (DHIS) (12,40).

In 2021, a study was carried out in Mopti, Mali to investigate the obstacles and factors that help in incorporating community-level health data into Mali's web-based District Health Information System (DHIS2). Although Mali has implemented a web-based DHIS for data aggregation and analysis, Community Health Workers (CHWs) still use a paper-based system to collect and report data. During the study, CHWs were provided with tablets to assess the timeliness and completeness of data using a digital community-based information system. They were also asked to share their experiences. The study gathered the experiences of CHWs and their supervisors in reporting routine community-level data using DHIS through quantitative surveys and focus group discussions. The key findings of the study revealed that CHWs and their supervisors were comfortable using the tablets and reported improved data timeliness and completeness. However, they encountered challenges related to limited network connectivity and poor tablet quality. Despite their preference for using tablets, CHWs were required to collect data on both the tablet and on paper as a backup in case of data loss. This increased their workload and limited the study's findings as they do not fully represent the implementation of a digital-based system (41).

In 2015, a retrospective study was carried out in Tanzania to determine the costs associated with implementing and running a clinical decision support system. The system was trialled in six health centres, and the software was installed on laptops to provide healthcare workers with computerized support and guidance for routine antenatal care, care during delivery, and

postpartum care. The costs were classified as installation and operational costs. The study found that 77% of the total costs were incurred during the installation phase. Training accounted for the largest portion of the costs, making up 33% of the total cost and more than half of the recurring expenses, followed by the cost of the software. These findings can offer insights for the planning of similar digital health interventions (42).

In the South African context, mHealth research covers a wide range of health issues, technological innovations, and implementation challenges, providing valuable insights into the potential and limitations of mHealth. A recent scoping review analysed 36 articles in 2023, focusing on mHealth use in South Africa. It found that mobile applications and short messaging services were among the primary digital health interventions employed in South Africa. Research on mHealth has increased over the past seven years, with most studies carried out in the Western Cape, Gauteng, and KwaZulu-Natal. The studies mainly consist of formative qualitative research with a focus on the acceptability and feasibility of mHealth pilot projects (43). The results of these studies usually suggest acceptability among users, such as patients and healthcare providers (43–46). The focus is usually on maternal and child health and HIV-related outcomes, although studies have not been able to establish a direct link between mHealth and improved health outcomes (43). This can also be attributed to the scarcity of sustained mHealth applications and digital health interventions in South Africa, with most projects reaching a premature end, limiting a full assessment of their impact (47).

The studies reviewed were predominantly qualitative with relatively small sample sizes ranging from small pilot studies with 15 CHWs to larger studies involving over 60 participants. The findings indicate that mHealth applications enhance consultation quality, patient monitoring, and adherence to care protocols. While research conducted in India, Senegal, South Africa, and Ethiopia demonstrate positive outcomes, challenges related to internet connectivity and sustainability persist. Adoption and effectiveness continue to be influenced by technological literacy, education levels, social and cultural contexts, and, additionally, political buy-in.

With an increasing shift towards digital health interventions as per the National Digital Health Strategy 2019-2024, the limited scope of mHealth research is an area of concern. Future research should address gaps regarding upscaling, sustainability, and monitoring and evaluation.

1.4 Problem Statement

We live in a world saturated with technology, with multiple digital health interventions being piloted globally and daily yet we still face problems of non-adoption, abandonment, and failure of scale-up and sustainability(27).

Time after time, the strategic focus is drawn narrowly to the technology and promise of improved health system outcomes without consideration of context, organisational structure and leadership, human resource capacity and technological infrastructure all of which are key drivers of scale-up and sustainability (40).

The processes and lessons learnt about implementing a mobile health application at a district level were not documented in the initial pilot phase in Ekurhuleni. The fact that CommCare was introduced and utilized over 5 years in the Ekurhuleni Health District provided additional experiences that could be of value in documenting this process. This study provides the opportunity to understand the factors and processes of implementation of mobile health applications that will assist the Ekurhuleni Health District and Gauteng province in the scale-up and sustainability of such digital health interventions.

1.5 Justification

There have been very few studies conducted on the implementation of all digital health interventions in South Africa. Most of the studies have focused on the challenges of scaling up and sustainability, but none have addressed the implementation of a digital health intervention in a district setting with feedback from key stakeholders.

With the development of documents such as the National Digital Health Strategy for South Africa, 2019 – 2024 and the National Health Normative Standards Framework for Interoperability in eHealth in South Africa it is evident that the South African health system is advancing into an era of digital health interventions which must serve as a prompt to health researchers to contribute to the body of evidence on the impact, health outcomes and lessons learned during implementation of digital health interventions to justify financial investment and redirection of resources when compared to other non-digital interventions (2,11,26).

The implementation of existing digital health interventions must therefore be documented and analysed to determine what factors were facilitators or obstacles to success, and to guide the implementation of other digital health interventions at all levels of healthcare and to strengthen positive determinants of scale-up and sustainability.

1.6 Aim

The aim of the study is to assess the experiences of end-users and key stakeholders in the implementation of CommCare within the Ekurhuleni Health District over a five-year period.

1.7 Objectives

1. To determine perceived usefulness and end-user satisfaction amongst the Outreach Team Leaders and Community Health Workers in using the CommCare mobile health application in the Ekurhuleni Health District.
2. To describe facilitators and barriers to the implementation of a mobile health application amongst different stakeholder groups within the Ekurhuleni Health District.
3. To determine perspectives of different stakeholder groups in form of best practices and lessons learned on their involvement in the implementation of a mobile health application within the Ekurhuleni Health District.

2. Methodology

2.1 Study design

The study is classified as a mixed methods cross-sectional descriptive study. Primary data collection was performed using semi-structured interviews with key informants and the distribution of an online self-administered questionnaire to CHWs and OTLs.

2.2 Study Setting

Ekurhuleni Metropolitan District - The City of Ekurhuleni is one of three metropolitan municipalities in Gauteng province. Geographically it can be divided into three subdistricts, North, East and South. These districts can further be divided into two subdistricts each i.e. North 1, North 2 etc. In 2019, the population of the city was 3 774 638 comprising of 1 299 490 households with 31% of the population living in poverty. It has a total of 84 Primary Health Care clinics, nine Community Health Centers, one district hospital, four regional hospitals and one tertiary hospital in the North of the district (17).

2.3 Study population

The study population consisted of two informant groups consisting of 1205 participants in total as illustrated in Table 1. These were the WBPHCOT sub-district co-ordinators and ICT officials at district level, the district support partners, Aurum and Dimagi and lastly the Outreach Team Leaders and the Community Health workers who are the end users within the facilities.

The eight informants at district and sub-district level were key players in the implementation and ongoing management of the intervention. Therefore, semi-structured interviews were planned (see Appendix A1 – C3) to be conducted with this group of key stakeholders. The 1197 end-users at facility level were to give feedback on the perceived usefulness and satisfaction with the mobile health application through answering an online self-administered questionnaire (see Appendix D1 – D3).

The service provider, CosmoNet was not directly involved in the implementation but was liaising with the district partner Aurum overseeing the project at the time. Attempts at contacting Cosmonet for an interview were unsuccessful therefore reducing the number of key informants to seven.

Table 1 A list of the members within each of the two key stakeholder groups.

Informant Group		Research objective	Data collection method
End-users	Outreach Team Leaders (170 participants) Community Health Workers (1027)	**Objective 1**	Self-administered online questionnaire. *Themes: Perceived usefulness, User satisfaction*
District/Sub-district level	ICT officials (2 participants) WBPHCOT Sub-district co-ordinators (3 participants)	**Objective 2** **Objective 3**	Semi – structured interviews *Themes: Experiences, Facilitators, Barriers*
District support partners	Aurum (1 participant) Dimagi (1 participant) CosmoNet (1 participant, excluded) *		

*This key informant could not be reached for interviews.

2.4 Study Sample

No sampling was done for this study.

All key stakeholders involved in implementing the CommCare mobile health application in Ekurhuleni Health District were invited to participate in the study. This includes the seven key informants who are the WBPHCOT sub-district coordinators, ICT officials and district support partners representatives.

All the 1027 CHWs and 170 OTLs utilising the CommCare mobile health application in Ekurhuleni Health District were sent an online self-administered questionnaire via Whatsapp.

2.5 Data Collection

Different elements of existing conceptual frameworks within the literature were adapted and utilised to develop the data collection tools in this study, see Figure 2.

The different elements were derived from the following conceptual frameworks: NASSS Framework (27) Expectation-Confirmation Theory (28) and the Technology Acceptance Model (TAM) (29).

The semi-structured interviews followed an interview guide (see Appendices A3, B3 and C3) developed from the adapted conceptual framework with a focus on the domains of technology, organisation, the wider system and best practices.

Participants were contacted in September 2023 via email, and study information sheets and consent forms were sent out before the interviews. Further verbal consent was obtained before the start of the semi-structured interviews which were conducted at district level as well as with district partners.

All interviews were conducted from September to October 2023, by the primary investigator virtually over Microsoft Teams which is available to staff members at Ekurhuleni Health District and was accessible by district support partners.

The questionnaire was developed using the adapted conceptual framework with a focus on the perceived usefulness, pre-conceived expectations, perceived ease of use and intention to repurchase.

A link of the self-administered questionnaire (see Appendix D3) as sent in September 2023 via Whatsapp to OTLs and CHWs at facility level to determine their end-user experience. The participants were asked for their consent prior to answering the questionnaire. Responses were collected over two months.

For study information sheet, informed consent and interview questions for the WBPHCOT sub-district coordinators, district support partners and district ICT technicians – see Appendices A1 – C3.

For the study information sheet, informed consent and online questionnaire – see Appendix D1 – D3.

Figure 2 below illustrates the conceptual frameworks that were adapted and utilised to develop data collection tool for the key informants and end-users. The key concepts used in the adapted framework coordinate with the representative colour of the framework in the diagram.

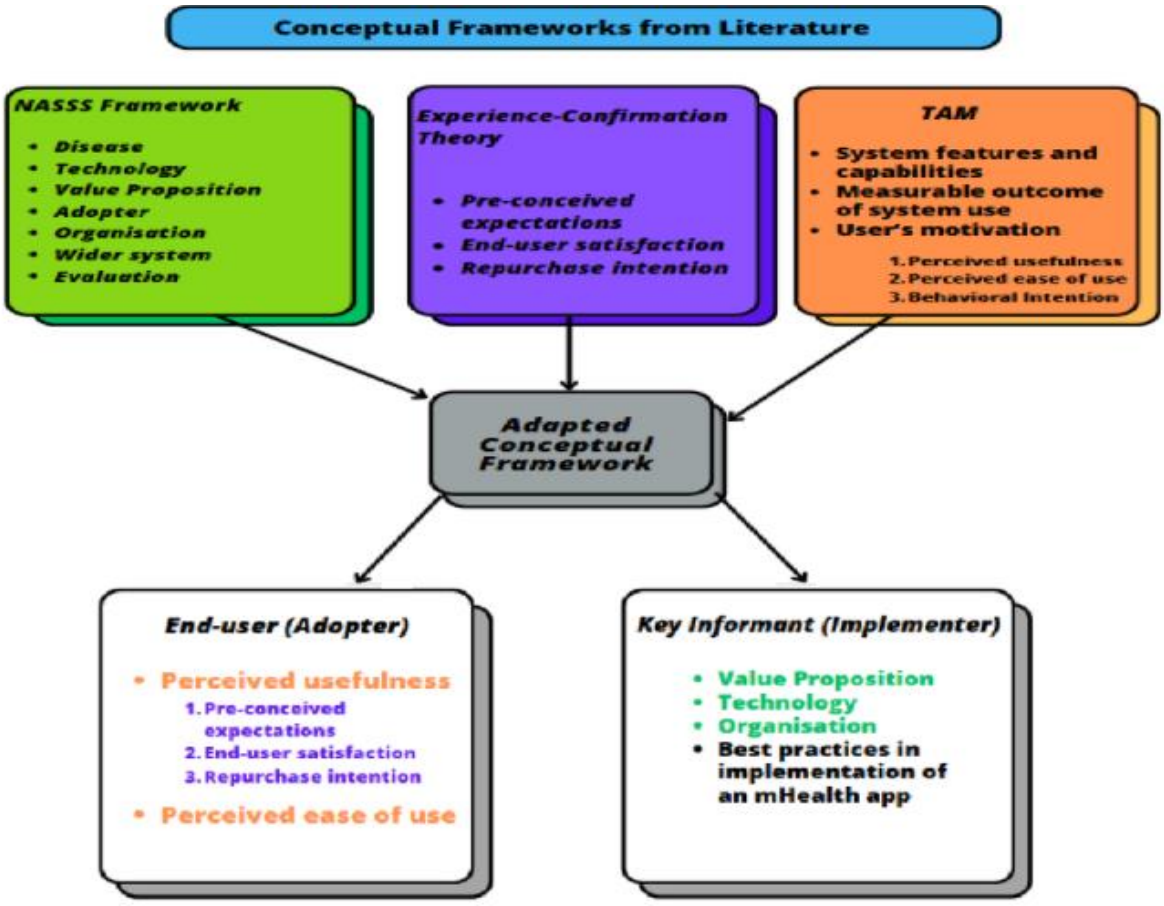

Figure 2 illustrating the adapted conceptual framework used to develop study data collection tools (27–29)

2.6 Data Management & Analysis

Data from the online questionnaire (see Appendix D3) was de-identified and aliases were used for the interviews and transcripts.

The quantitative segment of the questionnaire was collected using Microsoft Forms and the same platform was used to conduct a descriptive analysis.

Interviews were conducted and recorded by the principal investigator using a questionnaire with open-ended. The interviews were transcribed automatically during the interview and these transcriptions were then further reviewed multiple times by the principal investigator to ensure immersion and understanding.

A thematic analysis was conducted using inductive reasoning within a grounded theory approach, guided by existing conceptual frameworks. Broad themes were initially identified from mapping of existing conceptual frameworks. These themes were systematically broken down into detailed codes to capture nuances within the data. The data was then analysed using Atlas.ti, capturing recurring patterns within the pre-identified themes while also uncovering additional key insights. The codes were then re-evaluated, and themes were adjusted iteratively, ensuring coherence, depth, and alignment with the research objectives.

The data was then stored on a laptop with password protection and backed up to a cloud in Windows.

Table 2 Data analysis method for Objective 1

Objective 1 To determine perceived usefulness and end-user satisfaction amongst the Outreach Team Leaders and Community Health Workers in using the CommCare mobile health application in the Ekurhuleni Health District.
Variables: Age(categorical), Education(categorical), Gender(categorical), Role(categorical) Expectation(categorical), Satisfaction (categorical), Challenges (categorical), Training (adequate training) – [categorical], Support (sufficient support) – [categorical], Recommend (would they recommend the app for further use and scale-up) – [categorical] **Analysis method:** For the categorical variables the frequency of occurrence and the percentage were assessed via descriptive analysis. **Themes (from open-ended questions):** Expectations, Challenges, Suggestions **Analysis method:** Recordings of interviews were transcribed and coded according to the above themes and further thematic analysis was done using Atlas.ti.

Table 3 Data analysis methods for Objective 2

Objective 2 To describe facilitators and barriers to the implementation of a mobile health application amongst different stakeholder groups within the Ekurhuleni Health District.
Themes: Challenges, Highlights/Achievements, Lessons Learned **Analysis method:** Recordings of interviews were transcribed and coded according to the above themes and further thematic analysis was done using Atlas.ti.

Table 4 Data analysis methods for Objective 3

Objective 3 To determine perspectives of different stakeholder groups in form of best practices and lessons learned on their involvement in the implementation of a mobile health application within the Ekurhuleni Health District.
Themes: Role/Responsibility, Level of understanding of CommCare, Facility readiness, App design, Programme support systems, Recommendations **Analysis Method:** Recordings of interviews were transcribed and coded according to the above themes and further thematic analysis was done using Atlas.ti.

2.7 Ethical considerations

An application for ethical clearance was submitted to the Human Research Ethics Committee at the University of the Witwatersrand, and approval was granted before the study commenced (see Appendix E). Permission was also received from the Ekurhuleni health district to conduct this research (see Appendix F).

The OTLs and CHWs were provided with information on the study and asked for their consent before they could access the online questionnaire.

Before conducting the semi-structured interviews, the participants were contacted via email, and study information sheets and consent forms were sent to them. Further verbal consent was also obtained before the start of the interviews.

Data was only accessible by the primary investigator and supervisors. Anonymity of participants was further maintained through the generation and assignment of unique identifiers.

3. Results

Data were collected from Community Health Workers (CHWs) and Outreach Team Leaders (OTLs) by having them complete an online questionnaire. The questionnaire aimed to assess their expectations of the CommCare mobile application and its perceived usefulness for end users.

Additionally, semi-structured interviews were conducted with district support partners and sub-district coordinators to understand any challenges or lessons learned during the implementation process.

3.1 Objective 1: Perceived usefulness and end-user satisfaction amongst Outreach Team Leaders and Community Health Workers using CommCare

3.1.1 Biographical Information

A total of 1027 community health workers (CHWs) and 170 outreach team leaders (OTLs) were invited to participate in the study by completing an online questionnaire over a period of two months. A total of 476 participants responded to the invite, however only 464 (39%) consented to being a part of the study and answering the questionnaire. The final number of the 464 participants consisted of 393 CHWs and 71 OTLs.
The study participants included were mostly females, accounting for 94% of the participants, see Table 5. There were 26 male participants, and three participants chose not to report their gender. All participants were over the age of 25, with 55% of them being over 40 years old. The highest level of education among the participants was secondary school, with 39% having completed matric and 22% having pursued tertiary education.

Table 5 describing the demographic information of the end-user participants.

Variable	Category	Frequency n (464)
Age	25-40	207 (45%)
	40+	257 (55%)
Occupation	CHW	393 (85%)
	OTL	71 (15%)
Highest level of education	Secondary school	183 (39%)
	Matric	181 (39%)
	Tertiary	100 (22%)
Gender	Female	435 (94%)
	Male	26 (5%)
	Prefer not to say	3 (1%)

3.1.2 Initial Expectations of CommCare amongst Outreach Team Leaders and Community Health Workers

When asked about their expectations of CommCare the responses of the OTLs and CHWs were grouped under the following themes and sub-themes as illustrated in Figure 3 below:



Figure 3 Themes and sub-themes derived from responses of CHWs and OTLs around their expectations of CommCare.

a) **Efficiency:** The participants expected the app to decrease workload by saving time that is usually spent on manually recording clients' details. They also expected it to help with household screening and registration by streamlining these processes.

b) **Data Management:** Through the elimination of paper-based activities the participants expected the app to improve the safekeeping of patient information and streamline the process of integrating information into the DHIS.

c) **Decision support tool:** The participants expected the app to guide the correct questions to ask during household screening and improve the quality of care provided to patients.

d) **Professional development:** The participants expected the app to be an opportunity to develop their technical skills.

e) **Remote monitoring of CHWs:** OTLs expected to be able to trace and monitor their CHWs and their work remotely using the app.

Quotes supporting these themes can be found in Table 6 below:

Table 6 Quotes supporting the themes around the expectations of CommCare by OTLs and CHWs

Theme	Quote 1	Quote 2	Quote 3	Quote 4
Efficiency	"To minimise paperwork & makes work more easier especially when doing follow up visits of the households"	" [I was] expecting the app to remind me [about] my follow-ups To keep important information about your client."	To utilise the tracing app I expect it to help with registrations screening and tracing of patients."	"I thought it will reduce too much work especially in writing Fast and collection of data or information."
Data Management	"I expected it to have all indicators & and accomodate all the reports that we doing [right] now I don't see a need for us to have it if we still writing reports on a paper it must automatically compile and send information."	"I thought everything will be much easier,expecially paperwork but no we still writing everything even if it's on the phone."	"I expected it to stop paper based reporting completely as well as the app being linked to DHIS for sending reports and also allowing me as an OTL to view my CHWs location remotely."	"To fix tracing, Commcare help me a lot because I store my patients information and it safer than that time we use to write in papers."
Remote monitoring of CHWs	" To improve communication between CHWs and OTLs To respond to CHWs challenges in the HH immediately even when I'm in the clinic or supervising other team"	"Monitoring, supervised CHW's work and compile weekly and monthly report in time."		"To show and count CHWs daily stats and track the location of CHWs."
Professional Development	"I expected it to empower me with more information and also assist me on doing my work professionally as well as understanding the questions that I am supposed to be asking when I'm doing my work."	"To compile an acute monthly report and it guide me to see where I am lacking if I meet my monthly recommended target or not, if I don't reach I have to evaluate why and what steps I should take to reach my target?"	"I expect that will help me with Technology. To gain more knowledge and experience and learn more from it."	
Decision Support Tool	"Correctly leading me according to the need of a client and [reporting] back correct activities I performed to the client in monthly summary."	"I expected it to help me with doing my job thoroughly e.g screenings."	"I expected it 2 help me with screening questions [and Commcare] did exactly that."	

Figure 4 below summarizes the responses of the CHWs and OTLs into a word map about their expectations of CommCare.

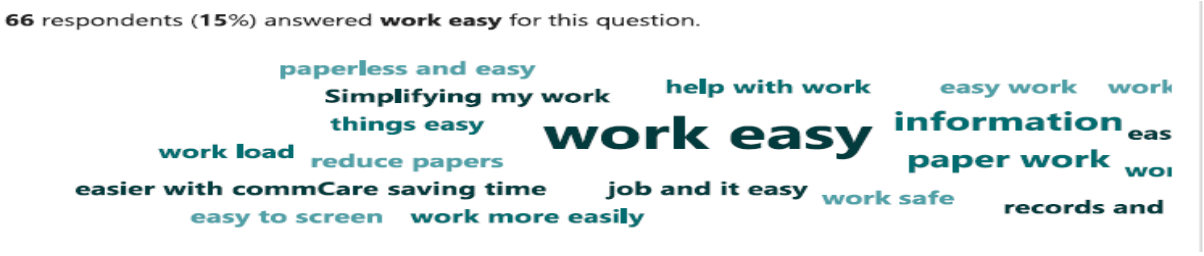

Figure 4 Word map illustrating common words used by CHWs and OTLs in describing their expectations of CommCare.

When further asked whether these above expectations were met 83% of the respondents replied that CommCare met their expectations, 10% remaining neutral and 6% saying no.

3.1.3 Reported end-user satisfaction amongst the Outreach Team Leaders and Community Health Workers

When asked about their overall satisfaction with CommCare 85% of the respondents answered "yes", to being satisfied with the mHealth application. See Figure 5.

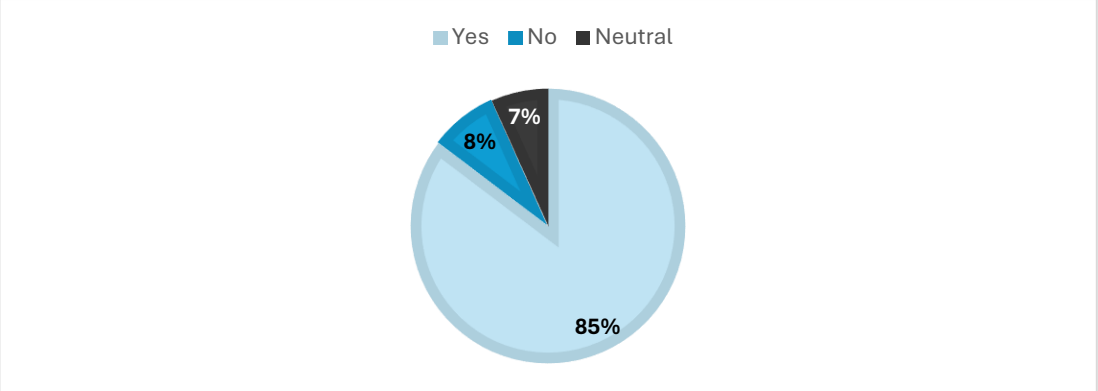

Figure 5 Pie chart illustrating the distribution of responses regarding end-user satisfaction.

When asked if they would recommend CommCare to be used by OTLs and CHWs in other districts, 95% of the respondents answered that "yes" they would recommend CommCare to other WBPHCOT teams. 4% reported they wouldn't recommend it and 1% remained neutral.

3.1.4 Challenges experienced by Outreach Team Leaders and Community Health Workers while using CommCare

The CHWs and OTLs were asked if they experienced any challenges when using CommCare of which 35% of the respondents reported that yes, they had experienced challenges with the app and 62% reporting that they had not. 3% of the respondents were neutral.

See Figure 6 below for quotes from participants who did not experience challenges.

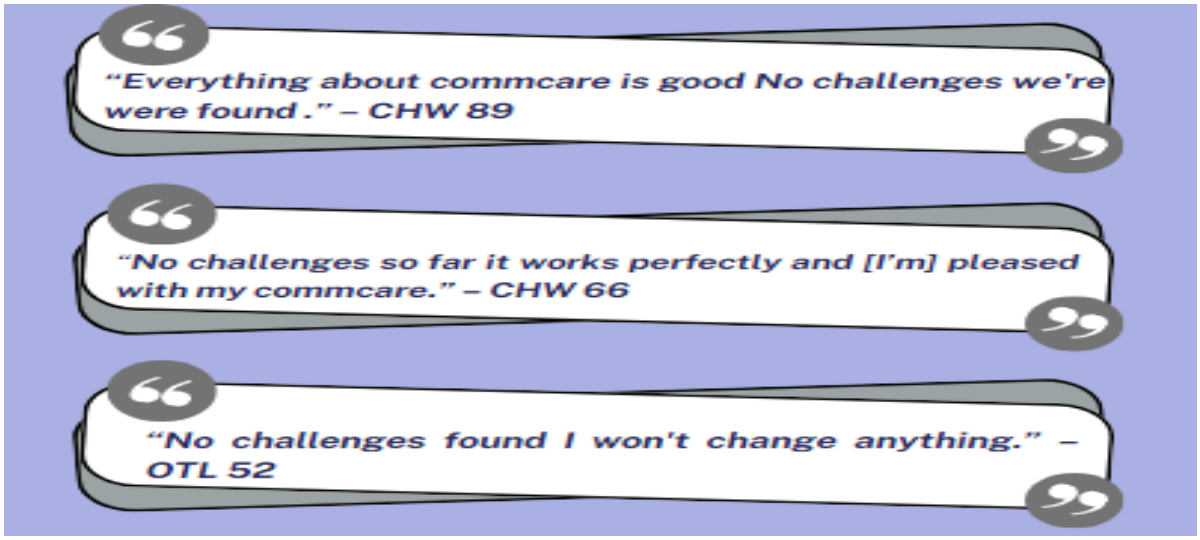

Figure 6 Quotes from some of OTLs and CHWs who did not experience challenges with CommCare

The participants were then asked to list the challenges they experienced with CommCare and these were arranged into the following themes illustrated in Figure 7 below:



Figure 7 Illustrating themes derived from responses of CHWs and OTLs around their challenges with CommCare.

a) **Connectivity:** The participants reported challenges with connectivity. They said that connectivity negatively affected the tracking of CHWs by OTLs and the reporting of data, as they were unable to sync their work onto the server.

b) **Data removal:** Multiple participants reported having difficulty with deleting erroneous data or removing clients who have since moved away or are deceased. They also stated that even when the data is entered correctly there are still sometimes missing values, wrong totals and fabricated data.

c) **Inappropriate referrals:** Patients who had already come from the clinic may be referred again by CommCare. Some patients may also not need to be referred according to the CHW and OTL but there is still prompting to do so when using the app.

d) **Testing and screening:** There were challenges with the screening prompts with some users of the app reporting that sometimes the screening prompts were inappropriate for the patient's needs, or that the questions were irrelevant or too similar.

e) **Technological challenges:** The app has also been reported to have a tendency to freeze or not work correctly. This also results in data errors and inaccurate report compilation.

Quotes to support these themes are illustrated in Table 7 below:

Table 7 Quotes supporting the themes around the challenges experienced using CommCare by OTLs and CHWs

Theme	Quote 1	Quote 2	Quote 3	Quote 4
Connectivity	'In a place where there is no network,it doesn't want to record location. And also in some unsafe place is not easy to use the gadget, community care workers are scared of thieves."	"In a place where there is no network,it doesn't want to record location."	"Network is hectic when weather is not right."	"Other information was not saved [due to] Network problems Network is a challenge."
Data Removal	"...dead clients you can't take them out, when you screen patient it's will take you somewhere else eg. you will screen client and Commcare will end up referring that client while there is no need for referrals,it's give you numbers that you didn't do them when it's come to month end stat numbers are not corresponding"	"If house hold relocate to unknown address you [can't] delete the information."	"Some activities and those recently added do not appear on monthly report. "	" I can't delete information if there's an error or if the information change."
Inappropriate Referrals	"Referring without my concern especially on STI screening."	"Not to expect a person who already is attending clinic to be referred cos it will ask for aan up to date patient to be referred."		
Testing & Screening	"Sometimes when you screen someone of family planning methods even if the person is not sexually active it request you to ask if the person is on family planning methods of which the person has already told you you that she is abstinent"	"The challenges is a shortage of screening like Hiv and etc.	"To give more information about clients because other information is not in the comcare."	"Having to read everything with English It should introduce home language No challenges were observed"
Technological Challenges	"No we experience many problems now with this tool,it stops,freeze, sometimes in 2 days doesn't show other apps.."	"Wrong totals, not syncing at times, gets stuck at times, fabricates other information, irrelevant questions, and too many similar		

3.1.5 Suggestions given by Outreach Team Leaders and Community Health Workers to improve CommCare

The OTLs and CHWs were also asked to give their suggestions on how the app can be improved. Approximately 47% of the participants provided suggestions for the improvement of CommCare. The suggestions fell under the following themes and sub-themes:

a) **Screening:** The respondents stated that more disease screening tools should be added to the app and that screening tools should be available in vernacular languages.
b) **Data Management:**
    a. **Household registration:** The respondents suggested the cumulative recording of data. Currently, once the household registration target of 250 households is reached the mHealth application reboots. The counting of households also starts afresh every new year and CHWs must begin again with recording households from 1 to 250. The OTLs then stated that they experienced challenges in recording the amount of work that is done by the CHWs and that this feature must be removed.
    b. **Detailed narrative report:** The respondents suggested that further details be added to the narrative report, such as the gender of the client and age categories.
    c. **Data removal:** There should be an option to remove erroneous data, data of deceased clients or those who have moved away.

c) **Remote Monitoring of CHWs:** A suggestion from OTLs was that they want to be able to trace CHWs and monitor their work remotely via the app.

Quotes to support the above-mentioned themes and sub-themes can be seen in Table 8 below:

Table 8 Quotes supporting the themes derived from the suggested ways to improve CommCare by OTLs and CHWs

Theme/Sub-theme	Quote 1	Quote 2	Quote 3	Quote 4
Household Registration	"I Would like to change the Way they count the House Holds ,When they are doing the house hold Registration every Year..For example When the Person is finished with the 250 House hold this Year ,He / She will start from 1 to 250 next year ,not to continue With the same numbers ,This is Confusing Really.As Otls it is Difficult for Us to Count the Chw's Work Properly".		"When I start my registrations from the start after completing 250 Households.It doesn't give me an option of starting to register from household number one,it only allows me to edit patients and can't delete those who have relocated."	
Detailed Narrative Report		"I recommend that everything.be added eg narrative where by you had to count how many men and women,also to be able to differentiate between different ages for BP and db, 18-44 ,45 and above less than 18 pap smear to be added for screening,also cataract."		"To recommend on Gender female and male should appear on the compiled start not just a number"
Data Removal	"[Removal] of information. [When] someone passed on must be removed [from app] [app must allow] editing of patients who no longer exists."			"Can u please change if a person is no longer staying at the address the should be a option of removing that person from the household members"
Remote Monitoring of CHWs	"I recommend that I as an OTL wish to see how many follow ups the Chw did every day."	"The phone must allow us to see weekly work for chw or daily work."	"For OTL's to be able to see or monitor the households the CHW's managed to visit a day."	
Screenings	"Maybe we can add a vernacular/our home language."	To add screening of prostate and cervical cancer.	"It should have language optional."	"Again incase of clients who experience amenorrhea due to injectable method of family planning it must not lead us to screening the pregnancy."

The following quotes did not fall under any of the themes but express the end-user satisfaction of the CHWs and OTLs as well as other suggestions of note. See Figure 8 below:

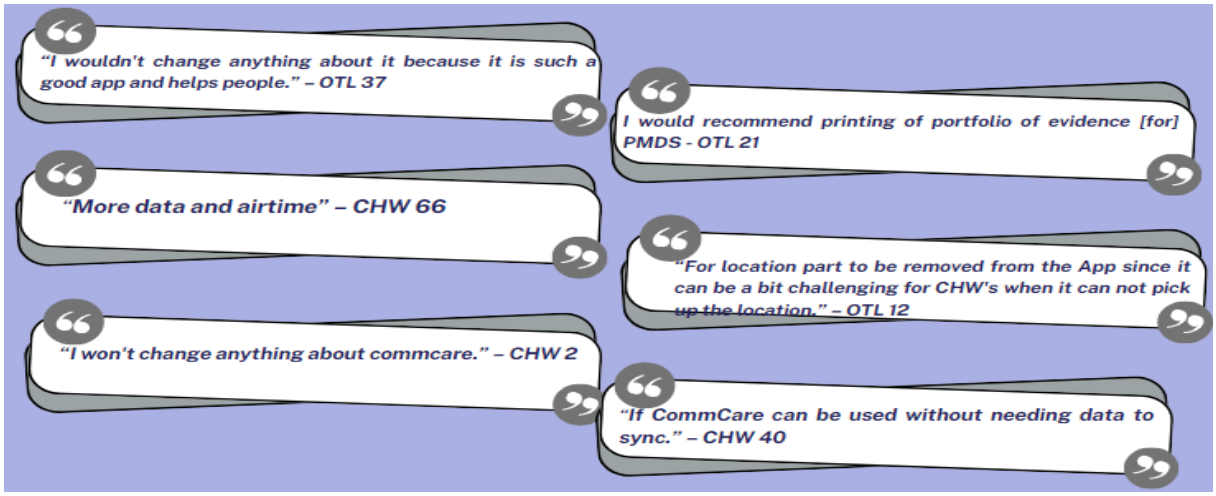

Figure 8 Quotes about suggested ways to improve CommCare by OTLs and CHWs.

3.2 Objective 2: Structured interviews involving key stakeholders

Initially, eight interviews were planned with key stakeholders who were purposefully selected because of their contribution to the implementation of CommCare in Ekurhuleni district. Of the eight, seven interviews were conducted. Service provider CosmoNet, who were not directly involved in the implementation but were liaising with the district partner Aurum overseeing the project at the time, could not be traced. The key stakeholders who were interviewed include the WBPHCOT sub-district coordinators, ICT technicians at district and district support representatives from Aurum and Dimagi.

3.2.1 Reported facilitators and barriers to implementing a mobile health application at district level

Table 9 Describing reported facilitators and barriers to implementing a mobile health application by themes

Theme	Barriers	Facilitators
Technological (Hardware & Software) challenges	Difficult app user interface Software bugs No technical support from the district Malfunctioning hardware	mHealth coordinators Mentors Video tutorials CHW pairing
Data management	Disappearing data Inaccurate data entry Language barriers Barriers to accessing information between CHWs	Backing up data for recording later
Collaboration	Workplace conflict	Orientation of Operational Managers
Training	Logistics Barriers to access Learning difficulties Illiteracy Advanced age	CHW Pairing Collaboration
Remote monitoring	Connectivity issues Inadequate reporting Mapping issues Inaccurate data entry	
Asset management	Load shedding Electricity issues Loss/Theft of gadgets	Asset management policy

a) **Technological (Hardware & Software) Challenges:** Some participants reported that the difficult user interface of CommCare contributed to the technological issues. This led to some of the users at all levels having difficulty interacting with the app. An example given was of how CHWs had to give paper-based reports to their OTLs because of the difficulty experienced with the application. Another technological issue that was reported was gadgets freezing or malfunctioning and not being able to get fixed. There was common mention of a lack of technical support from ICT among the participants, see Figure 9 below. They mentioned that this was due to administrative issues of working with gadgets that were sourced from service providers outside of government tender. Differences in age and education were also reported to contribute to some of the challenges experienced while using the application. CHWs were paired to assist each other. The interviewees also reflected on how later on in the implementation of the app the role of mHealth coordinators was introduced and how this was a facilitator in response to technical issues experienced at facility level. The software developers also created videos for easy access and troubleshooting.

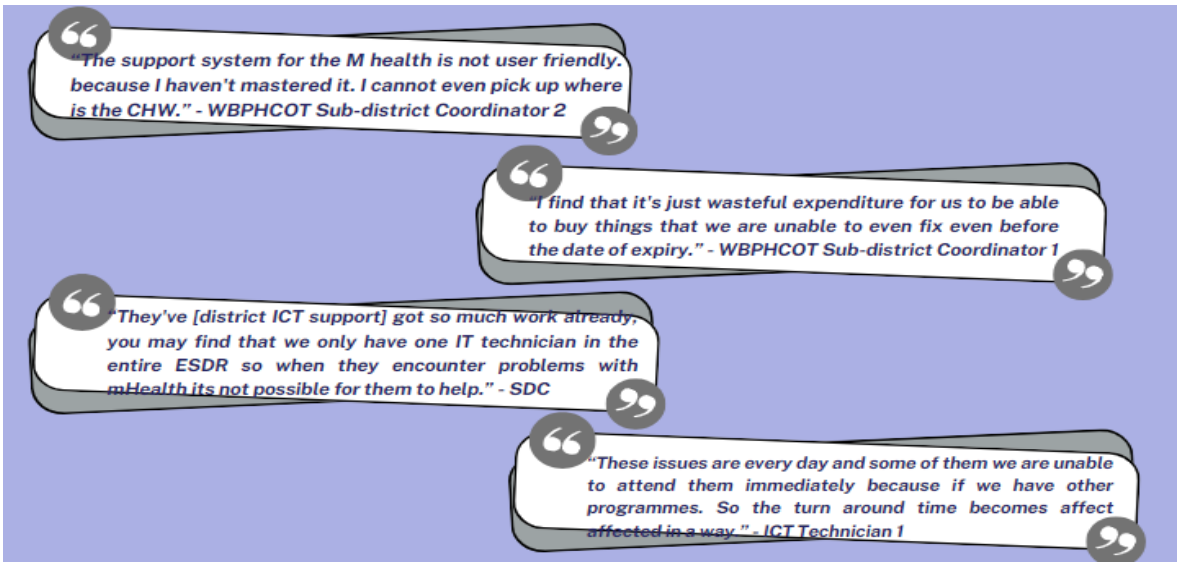

Figure 9 Quotes from key stakeholders reflecting on technological issues.

b) **Data Management:** Some of the stakeholders at district reported that there has been a recurring report of missing and inaccurate data on the app that in turn affects the integrity of the reports. They said that part of it is due to technological glitches and the other due to incorrect data entry due to language barriers of the CHWs. One interviewee reported that some CHW skip questions and prompts they do not understand, and this leads to further wrong prompts as well as some activities not being reported. Another challenge is the barrier to accessing information. CHWs and OTLs are not able to access each other's households and cases therefore delaying service provision when a colleague is not at work. Although admitting to the method's inefficiency some of the Sub-district coordinators stated that to verify their data and bypass this challenge, the CHWs back up their work by either taking pictures of it or recording it in a booklet. This information is then said to be uploaded

weekly into the application. However, the app was also reported to have improved data management overall, see Figure 10 below.

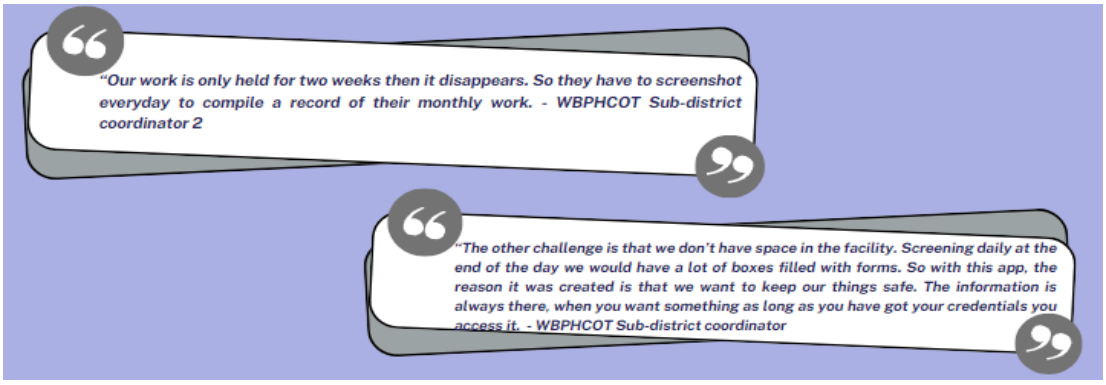

Figure 10 Quotes from key stakeholders reflecting on issues around data management

c) **Collaboration:** The participants reported instances of conflict between employees at the facility and members of the WBPHCOT, see Figure 11 below. They mentioned that these conflicts might be due to employees at the facility not being aware of the roles of CHWs and OTLs. Additionally, there is workplace tension caused by clashes between different spheres of government. They report that there are sometimes queries about WBPHCOT team members using the resources of local government such as computers, when the WBPHCOT is overseen by the provincial government. This also sometimes results in CHWs and OTLs not having a dedicated space to work or meet. Orientation of operational managers at facilities was reported to assist in gaining buy-in and providing access.

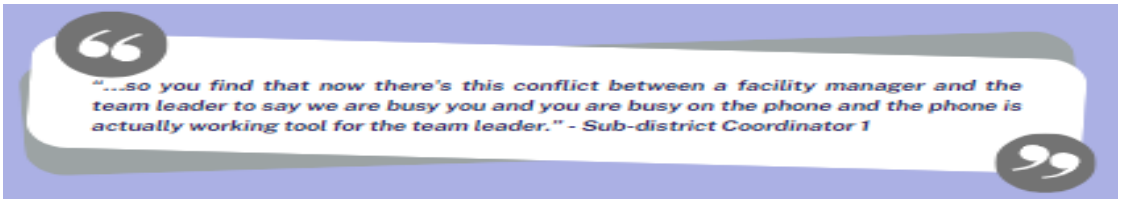

Figure 11 Quotes from key stakeholders reflecting on data collaboration issues between WBPHCOT and facility users

d) **Training:** Various stakeholders reported logistics to be a challenge during training. The sourcing of venues was challenging due to the large number of CHWs that needed to be trained at the same time. Venues such as churches and halls had to be used which were usually free of charge or at a minimal fee for payment of amenities. Because of the wide variety of venues that had to be sourced, this created a challenge for some CHWs not being able to access the training venues. As mentioned above, differences in age and education of the CHWs created gaps in learning paces. The implementers report that through pairing the CHWs were able to assist each other and move through the modules, see Figure 12 below.

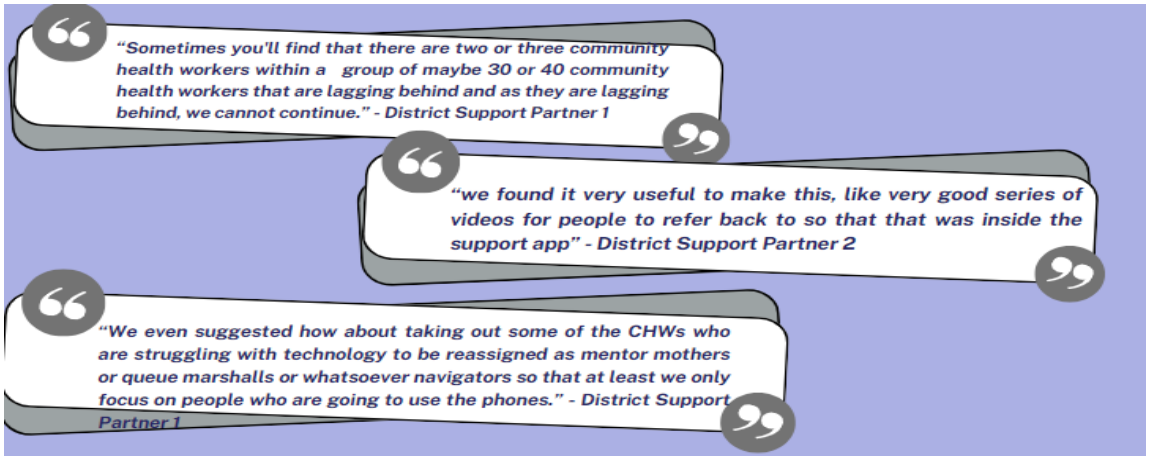

Figure 12 Quotes from key stakeholders reflecting on facilitators and barriers of training OTLs and CHWs

e) **Remote monitoring of CHWs:** The implementers also reported issues with remote monitoring, see Figure 13 below. Because of connectivity issues that are caused by poor coverage or depletion of cellphone data, CHWs may have difficulty entering their locations while on site. This is then said to hinder OTLs from being able to track the activities of CHWs during the day. Mapping was reported to be a complex issue during the development of the application with the interviewees at the district level reporting that it was not done correctly and that this has made it difficult for them to track where reports are coming from and for OTLs to track the CHWs assigned to them. Another challenge reported with the app is that it does not record the time when CHWs start logging entries or include incomplete activities in their monthly summaries.

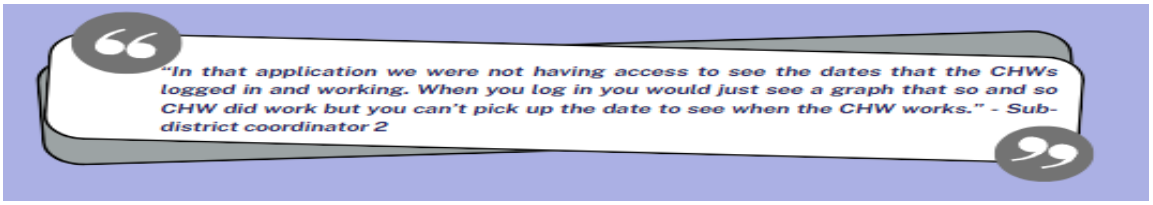

Figure 13 Quote from one of the key stakeholders regarding remote monitoring of CHWs.

f) **Asset management:** All the participants conveyed that the reported loss of gadgets was a major issue. CHWs are reported to sometimes use their gadgets over the weekend and in turn lose them. Following the loss of a gadget it is either replaced by the district partner or if following investigation, the CHW was found to be negligent then they must either use their own device or remain without one. Interviewees stated that the provincial asset management policy had been implemented where CHWs sign a contract to take the responsibility of replacing a lost gadget if it can be proven that it was due to negligence. The actual reporting process was also said to have issues with CHWs sometimes bypassing their OTLs and sub-district coordinators to report directly to the ICT technicians in the district. To solve this issue the ICT team at district collaborated with the risk management team to do roadshows to teach the CHWs about the correct processes to follow in the instances of theft and loss, see Figure 14 below.

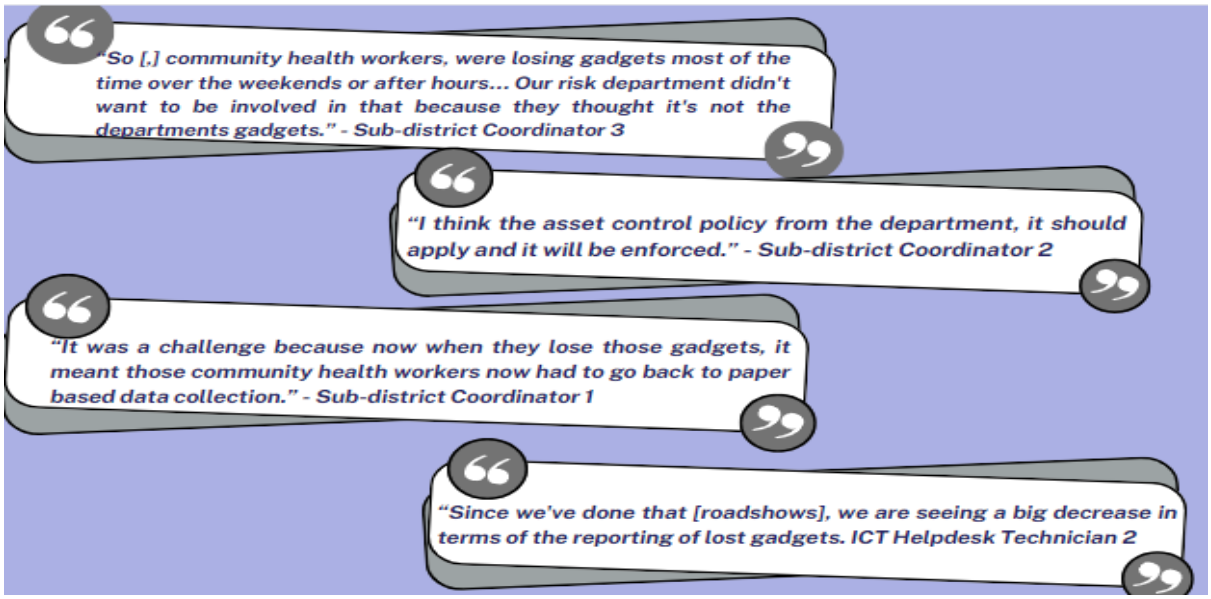

Figure 14 Quotes from key stakeholders reflecting on issues around asset management.

3.3 Objective 3: Suggestions and best practices by key stakeholders at district level regarding the implementation of a mobile health application at district level

The suggestions were grouped under the following themes:

a) Training: All of the interviewees reported the cascade model of training as a best practice in the training of the CHWs and OTLs on the use of CommCare, see Figure 15 below.

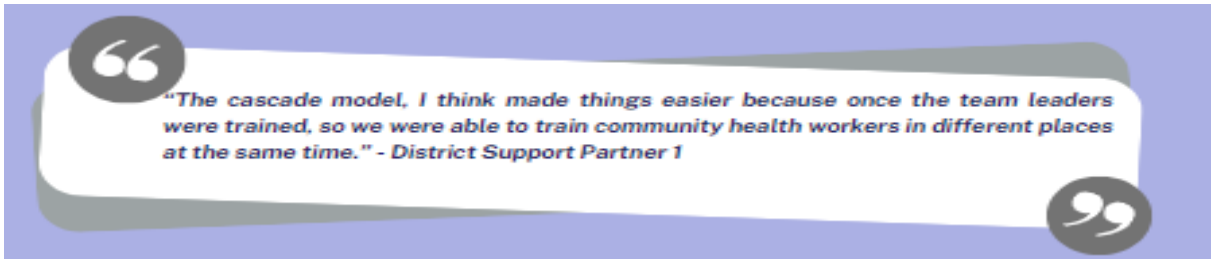

Figure 15 Quote from a key stakeholder reflecting on best practices for the implementation of an mHealth app.

b) Implementation of digital health interventions: Several interviewees reflected on the complexity of implementation. They stated that implementation should be a separate project in itself when scaling up digital health interventions. It was stated that it is important to establish technical teams at government level to ensure consistency and to achieve congruency when it comes to the selection of indicators that are to be selected for the application. Human resources are therefore needed for training and support. Some of the participants also suggested that the process of implementing a digital health intervention be rolled out over long periods of time and that all stakeholders should be sensitized to the various components of the plan to achieve success. One respondent mentioned the district WBPHCOT programme's strength, which allowed for the smooth implementation of the app, see Figure 16 below.

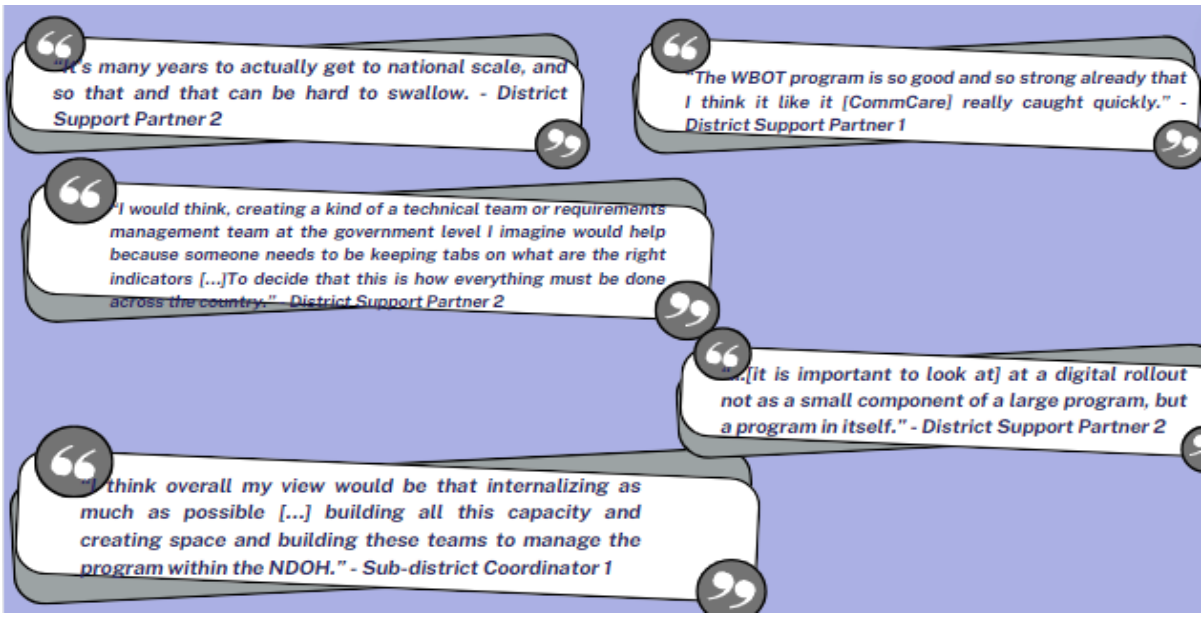

Figure 16 Quotes from key stakeholders reflecting on best practices regarding the implementation of an mHealth app.

c) **Infrastructure:** Some participants stated that the government would need to internalize its mHealth program by investing in and maintaining its own IT infrastructure and hosting software in order to achieve sustainability and successful scaling up of digital health interventions, see Figure 17 below.

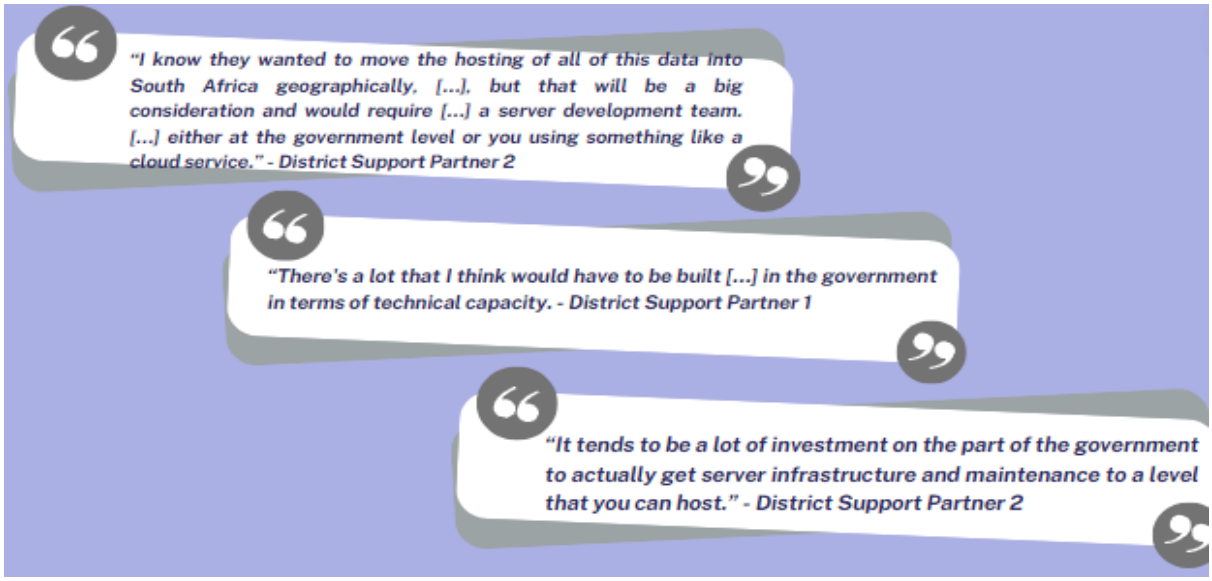

Figure 17 Quotes from key stakeholders reflecting on infrastructure for the successful implementation of an mHealth app

d) **User interface and accessibility:** Some of the participants suggested that vernacular languages be integrated into the app to improve the understanding of the end-users, see Figure 18 below. They stated that having a user interface that is easy to engage with will also be beneficial for managers to access information without having to undergo extensive training. Another suggestion touched on the accessibility of information

between end-users. The participants stated that CHWs who are paired or who belong to the same facility should be able to access one another's cases for continuity of care in the absence of the assigned household CHW.

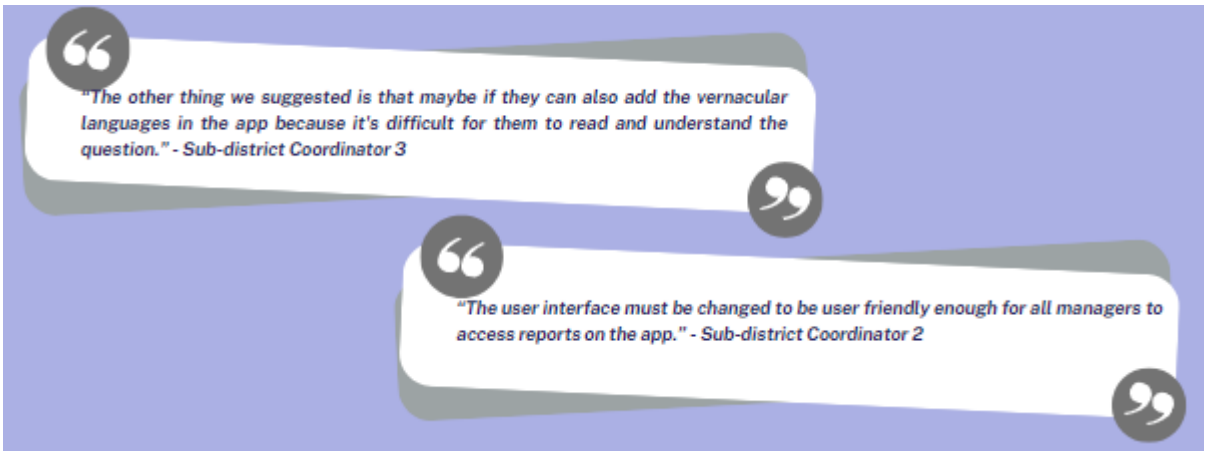

Figure 18 Quotes from key stakeholders reflecting on the user interface and accessibility of an mHealth app.

e) **Improved data quality:** Several interviewees emphasized the need to improve the quality and detail of the narrative reports. They also spoke about the importance of CommCare being linked directly to DHIS for data verification as the current process of verifying data from CommCare is still user-dependent and unreliable. With regards to the information presented in the report, it was recommended by some of the participants that all activities be recorded according to date and time, and those not performed be included in a standardized report to improve remote monitoring and the identification of gaps in service delivery, see Figure 19 below.

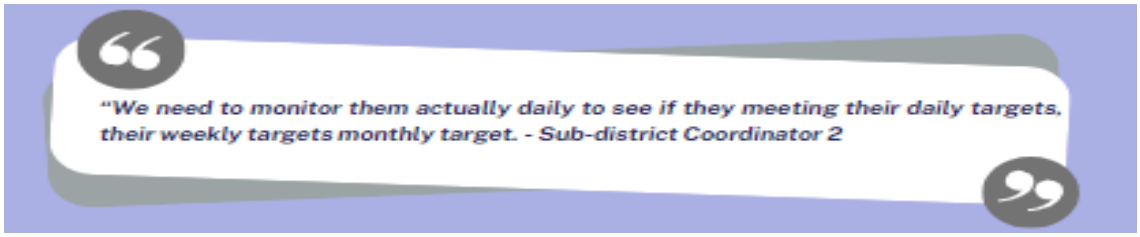

Figure 19 Quotes from key stakeholders reflecting on data quality.

f) **Appropriate stakeholder engagement:** The interviewees suggested that there be significant emphasis placed on involving the appropriate stakeholders from the commencement of the project for them to provide insight during the planning process, see Figure 20 below. This also includes community leaders who must be involved to increase the protection of CHWs from theft within the community. Within the government, departments such as risk management, monitoring & evaluation and ICT should be roped in for discussions regarding the selection of gadgets, their maintenance and policies around theft and loss.

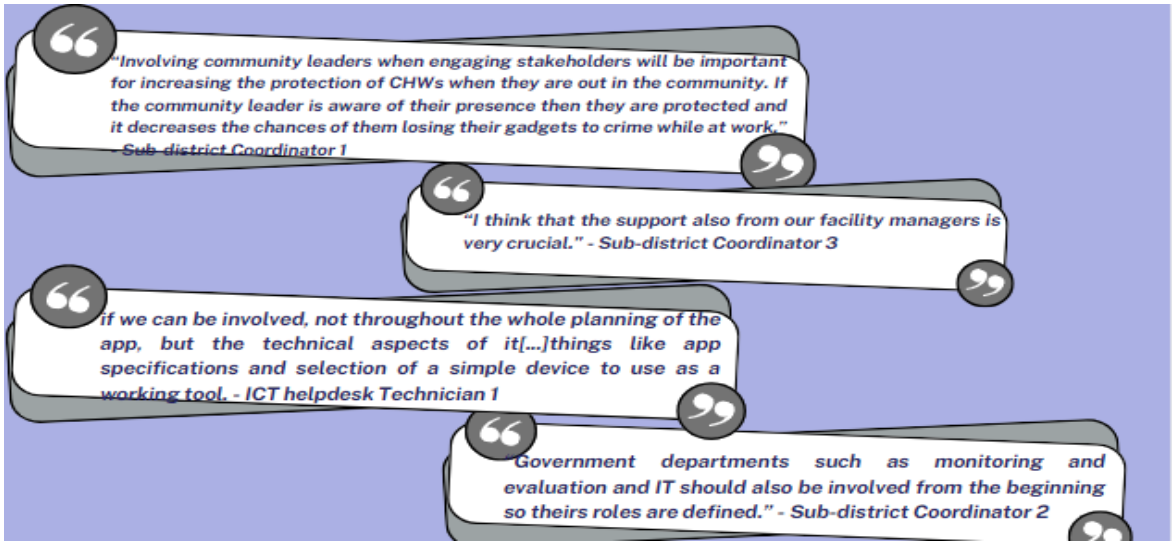

Figure 20 Quotes from key stakeholders reflecting on appropriate stakeholder engagement.

g) **Technical support:** The participants said that there is a need for ongoing technical support with the involvement of the ICT department and mHealth coordinators during the beginning stages of training and throughout the program. According to the feedback received, it is also recommended that each sub-district be assigned an ICT helpdesk technician. This recommendation is rooted in the observation that the current ratio of two technicians overseeing over 1000 devices and other digital health interventions at the district level may lead to delays and be operationally burdensome, see Figure 21 below.

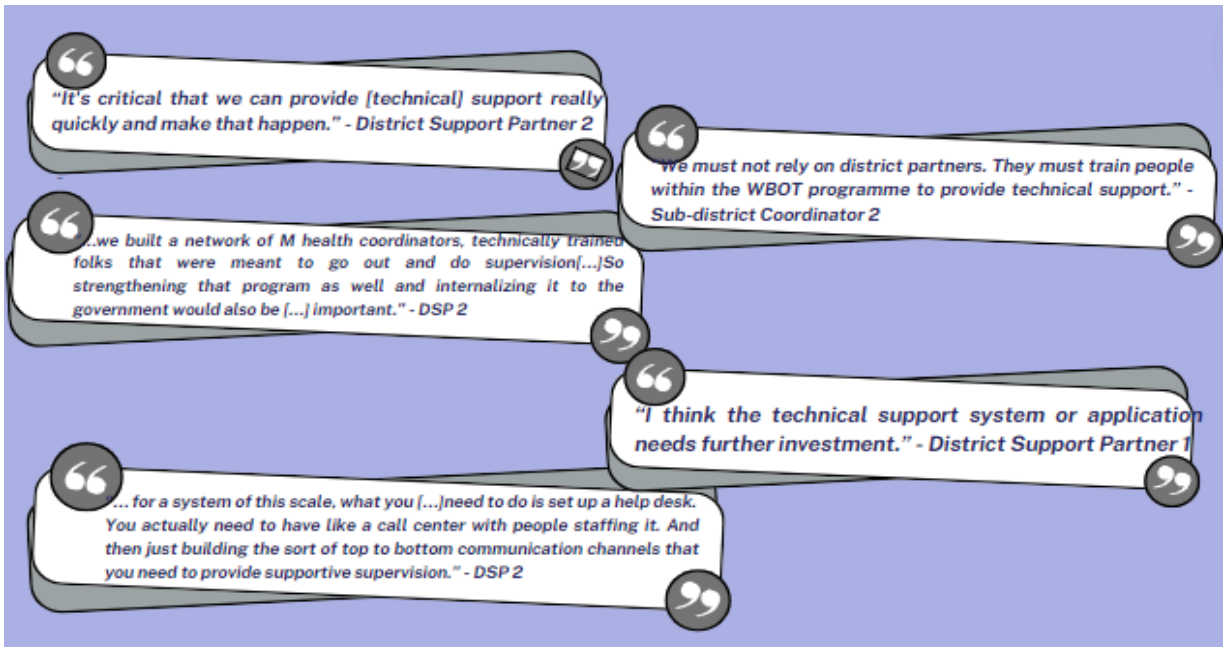

Figure 21 Quotes from key stakeholders reflecting on technical support.

h) **Governance:** A recurring challenge of governance was reported, with facility managers and WBPHCOT sub-district coordinators having different lines of reporting. A recommended solution to this was that there be one government facility to oversee the programme to avoid clashes, see Figure 22 below.

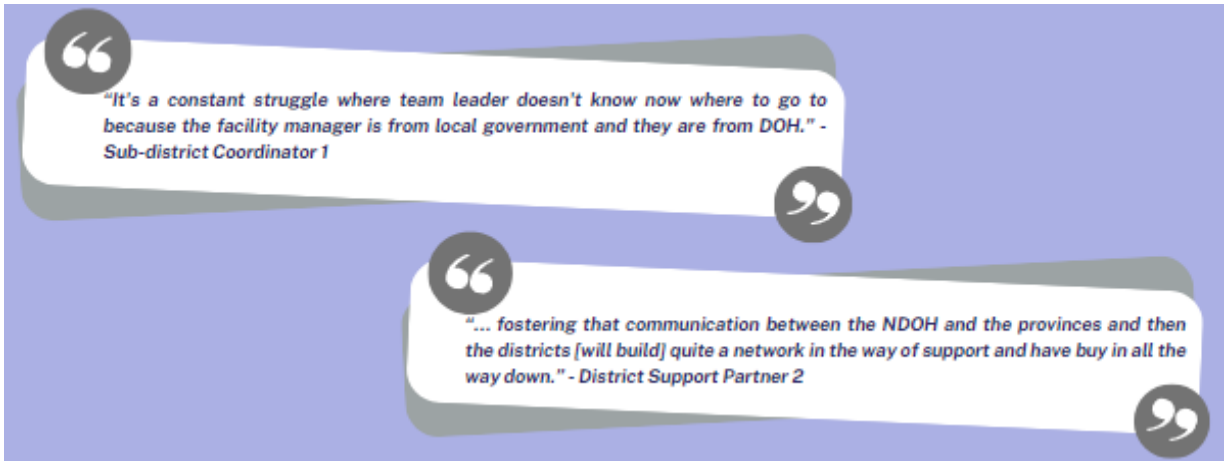

Figure 22 Quotes from key stakeholders reflecting on governance.

i) **Software Updates:** Some participants spoke about the difficulty of implementing changes and updates to the application. They suggested that the changes/updates be gathered and released once every month or every two months. They said this is because constant changes to the application can be costly and another aspect is the end-user as everyone needs to be made aware and trained. They stated that updates should be rolled out systematically to make sure that everyone is working with the same version and the changes made are accepted.

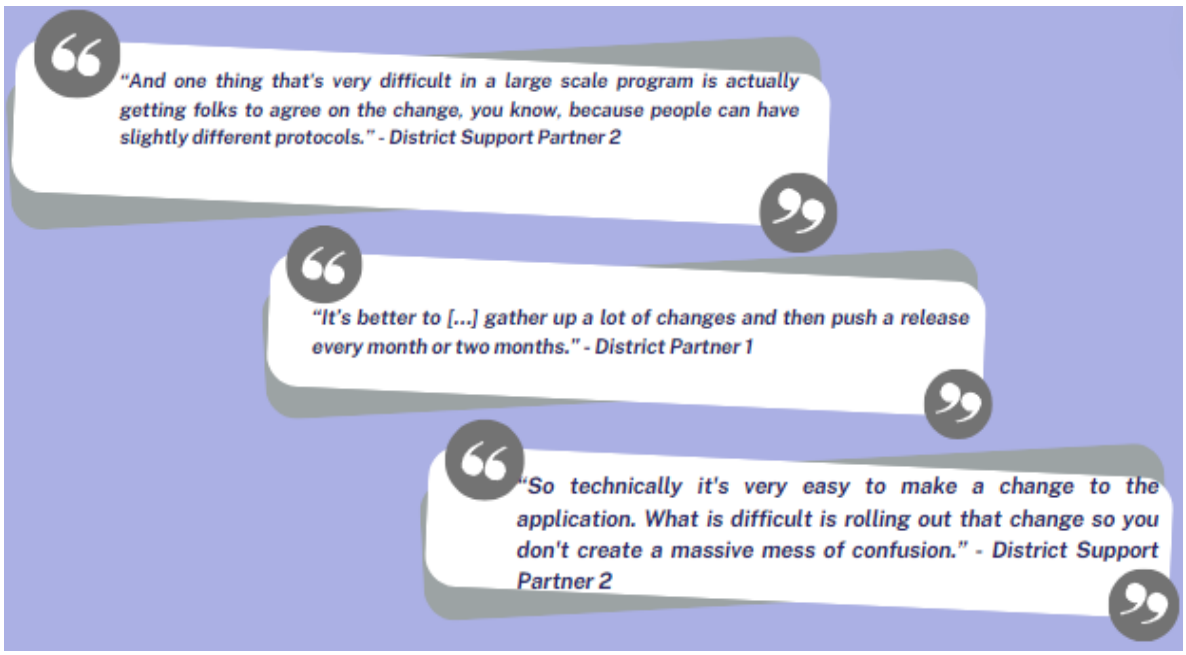

Figure 23 Quotes from key stakeholders reflecting on Change management.

The following quotes illustrated in Figure 24 below are from various key stakeholders that did not fit into any specific themes above but echo previous sentiments regarding remote monitoring of CHWs detailed narrative reports, asset management, collaboration between WBPHCOTs and facilities and connectivity issues.

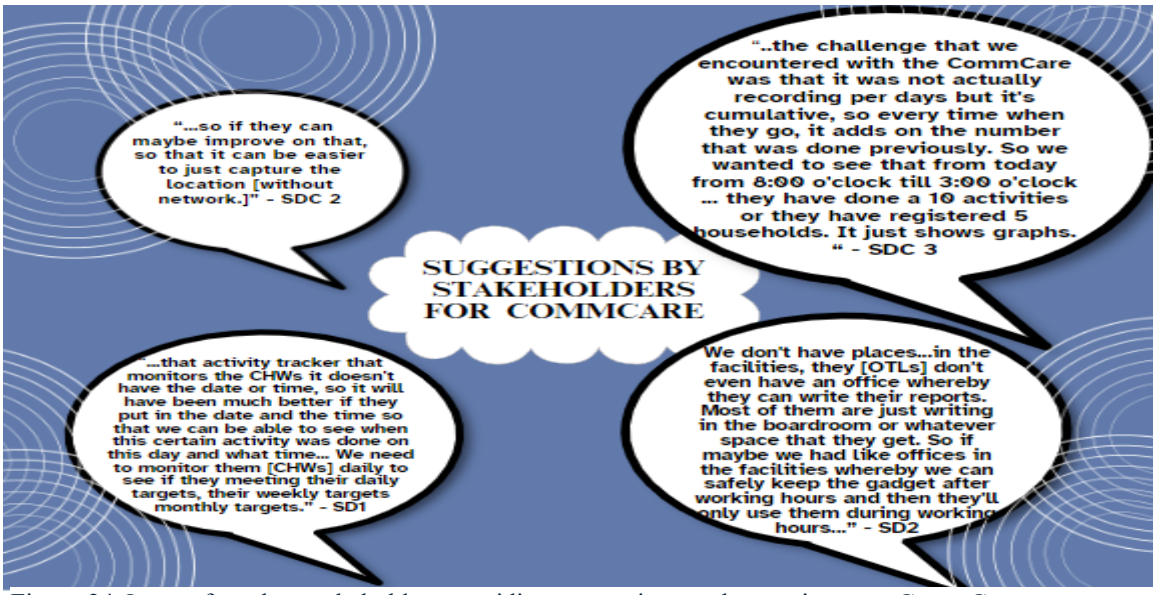

Figure 24 Quotes from key stakeholders providing suggestions on how to improve CommCare

4. Discussion

4.1 Objective 1

For a digital health intervention to be successful buy-in from implementers at a government alone is not enough to ensure sustainability (12). According to the Non-adoption, Abandonment, Scale-up, Spread, and Sustainability (NASSS) framework for studying the non-adoption and abandonment of digital health solutions by individuals and the challenges to scale-up and sustainability there are seven domains of importance. These domains are the disease/condition, technology, value proposition, adopters, organisation, wider system - environment such as the political context and evaluation (27).

In the case of WBPHCOTs there are multiple diseases and conditions that they screen, assess, and refer for social support or clinical management (25). The mHealth application CommCare's value proposition lies in its ability to tackle health system challenges by addressing issues such as inadequate quality/reliable data due to inefficient data collection and poor-quality health service delivery. (48).

To assess the domain of the adopters or end-user in order to ascertain their perceived usefulness and satisfaction with the app, elements of the Expectation-Confirmation Theory (28) and Technology Acceptance Model (29) were used.

The Expectation-Confirmation Theory is a marketing theory to measure the perceived usefulness and satisfaction of the end user following the use of the product. It measures whether the product met their pre-conceived expectations and whether they were satisfied with it during

its consumption by measuring its performance and it lastly measures the consumers repurchase intention (28).

When responding to the questionnaire about their expectations of CommCare many of the answers could be grouped under the theme Efficiency with responses such as “making my work easier,” and decreased paperwork.” The CHWs and OTLs expected CommCare to make their work easier by reducing the time taken during household visits and eliminating the use of paper in data collection. They expected the app to remind them about patients for follow-ups and for it to assist in them locating patients that need to be traced and therefore streamline potentially time-consuming processes.

As a decision support tool, the CHWs expected the app to improve the screening and referral process, leading to better quality care. They anticipated that the prompts from the app would help them enhance their clinical skills by learning about different conditions. A study conducted in Guatemala yielded similar results when CHWs utilized CommCare as a decision support tool for managing diabetic patients, resulting in improved clinical management and better glycemic control in the patients (35). An expectation that was specific to OTLs was how they expected the app to assist them with the tracing and monitoring of the activities of CHWs. Before CommCare, it was difficult to track the location of community health workers (CHWs) and monitor their productivity in the field. With an application that monitors their activities and locations, supervisors are able to better monitor the performance of the CHWs assigned to them.

Lastly, the OTLs and CHWs both emphasized their expectation of the app improving data management. They expected the app to eliminate paperwork and safely store patient information for ease of access. They also expected the app to be interoperable and feed information directly into DHIS. A study conducted in Ethiopia involving health care workers collecting routine healthcare data using an mHealth application reported positive reviews of the participants regarding improved data management (39). However, the expectation of CommCare feeding directly into DHIS was not met at this time. CommCare was not interoperable as reported by the interviewees, therefore adding further complexity to its integration into an already fragmented health system, hindering scale-up and sustainability (12).

When asked about whether CommCare met their pre-conceived expectations over 80% of the respondents reported that the app had met these expectations, and they would recommend its use amongst CHWs and OTLs in other districts. This is in keeping with a similar study in South Africa CHWs and OTLs were asked about their satisfaction with a data collection and decision support mHealth application. The findings revealed that CHWs found the mHealth application useful and easy to use and that it supported their workflow (37).

The Technology Acceptance Model (TAM) is a conceptual framework that aims to explain and predict how users accept and use technology. It is based on three main pillars: the system's features and capabilities, the user's motivation and a measurable outcome of system use. The user's motivation can be explained by three factors: 1) Perceived usefulness: This refers to the user's belief that using a particular technology will enhance their performance or make their tasks easier. 2) Perceived ease of use: This component reflects the user's perception of how easy or difficult it is to use the technology. 3) Behavioural intention: This component represents

the user's intention to use a technology based on their attitudes and perceptions of usefulness and ease of use (29)

The expectations of CommCare that were reported by the OTLs and CHWs speak to its perceived usefulness and the positive response purveying their satisfaction with the app and recommending it for WBPHCOTs in other districts sums up their behavioural intention. Both of these factors significantly influence an end-user's attitude to adopting a technology (29).

Perceived ease of use was assessed by asking about challenges experienced when using the app of which only 35% of end-users reported experiencing challenges using the app. A study in India found that CHWs who were literate and more educated had increased proficiency in using CommCare and that age was found to affect app proficiency negatively (32). The majority of the respondents within this study were above 40 years of age (55%), with stakeholders at district level reporting that a few older CHWs did have issues with using the app. Therefore, the participants' level of education may explain why so few found the app challenging, as all had at least a secondary school education.

The main challenge reported was with internet connectivity. CHWs reported that they were unable to report their activities or sync their work to the server. Because the CHWs are not able to document their work or location in areas with poor network or when they run out of data the OTLs were not able to monitor their activities or track them. An inability to use the application because of depleted data or network issues is a common issue when using mHealth apps with multiple studies in Africa citing this challenge (39,49–51). To mitigate this issue some of the CHWs would write on paper to either submit to the OTLs at the end of the day or enter the data into app once connectivity has been restored. This therefore defeats the purpose of CommCare to provide timeous and accurate data.

Product design challenges are also a common finding amongst end users with issues such as software bugs leading to the app freezing, submission errors and a lack of interoperability with other existing health information system databases (49). Amongst the challenges reported in this study, submission errors were a common response. The CHWs reported that they had problems deleting erroneous data off the app and could not remove information of deceased patients or those who have moved away. A similar study conducted in Limpopo province focused on the experience of CHWs and OTLs using an mHealth app called Mobenzi which was piloted over three years and reported similar challenges. The end-users reported that it was difficult to delete erroneous or unwanted household data (52). From the side of the OTLs they complained that a source of erroneous data was because of language barriers and the CHWs not understanding some of the phrases used while screening. This led to a suggestion that the screening tools be translated into vernacular languages for ease of use by the CHWs.

Another key suggestion for improving product design was the addition of more patient-focused elements and screening tools. Participants noted that several conditions, such as cancer, epilepsy, and asthma, were not covered. Expanding the screening capabilities would allow for broader disease detection and enable more detailed narrative reports by incorporating additional categories such as gender and age groups. This will allow for more diseases to be screened for, and further details to be added to the narrative reports with the addition of more categories such as gender and age groups. CommCare has proven to be a valuable tool for enhancing healthcare services in multiple studies, with end-users reporting improved communication and more appropriate patient care through timely and accurate information

sharing (32). In one study, CHWs who used CommCare experienced increased professional credibility and status within their communities, positively influencing how they were perceived (33). Expanding the range of diseases covered by the application would provide a more comprehensive picture of a community's health needs. It would also facilitate prompt information sharing, enhance CHWs' clinical acumen, and strengthen referrals to health facilities for a broader spectrum of conditions.

4.2 Objective 2

To assess the domains of the organization and wider system, interviews with key stakeholders at the district provided insight into certain barriers and facilitators from the implementation of CommCare within the district and throughout the project.

The initial barriers reported by stakeholders started during training and dealt with the issue of logistics and sourcing venues that were accessible for all CHWs. Because the CHWs consist of such large groups that are located across the district, it was difficult to source multiple training venues as the CHWs sometimes had trouble accessing them. To tackle this barrier there was engagement with different members of the community who in turn provided access to halls and even churches for training.

Once training began, the stakeholders at district level noted gaps in the learning paces of the CHWs based on their differences in age and education. A way to bridge this was through the pairing of CHWs who could assist each other. This finding among the stakeholders at district is in keeping with the abovementioned study conducted in India based on the proficiency of use of CommCare depending on age and literacy(32). Amongst the end-users, only 35% reported challenges and the issues reported were mainly around product design, connectivity and submission errors. The response rate for the online questionnaire directed at the end users was 39%. Although this response rate may seem low, the sample size number is still significantly large in comparison to other studies that have been conducted of a similar nature within Sub-Saharan Africa (39,41,52). However, this does leave 61% of the cohort unaccounted for who may represent some of the CHWs who were experiencing challenges during training and in using the app and may have therefore been apprehensive in accessing and responding to a digital online questionnaire.

Following training and distribution of devices, stakeholders reported that the CHWs were experiencing hardware and software challenges with the app. Some of them stated the user interface was too complex, prompting them to return to paper-based data collecting. The gadgets were also reportedly malfunctioning. Initially, support pertaining to the app came from the district support partner and software developers, Dimagi, through the answering of queries developed a support desk app that was used by OTLs. This then led to the introduction of mHealth coordinators who were employed by Aurum and were trained to provide technical support for software issues to WBPHCOTs within facilities. mHealth coordinators were considered to be highly beneficial as stated by stakeholders. However, they were not sustainable following the withdrawal of the district support partner in 2022, with their functions being carried out by the three WBPHCOT sub-district coordinators, who already have other responsibilities. This may lead to decreased turnaround times when it comes to attending to issues with the app. A study in Peru also explored the role of having on-site application

developers to assist with training of the field staff and troubleshooting. They took it a step further by also accompanying the field staff on site visits and this was found to improve data quality and app usage (36).

There are only two ICT helpdesk technicians in the district, who oversee multiple digital health interventions for various programmes across the district. For the WBPHCOT programme alone they have to oversee the functioning of over 1000 devices which can inevitably lead to service delays and in turn affect service provision and data collection on the ground. Limited access to local technicians was also a finding from the study conducted in Limpopo regarding the experience of OTLs and CHWs using the Mobenzi app. It was reported that the turnaround time for resolving certain technical issues was as long as one month. One of the discussion points in the study highlighted the importance of comprehensive planning for launching digital health interventions, emphasizing the need for adequate technical support(52).

Asset management was another major issue described by the respondents at district and sub-district level. With the increased incidences of theft and loss of gadgets reported by CHWs, the district ICT team was called on for assistance. Yet, due to the gadgets being obtained outside of government tender, there were limitations on how much they could do in terms of support or replacement of gadgets. To tackle the issue of lost or stolen gadgets the district ICT utilized the Provincial Health Department Asset Management Policy (Motshele P, 2023, personal communication, August 18) that CHWs had to sign, which included replacing their own gadgets if lost due to negligence. The signing of this document introduced a level of accountability amongst the CHWs which led to a reported decrease in incidences of theft and loss as stated by the interviewees. The district ICT team also went on a roadshow to all the facilities along with the risk management unit to explain the reporting process for theft and loss as well as housekeeping rules for devices in order to maintain warranty and theft cover. They reported that following these roadshows there was a further decrease in the incidence of theft and loss of gadgets. They attributed the initial spike in theft and loss reports to the type of device that was purchased by the district support partner. The device was described to be "fancy," and therefore likely to lead to its use outside of working hours which was reported to be the case in several incidences reported. The district ICT technicians were not involved in the initial stages of planning of the CommCare app roll-out in Ekurhuleni and were only called upon once the app was implemented. They then received training about the app from the developers. The training offered was also limited and did not involve training on the back end of the app and was more of an orientation of the app's functions, so they were able to respond to issues regarding the hardware. Therefore, when an issue was experienced regarding the actual mHealth application, they had to go through the sub-district WBPHCOT coordinator who would then communicate with the developers to have the problem resolved. The lack of capacitation of the local district ICT technicians regarding the app hinders sustainability and perpetuates a dependency on district support partners. Also, involving ICT during the initial planning stages may allow them to offer insight into the appropriate devices to be used by the CHWs. Keeping in mind that the decision on which hardware to select must be informed by finances, the type of data that needs to be collected, and a broader consideration of the social context. It is important to have an understanding of the environment into which a digital health intervention is being introduced and the circumstances of the end-user as well as those of the community (34).

The stakeholders at district reiterated issues around poor connectivity resulting from poor network coverage in certain areas and data depletion which in turn limits remote monitoring of CHWs. Some of the interviewees reported that a possible cause of data depletion may be due to personal use of data for activities unrelated to work. The complex issue of mapping that arose during the early stages of design proved to be another barrier to successful remote monitoring of CHWs. This activity entails mapping CHWs by linking them to their facilities and OTLs. During the planning phase, the interviewees at the district level reported that the mapping of the CHWs to their OTLs was not done correctly as no data about this existed previously and that due to the inaccuracies of this process, it made it difficult for them to track where some of the reports are coming from, and for OTLs to track the CHWs assigned to them. This activity needs to be repeated and documented clearly to ensure that remote monitoring is carried out efficiently.

4.3 Objective 3

The stakeholders went on to provide suggestions and best practices regarding the implementation of CommCare that will likely contribute to its successful scale-up in other districts.

The cascade model of work integrated learning and training used in the district was identified as a best practice by all interviewees. This approach allowed multiple groups to be trained in different venues within the district over a shorter period of time. In addition, this approach enabled master trainers to identify CHWs experiencing difficulties during training in smaller groups. A limitation of using this training model is that due to the multitude of master trainers it may be difficult to monitor the quality of the content that is being delivered by the master trainers and the long-term impact on app proficiency and usage (22) However, this study found that app proficiency and usage remained high even after five years.

Stakeholders emphasized the complexity of implementing a digital health intervention, recommending separate planning and implementation projects, especially for national scale-up. Implementing an mHealth intervention requires large investment in ICT infrastructure and human resources (36,49). Thus, dedicating time to the processes of planning and implementation is a logical and prudent decision (39). Following its implementation, it requires ongoing supervision, technical support and monitoring and evaluation (40,49). Very few studies provide evidence of the long-term impact of digital health interventions, and this is because of multiple factors such as a lack of sustainability as well as poor monitoring and evaluation (43). The interviewees proposed the establishment of technical teams at national level for planning and ensuring necessary infrastructure is in place before implementation.

A lack of infrastructure was identified as one of the three most common barriers in a 2019 systematic review on the use of mHealth applications to improve health outcomes (53). This concern was echoed by stakeholders, who emphasized the need for significant government investment in ICT infrastructure. One informant pointed out that, at the time of the study, CommCare data was being hosted outside the country, therefore highlighting concerns about data sovereignty and security. Additionally, stakeholders noted that CommCare is not

interoperable with DHIS, requiring manual data entry of the CommCare narrative report into the system. To effectively adopt and sustain digital health interventions, the government must invest in and maintain its own IT infrastructure and hosting capabilities to reduce reliance on external parties for data hosting and technical support. Furthermore, adequate human resource capacity is essential to ensure ongoing training and system support (49).

Early and comprehensive stakeholder engagement and involvement is imperative to the successful planning, implementation and scale up of a digital health intervention (33,38). The interviewees made mention of a comprehensive list of possible stakeholders from the community, facility and at district. A qualitative study conducted in Senegal explored the key social and cultural factors influencing the adoption of an mHealth application. One of the primary findings was that using the CommCare application positively influenced how community health workers (CHWs) were perceived within the community. The application enhanced their professional status and credibility, fostering greater trust between CHWs and community members. Strengthening the relationship between the CHWs and community could lead to greater engagement and increased uptake of health services provided by CHWs. The involvement of stakeholders, such as community leaders, can further reinforce this alliance by fostering trust and promoting the continued use of mHealth interventions. Moreover, the involvement of community stakeholders can also provide CHWs with greater protection against theft of their gadgets, ensuring the sustained use of the application in delivering healthcare services (33). At district level, departments such as Monitoring and Evaluation and ICT should be involved in the initial planning stages to provide context regarding existing IT infrastructure and capacity and assistance in asset management. Finally, at the facility level, operational managers should be orientated on the roles of CHWs and OTLs in order for the staff at facility and the WBPHCOT to function together effectively, as the data collected by the CHWs has the potential to inform their decisions at a facility level as well. Various stakeholders have mentioned that WBPHCOTs on occasion encounter difficulties with storage or office space, and that facility managers do not understand what their duties are. All of the stakeholders need to understand the complexity and magnitude of the intervention, to facilitate the various stages of the process and improve its likelihood of success (49).

Digital health interventions are designed to complement and enhance existing health systems. Successful implementation depends on the strengths of the current systems. The successful implementation of CommCare was attributed to the strong foundations of the WBPHCOT programme within Ekurhuleni Health District and the trust built with its district support partner, Aurum over the years. This led to a one-year pilot project being extended and funded for a five-year period, and allowed for the district to move away from a paper-based system to a digital health solution that ultimately benefited the district. It's crucial to note that having a health workforce, financing, leadership, and governance are fundamental components of a health system and are vital to the successful scale-up and sustainability of all health interventions (26).

4.4 Limitations

Only 464 out of 1197 invited CHWs and OTLs responded to the questionnaire, which is less than half of the target population. To mitigate this, weekly reminders were sent to the sub-district coordinators for them to encourage their OTLs and CHWs to respond to the questionnaire. A link to the online questionnaire was also sent on Whatsapp for ease of access

and sharing with OTL and CHW Whatsapp groups. The limited response rate may not fully represent the experiences and opinions of all users with those who are less technologically proficient being hesitant to respond to a digital link. However, the respondents offered valuable insights and suggestions that will be able to inform scale-up of the mHealth application within other districts.

The study relies on retrospective self-reported data over a five-year period, which can be subject to recall bias, social desirability bias, and inaccuracies. Recall bias and inaccuracies were mitigated through the cross verification of data obtained from respondents during interviews. For the end-users, social desirability bias was mitigated through the administration of an anonymous standardised questionnaire for the end-users.

Due to variations in aspects of the health system, including leadership and governance, the conclusions from this Ekurhuleni health district might not apply to other districts. However, the lessons learned, and best practices identified in this study can be applied in other districts to help strengthen their programmes to aid in the successful implementation of digital health interventions. This is because of the large sample size and solid foundation of the WBPHCOT program within Ekurhuleni health district.

The perspectives gathered are primarily from CHWs, OTLs, and district-level stakeholders. Including additional stakeholders, such as patients, community leaders, and higher-level policymakers, might have provided a more comprehensive view of the app's impact and implementation challenges. Addressing these limitations in future research could provide a more comprehensive understanding of the factors influencing the successful implementation of mHealth applications in similar settings.

5. Conclusion

In conclusion the implementation of the mHealth application CommCare in the Ekurhuleni health district revealed both significant challenges and successes over a five-year period. The respondents offered very valuable insights and suggestions. Despite the initial technological and logistical obstacles, the CommCare app largely met expectations of end-users for improved data management and optimizing the efficiency of household visits. The feedback from stakeholders emphasized the need for more robust planning and investment in ICT infrastructure and human resources prior to implementation. Early engagement with a comprehensive list of stakeholders from district, facility to community level will ensure that both the organisational, and social contexts in which the app will be implemented, are considered. The views of the end-user and technicians on the ground were also of great value when it came to suggestions for product design and device specifications. In order to ensure sustainability, it is important to capacitate those on the ground by providing technical training and increasing the technical staff complement locally to ensure smooth data collection processes and adequate app usage.

6. Recommendations

The Technological-Organizational-Environmental Framework is an organizational-level theory that explains three critical pillars within an institution's context that influence its adoption of new interventions (28). The following recommendations will be grouped under these three pillars and are proposed to enhance the implementation and scalability of CommCare and similar digital health interventions.

6.1 Technological Context

This pillar examines the technological aspects of implementing a new system or innovation, including the tools, software, infrastructure, and their ease of use or complexity (28).

- Expand the use of CommCare as a mHealth solution across the entire country, enhancing the reach and effectiveness of WBPHCOTs.
- Simplify the mHealth application's user interface to make it more accessible for all users, especially older CHWs and facility managers, reducing the need for extensive training to access reports.
- Translate screening tools into local languages to reduce comprehension barriers and improve data accuracy. Additionally, integrate screening tools for conditions not currently covered.
- Make the application zero-rated for data costs to facilitate remote monitoring and data management, ensuring users can access the app without incurring charges. Thereby promoting consistent app usage and data collection.
- Repeat the process of linking CHWs to their OTLs and facilities, and document this clearly to ensure efficient tracking and reporting.
- Invest in internal cloud services to reduce reliance on external providers, enhance data security, and ensure sustainable digital health interventions.
- To enhance data accuracy, eliminate duplication, and ensure seamless verification, CommCare should be fully interoperable with DHIS and other health information systems. Establishing system integration will enable automated data exchange, reducing reliance on user-dependent verification while ensuring consistency and reliability across platforms.

6.2 Organizational Context

This pillar considers the internal characteristics of the organization that impact technology adoption, such as organizational structure, culture, human resources, and leadership (28).

- Continue using the cascade model for training to ensure thorough and consistent instruction for all CHWs. Pair CHWs with varying levels of technological proficiency to foster peer learning and support.
- Develop local district capacity by introducing a new cadre of dedicated mHealth coordinators at the district level to provide ongoing technical support and mentorship. To address resource constraints, interns in Communications and ICT can be trained and utilized for this role.

- Strengthen district ICT capacity by employing additional helpdesk technicians and strategically allocating them to subdistricts to not only support CommCare but have the capacity to also support other digital health interventions.
- Equip ICT technicians with advanced software management skills by having software developers educate them on backend application processes to foster sustainability and reduce reliance on external support.
- Develop comprehensive asset management policies to address issues related to device loss and malfunction.
- Funding Allocation: Ringfence funding for the scale-up of digital health interventions within district budgets, with specific allocations for ICT infrastructure and human resources.
- Assess and enhance organizational readiness by leveraging the well-established processes and roles within the WBPHCOT program for the adoption and scale-up of CommCare. Furthermore, support must be provided to ensure that all WBPHCOTs in all districts are adequately prepared to handle their expanded scope to facilitate a seamless and sustainable scale-up.

6.3 Environmental Context

The last pillar looks at factors external to the organization such as legislative frameworks, the outside market and socio-cultural influence (28).

- Engage a comprehensive list of stakeholders early at the district, facility, and community levels, including community leaders, to foster buy-in and support within the socio-cultural context.
- It is recommended that similar studies be conducted in other districts to determine whether the findings are consistent in different contexts with varying health system factors.

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8. Appendices

8.1.1 Appendix A1

Appendix A1: District Level Interviews

STUDY INFORMATION DOCUMENT AND INFORMED CONSENT

Implementation of a mobile health application used by community health workers in Ekurhuleni Health District

Good day, my name is Yarumia Ndombi, and I am conducting this research as a Masters student with the School of Public Health at the University of the Witwatersrand.

I will be conducting research about a mobile health application called CommCare that was used as a data-collection and decision support tool among community health workers in Ekurhuleni Health District during the years 2017 – 2022.

I am inviting you to take part in the following research study.

The purpose of this research is to improve the process of implementation, development and scaling up of digital health interventions at all levels of government by conducting research via the use of interviews and online self-administered questionnaires with key stakeholders who were involved in the development and implementation process of rolling out a digital health intervention at Ekurhuleni Health District as well as the users of the mobile health application CommCare.

I, Yarumia, as the principal investigator will be conducting all interviews during this study and will include questions on your role during the process of implementation, overall experience and recommendations.

Your participation in this study is voluntary and you can decide to withdraw at any time. Your personal details will be kept confidential, coded and will not be disclosed in the study.

The only exceptions - and all of them are rare - would normally be:

1. personal information may be disclosed if required by law

2. the Human Research Ethics Committees of the University may exceptionally require personal data to respond to a formal complaint, or for a compliance audit.

Only collective themes and experiences will be included in the final report. There are no risks to you participating in this study. There are no direct benefits to you individually participating in this study, but the information you provide will assist towards the overall improvement of the health system.

The interview will last approximately 45 minutes to 1 hour. There are no right or wrong answers and your point of view will be received with the utmost respect. You can choose not to answer any question or say if you need clarification. The outputs of this study will be shared with you upon request.

8.1.2 Appendix A2

Appendix A2

INFORMED CONSENT

Implementation of a mobile health application used by community health workers in Ekurhuleni Health District

1. I have been given a Participant Information Sheet which explains the nature and processes involved in this study.

2. I was given time to read it, or had it read to me, in the language I best understand.

3. I was given time to ask any questions I wanted to and found any answers given to me to be reasonable and satisfactory.

4. I believe I fully understand why the study is being conducted and what the intended outcomes will be.

5. I understand that there will be no immediate benefit to me, should I agree to participate, nor will I receive any payment; conversely, participation will not cost me anything but my time.

6. I understand that, even if I initially consent to take part in the study, I may subsequently withdraw at any time and would not be required to give any reasons; if that happened, any data collected about me for the purposes of the study would immediately be destroyed, unless I give consent for it to be retained

7. I have been given a range of contact details, listed below. If I require further information or become concerned about any aspect of this study I am free to speak to any of these contacts.

If you have any concerns or are in need of any further clarification concerning this study please do not hesitate to contact me.

Dr Yarumia Ndombi (Principal Investigator)

Telephone no: 0671200028

e-mail: Yarumia.Ndombi@gauteng.gov.za

If you consent to participate in this research study please complete the following:

Name of Participant: _____

Date: _____

Place: _____

Signature or mark _____

8.1.3 Appendix A3

Appendix A3: District Level Interviews – WBPHCOT Sub-district Co-ordinator Questions

These questions will administered via interview to the three WBPHCOT sub-district co-ordinators.

1. What was your role in the implementation of CommCare?
2. Describe your experience of the implementation of CommCare?
3. What is your understanding of mobile health application interventions and what were your expectations of such an intervention within the district?
4. Did you receive any training to assist you with your duties during the process?
5. How long did the process take and what steps were involved? (ie. Planning, training, implementation)
6. What were some of the challenges you experienced during each step of the process?
7. How did you overcome these challenges?
8. What were the highlights or achievements that you experienced during the process?
9. What resources or support systems were available to you during this process?
10. Based on the needs of the CHWs and the district, what factors did you consider when designing the application?
11. What changes would you make to the existing application?
12. What recommendations would you have for scaling up a digital health intervention?

8.2.1 Appendix B1

Appendix B1: District Partner Interviews

STUDY INFORMATION DOCUMENT AND INFORMED CONSENT

Implementation of a mobile health application used by community health workers in Ekurhuleni Health District

Good day, my name is Yarumia Ndombi, and I am conducting this research as Masters student with the School of Public Health at the University of the Witwatersrand.

I will be conducting research about a mobile health application called CommCare that was used as a data-collection and decision support tool among community health workers in Ekurhuleni Health District during the years 2017 – 2022.

I am inviting you to take part in the following research study.

The purpose of this research is to improve the process of implementation, development and scaling up of digital health interventions at all levels of government by conducting research via the use of interviews and online self-administered questionnaires with key stakeholders who were involved in the development and implementation process of rolling out a digital health intervention at Ekurhuleni Health District as well as the users of the mobile health application (CommCare).

I, Yarumia, as the principal investigator will be conducting all interviews during this study and will include questions on your role during the process of implementation, overall experience and recommendations.

Your participation in this study is voluntary and you can decide to withdraw at any time. Your personal details will be kept confidential, coded and will not be disclosed in the study.

The only exceptions - and all of them are rare - would normally be:

1. personal information may be disclosed if required by law

2. the Human Research Ethics Committees of the University may exceptionally require personal data to respond to a formal complaint, or for a compliance audit

Only collective themes and experiences will be included in the final report. There are no risks to you participating in this study. There are no direct benefits to you individually participating in this study, but the information you provide will assist towards the overall improvement of the health system.

The interview will last approximately 45 minutes to 1 hour. There are no right or wrong answers and your point of view will be received with the utmost respect. You can choose not to answer any question or say if you need clarification. The outputs of this study will be shared with you upon request.

8.2.2 Appendix B2

Appendix B2

INFORMED CONSENT

Implementation of a mobile health application used by community health workers in Ekurhuleni Health District

1. I have been given a Participant Information Sheet which explains the nature and processes involved in this study.

2. I was given time to read it, or had it read to me, in the language I best understand.

3. I was given time to ask any questions I wanted to and found any answers given to me to be reasonable and satisfactory.

4. I believe I fully understand why the study is being conducted and what the intended outcomes will be.

5. I understand that there will be no immediate benefit to me, should I agree to participate, nor will I receive any payment; conversely, participation will not cost me anything but my time.

6. I understand that, even if I initially consent to take part in the study, I may subsequently withdraw at any time and would not be required to give any reasons; if that happened, any data collected about me for the purposes of the study would immediately be destroyed, unless I give consent for it to be retained

7. I have been given a range of contact details, listed below. If I require further information or become concerned about any aspect of this study I am free to speak to any of these contacts.

If you have any concerns or are in need of any further clarification concerning this study please do not hesitate to contact me.

Dr Yarumia Ndombi (Principal Investigator)

Telephone no: 0671200028

e-mail: Yarumia.Ndombi@gauteng.gov.za

If you consent to participate in this research study please complete the following:

Name of Participant: _____

Date: _____

Place: _____

Signature or mark _____

8.2.3 Appendix B3

Appendix B3: District Partner Interviews – Aurum/Dimagi/CosmoNet Questions

These questions will be administered via interview to three different representative key informants from each of the respective district partner organizations.

1. What was your role in the implementation of CommCare?
2. Describe your experience of the implementation of CommCare?
3. What is your understanding of mobile health application interventions and what were your expectations of such an intervention within the district?
4. How long did the process take and what steps were involved? (Logistics, funding, asset management)
5. What were some of the challenges you experienced during each step of the process?
6. How did you overcome these challenges?
7. What were the highlights or achievements that you experienced during the process?
8. What changes would you make to the existing application or infrastructure?
9. What recommendations would you have for scaling up a digital health intervention?

8.3.1 Appendix C1

Appendix C1: District Level Interviews

STUDY INFORMATION DOCUMENT AND INFORMED CONSENT

Implementation of a mobile health application used by community health workers in Ekurhuleni Health District

Good day, my name is Yarumia Ndombi, and I am conducting this research as Masters student with the School of Public Health at the University of the Witwatersrand.

I will be conducting research about a mobile health application called CommCare that was used as a data-collection and decision support tool among community health workers in Ekurhuleni Health District during the years 2017 – 2022.

I am inviting you to take part in the following research study.

The purpose of this research is to improve the process of implementation, development and scaling up of digital health interventions at all levels of government by conducting research via the use of interviews and online self-administered questionnaires with key stakeholders who were involved in the development and implementation process of rolling out a digital health intervention at Ekurhuleni Health District as well as the users of the mobile health application (CommCare).

I, Yarumia, as the principal investigator will be conducting all interviews during this study and will include questions on your role during the process of implementation, overall experience and recommendations.

Your participation in this study is voluntary and you can decide to withdraw at any time. Your personal details will be kept confidential, coded and will not be disclosed in the study.

The only exceptions - and all of them are rare - would normally be:

1. personal information may be disclosed if required by law

2. the Human Research Ethics Committees of the University may exceptionally require personal data to respond to a formal complaint, or for a compliance audit

Only collective themes and experiences will be included in the final report. There are no risks to you participating in this study. There are no direct benefits to you individually participating in this study, but the information you provide will assist towards the overall improvement of the health system.

The interview will last approximately 45 minutes to 1 hour. There are no right or wrong answers and your point of view will be received with the utmost respect. You can choose not to answer any question or say if you need clarification. The outputs of this study will be shared with you upon request.

8.3.2 Appendix C2

Appendix C2

INFORMED CONSENT

Implementation of a mobile health application used by community health workers in Ekurhuleni Health District

1. I have been given a Participant Information Sheet which explains the nature and processes involved in this study.

2. I was given time to read it, or had it read to me, in the language I best understand.

3. I was given time to ask any questions I wanted to and found any answers given to me to be reasonable and satisfactory.

4. I believe I fully understand why the study is being conducted and what the intended outcomes will be.

5. I understand that there will be no immediate benefit to me, should I agree to participate, nor will I receive any payment; conversely, participation will not cost me anything but my time.

6. I understand that, even if I initially consent to take part in the study, I may subsequently withdraw at any time and would not be required to give any reasons; if that happened, any data collected about me for the purposes of the study would immediately be destroyed, unless I give consent for it to be retained

7. I have been given a range of contact details, listed below. If I require further information or become concerned about any aspect of this study I am free to speak to any of these contacts.

If you have any concerns or are in need of any further clarification concerning this study please do not hesitate to contact me.

Dr Yarumia Ndombi (Principal Investigator)

Telephone no: 0671200028

e-mail: Yarumia.Ndombi@gauteng.gov.za

If you consent to participate in this research study please complete the following:

Name of Participant: _____

Date: _____

Place: _____

Signature or mark _____

8.3.3 Appendix C3

Appendix C3: District Level Interviews – Information Communication Technological (ICT) Support

These questions will be administered via interview to two staff members at ICT Support at Ekurhuleni Health District who were involved in the implementation of CommCare

1. What was your role in the implementation of CommCare?
2. Describe your experience of the implementation of CommCare?
3. What is your understanding of mobile health application interventions and what were your expectations of such an intervention within the district?
4. How ready was the district to implement a mobile health application?
5. What were some of the challenges you experienced during each step of the process?
6. How did you overcome these challenges?
7. What were the highlights or achievements that you experienced during the process?
8. What resources or support systems were available to you during this process?
9. Based on the needs of the CHWs and the district, what factors did you consider when developing the application?
10. What changes would you make to the existing application or infrastructure?
11. What recommendations would you have for scaling up a digital health intervention?

- *(Prompts: Security issues, infrastructure, supply chain, funding, logistics, asset management)*

8.4.1 Appendix D1

Appendix D1: Facility Level Self-Administered Questionnaire

STUDY INFORMATION DOCUMENT AND INFORMED CONSENT

Implementation of a mobile health application used by community health workers in Ekurhuleni Health District

Good day, my name is Yarumia Ndombi, and I am conducting this research as Masters student with the School of Public Health at the University of the Witwatersrand.

I will be conducting research about a mobile health application called CommCare that was used as a data-collection and decision support tool among community health workers in Ekurhuleni Health District during the years 2017 – 2022.

I am inviting you to take part in the following research study.

The purpose of this research is to improve the process of implementation, development and scaling up of digital health interventions at all levels of government by conducting research via the use of interviews and online self-administered questionnaires with key stakeholders who were involved in the development and implementation process of rolling out a digital health intervention at Ekurhuleni Health District as well as the users of the mobile health application (CommCare).

This questionnaire has been developed for research purposes to gain insight on your experience using the CommCare app, your satisfaction with the application and whether it was a useful intervention for the WBPHCOT programme.

Your participation in this study is voluntary and you can decide to withdraw at any time. Your personal details will be kept confidential, coded and will not be disclosed in the study. Only collective themes and experiences will be included in the final report. There are no risks to you participating in this study. There are no direct benefits to you individually participating in this study, but the information you provide will assist towards the overall improvement of the health system.

The questionnaire should take approximately 20 minutes to complete. There are no right or wrong answers and your point of view will be received with the utmost respect. The outputs of this study will be shared with you upon request.

8.4.2 Appendix D2

Appendix D2

INFORMED CONSENT

Implementation of a mobile health application used by community health workers in Ekurhuleni Health District

1. I have been given a Participant Information Sheet which explains the nature and processes involved in this study.

2. I was given time to read it, or had it read to me, in the language I best understand.

3. I was given time to ask any questions I wanted to and found any answers given to me to be reasonable and satisfactory.

4. I believe I fully understand why the study is being conducted and what the intended outcomes will be.

5. I understand that there will be no immediate benefit to me, should I agree to participate, nor will I receive any payment; conversely, participation will not cost me anything but my time.

6. I understand that, even if I initially consent to take part in the study, I may subsequently withdraw at any time and would not be required to give any reasons; if that happened, any data collected about me for the purposes of the study would immediately be destroyed, unless I give consent for it to be retained

7. I have been given a range of contact details, listed below. If I require further information or become concerned about any aspect of this study I am free to speak to any of these contacts.

If you have any concerns or are in need of any further clarification concerning this study please do not hesitate to contact me.

Dr Yarumia Ndombi (Principal Investigator)

Telephone no: 0671200028

e-mail: Yarumia.Ndombi@gauteng.gov.za

If you consent to participate in this research study please complete the following:

Name of Participant: _____

Date: _____

Place: _____

Signature or mark _____

8.4.3 Appendix D3

Appendix D3: Facility Level Self-administered questionnaire – OTLs/CHWs

These questions will be administered via a questionnaire online to Outreach Team Leaders & Community Health Workers at facility level.

Demographics

Age:

Highest level of education:

- Grade 0 -7
- Grade 7 – 9
- Grade 9 – 12
- Tertiary qualification

Gender:

- Male
- Female
- Other

If you ticked 'other' please indicate what gender you identify with

_____

Q1. What is your role in the WBOT Program?

- OTL
- CHW

Q2. When CommCare was introduced, what did you expect it to help you with? (Open ended)

_____

_____

_____

Q3. Did the application meet your expectations?

- Yes
- No
- Neutral

Q4. Was the training you received enough to use the app?

- Yes
- No
- Neutral

Q5. Were you satisfied with the performance of the app?

- Yes

- No
- Neutral

Q6. Did you experience any challenges when using CommCare?

- Yes
- No
- Neutral

Q6. What were those challenges (Open ended)

_____

_____

_____

Q7. Did you find the Helpdesk (ICT) helpful when you had problems with the app?

- Yes
- No
- Neutral

Q8. Would you recommend for CommCare to be used by other districts?

- Yes
- No
- Neutral

Q9. Would you change anything about CommCare and if so what would you change? (Open ended)

_____

_____

_____

8.5 Appendix E (Ethics Clearance Certificate)

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG	HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

Office of the Deputy Vice-Chancellor (Research and Innovation)

TO:	Dr Y Ndombi School of Public Health Department of Community Health Medical School University E-mail: Yanumia.Ndombi@wits.ac.za
CC:	Supervisor: Professor L Thomas and Dr H Somaroo <thomasleenas@gmail.com> and <HREC-Medical Research Office@wits.ac.za>
FROM:	Mr Iain Burns Human Research Ethics Committee (Medical) Tel: 011 717 1252 E-mail: Iain.Burns@wits.ac.za
DATE:	2023/06/30
REF:	R14/49
PROTOCOL NO:	**M230425** (This is your ethics application reference number. Please quote it in all enquiries, oral or written, relating to this study.)
PROJECT TITLE:	*Implementation of a mobile health application used by community health workers in Ekurhuleni Health District*

Please find attached the Clearance Certificate for the above project. I hope it goes well and that an article in a recognized publication comes out of it. This will reflect well on your professional standing and contribute to Government funding of the University.

MSWorks2000\Iain0007\Clearscan.wps

UNIVERSITY OF THE WITWATERSRAND JOHANNESBURG

R49 Dr Y Ndombi

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
CLEARANCE CERTIFICATE NO. M230425

NAME: (Principal Investigator)	Dr Y Ndombi
DEPARTMENT:	School of Public Health Department of Community Health Medical School University
PROJECT TITLE:	*Implementation of a mobile health application used by community health workers in Ekurhuleni Health District*
DATE CONSIDERED:	2023/05/05
DECISION:	Approved unconditionally
CONDITIONS:	
NOTE:	If contact information regarding student study participants is required, please contact the Registrar's office - <Nicoleen.Potgieter@wits.ac.za>
SUPERVISOR:	Professor L Thomas and Dr H Somaroo
APPROVED BY:	Dr CB Penny, Chairperson, HREC (Medical)
DATE OF APPROVAL:	2023/06/30 **EXPIRY DATE:** 2028/06/29

This Clearance Certificate is valid for 5 years from the date of approval. An extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office secretariat on the 3rd floor, Phillip Tobias Building, Parktown, University of the Witwatersrand, Johannesburg.

I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated from the research protocol as approved, I/we undertake to submit details to the Committee. **I agree to submit a yearly progress report.** When a funder requires annual re-certification, the application date will be one year after the date when the study was initially reviewed. In this case, the study was initially reviewed in **April** and therefore reports and re-certification will be due in the month of **April** each year. Unreported changes to the study may invalidate the clearance given by the HREC (Medical).

Signature of Principal Investigator

30/06/2023

Date

8.6 Appendix F (District Permission Letter)

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

EKURHULENI HEALTH DISTRICT
PUBLIC HEALTH UNIT

Enquiries: Mpho Manamela
Tel no: +27 11 878 8617
Fax no: +27 11 878 8587
E-mail: Mpho.Manamela@gauteng.gov.za
04 NOVEMBER 2022

To: Ethics Committee, University of Witwatersrand

SUBJECT: IN-PRINCIPLE PERMISSION TO CONDUCT RESEARCH BY DR YARUMIA NDOMBI AT EKURHULENI DISTRICT, GAUTENG.

In-principle permission is granted to Yarumia Ndombi from University of Witwatersrand to conduct research in Ekurhuleni district for the following research topic: The implementation of an mHealth application used by community health workers in Ekurhuleni Health District, Lessons Learnt

AIMS
The aim of this study is to describe the implementation of a digital health intervention used by community health workers within Ekurhuleni Health District setting, and document the lessons learned with the broader intent of informing efforts to replicate and/or scale-up implementation of the intervention.

OBJECTIVE
1. To identify facilitators and barriers to the implementation of a digital health intervention amongst different study participants.
2. To obtain perspectives of different stakeholder groups in form of best practices and lessons learned on their involvement in the implementation of a digital health intervention within Ekurhuleni Health District.
3. To describe perceived usefulness and end-user satisfaction amongst the OTLs and CHWS in using the CommCare app.

Data collection tool
In-depth interviews will be conducted at district level as well as with NGO partners.

Ekurhuleni District Research Committee will review the proposal and will only give permission once we have received the final ethical clearance.

Yours sincerely,

Dr Ronel Kellerman
EKURHULENI DISTRICT RESEARCH COMMITTEE CHAIRPERSON
Date: 04 November 2022

40 Cullin Street, Germiston, 1401 – Private Bag X 1005, Germiston, 1400

8.7 Appendix G (Plagiarism Declaration)

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

FACULTY OF HEALTH SCIENCES

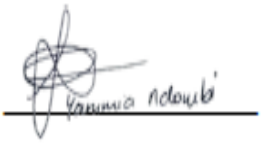
PLAGIARISM DECLARATION TO BE SIGNED BY ALL HIGHER DEGREE STUDENTS

SENATE PLAGIARISM POLICY: APPENDIX ONE

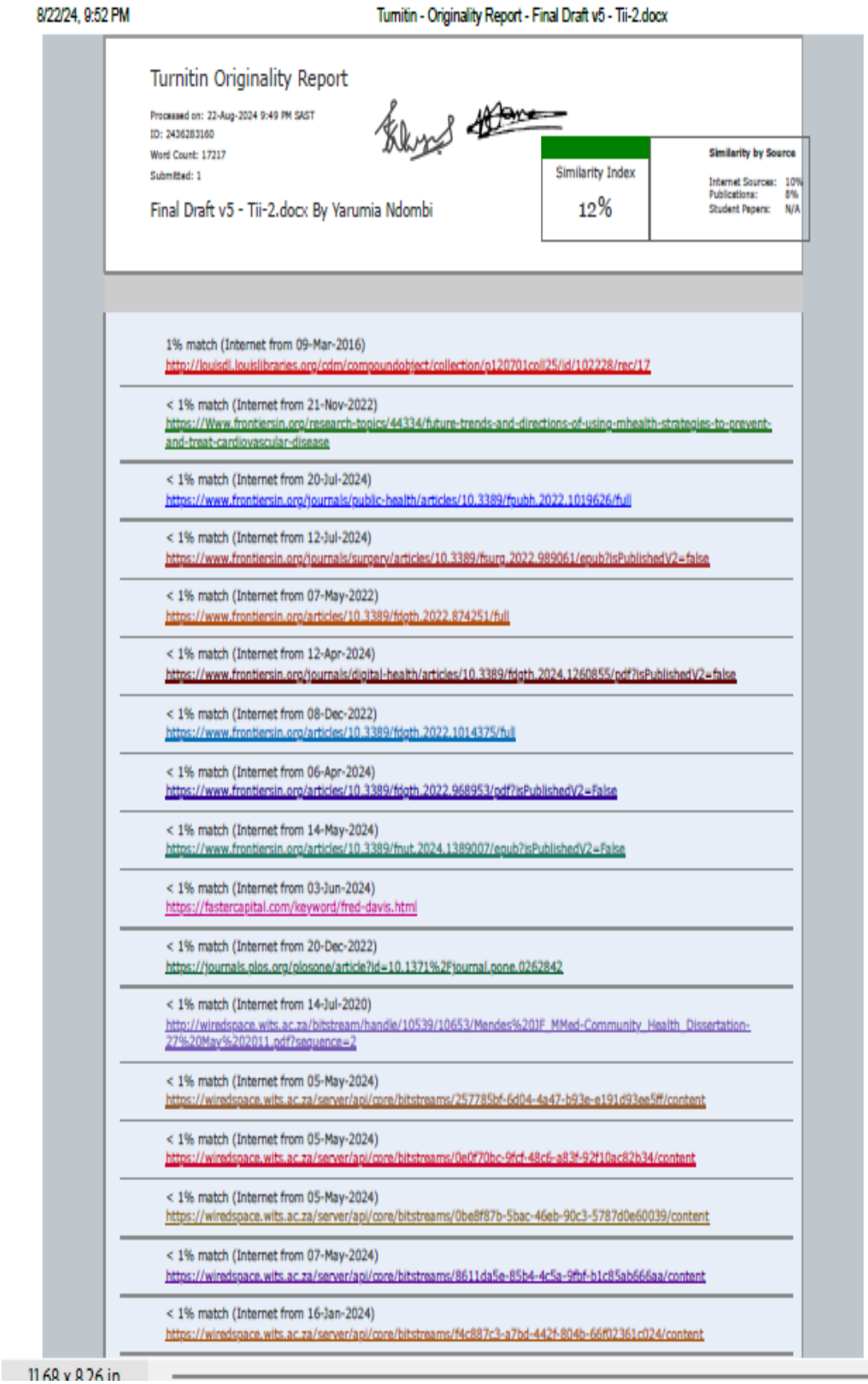
I Yarumia Ndombi (Student number: 349300) am a student registered for the degree of MMed Community Health in the academic year 2024.

I hereby declare the following:

- I am aware that plagiarism (the use of someone else's work without their permission and/or without acknowledging the original source) is wrong.
- I confirm that the work submitted for assessment for the above degree is my own unaided work except where I have explicitly indicated otherwise.
- I have followed the required conventions in referencing the thoughts and ideas of others.
- I understand that the University of the Witwatersrand may take disciplinary action against me if there is a belief that this is not my own unaided work or that I have failed to acknowledge the source of the ideas or words in my writing.
- I have included as an appendix a report from "Turnitin" (or other approved plagiarism detection) software indicating the level of plagiarism in my research document.

Signature:  Date: 27 August 2024

8.8 Appendix H (Turnitin Report)



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