UNIVERSITY OF KWAZULU-NATAL

Reducing Under-Five Mortality in Makonde District's Public Healthcare Institutions: An Exploratory Investigation into the Potential Role of Emerging Technologies

By

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PUBLICATIONS

This study produced five research papers, three conference papers and two journal articles. All the papers were submitted to DHET-approved outlets. One journal paper was published, and another is under review (first revision). The papers are listed below.

1. **J. Batani** and M. S. Maharaj, "Towards Data-Driven Pediatrics in Zimbabwe," *2022 International Conference on Artificial Intelligence, Big Data, Computing and Data Communication Systems (icABCD)*, Durban, South Africa, 2022, pp. 1-7, doi: https://doi.org/10.1109/icABCD54961.2022.9855907
2. **J. Batani** and M. S. Maharaj, "A Framework for the Adoption of Emerging Technologies to Reduce Under-Five Mortality in Zimbabwe," *2023 Conference on Information Communications Technology and Society (ICTAS)*, Durban, South Africa, 2023, pp. 1-6, doi: https://doi.org/10.1109/ICTAS56421.2023.10082723
3. **John Batani** and Manoj Maharaj (2022). *Towards data-driven models for diverging emerging technologies into maternal, neonatal and child health services in Sub-Saharan Africa: a review*, Global Health Journal, 6(4), 183-191. https://doi.org/10.1016/j.glohj.2022.11.003
4. **John Batani** and Manoj Maharaj (under review, first revision submitted 1 February 2023), *The role of emerging digital technologies in reducing under-five mortality in a low-resource setting: Perceptions of public health workers in Makonde District, Zimbabwe*, Journal of Child Health Care
5. **John Batani** and Manoj Sewak Maharaj. "A Deep Learning Model for Predicting Under-Five Mortality in Zimbabwe", *2023 International Conference on Artificial Intelligence, Big Data, Computing and Data Communication Systems (icABCD)*, Durban, South Africa

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DEDICATION

To my son, McJohn, I dedicate this thesis. I am proud of you, my boy, and you will only understand this when you grow up. With all my love, this is for you.

ACRONYMS

AI	Artificial Intelligence
CA CEO	Capability Approach Chief Executive Officer
COVID-19	Coronavirus diseases 2019
CPH	Chinhoyi Provincial Hospital
DOI	Diffusion of Innovation
DMO	District Medical Officer
DNO	District Nursing Officer
DL	Deep learning
DHIO	District Health Information Officer
DHSA	District Health Services Administrator
DEHO	District Environmental Health Officer
E-health	Electronic health
EHT	Environmental Health Technician
EMR	Electronic Medical Record
EPI	Expanded Programme on Immunisation
FGD	Focus Group Discussion
GoZ	Government of Zimbabwe
HCP	Healthcare professional
HIO	Health Information Officer

HSSREC	Humanities and Social Sciences Research Ethics Committee
ICT	Information and communication technology
IoT	Internet of Things
MIoT	Medical Internet of Things
MMR	Maternal Mortality Rate
SPSS	Statistical Package for the Social Sciences
TV	Television
U5M	Under-five mortality
UNICEF	United Nations Children's Fund
UNECA	United Nations Economic Commission for Africa
U5MR	Under-five mortality rate
UKZN	University of KwaZulu-Natal
UTAUT	Unified Theory of Acceptance and Use of Technology
UNDP	United Nations Development Programme
UN IGME	United Nations Inter-agency Group for child Mortality Estimation
5G	5^{th} Generation
3D	Three dimensional
OI	Osteogenesis Imperfecta
PCN	Primary Care Nurse
PMD	Provincial Medical Director
PHC	Primary Health Care

PICTO	Provincial ICT Officer
ML	Machine learning
MRCZ MRDC	Medical Research Council of Zimbabwe Makonde Rural District Council
MoHCC	Ministry of Health and Child Care
MoHCW	Ministry of Health and Child Welfare
IoT	Internet of things
RBF	Result-Based Funding
RGN	Registered General Nurse
RQ	Research question
RDC	Rural District Council
RHC	Rural Health Centre
RO	Research objective
SDGs	Sustainable Development Goals
MDGs	Millennium Development Goals
VHW	Village Health Worker
UN	United Nations
WHO	World Health Organisation
MICS	Multiple Indicator Cluster Survey
WSN ZESA	wireless sensor networks Zimbabwe Electricity Supply Authority

ZIMSTAT	Zimbabwe National Statistics Agency

ABSTRACT

Under-five mortality rate remains unacceptably high globally, with Sub-Saharan Africa being the region with the worst under-five mortality outcomes. The United Nations reported that an average of 15 000 under-fives died daily in 2018, translating to 5.3 million under-fives dying annually. The United Nations Inter-agency Group for Child Mortality Estimation (UN IGME) estimated that up to 5.5 million under-fives died in 2021. The outbreak of the Coronavirus Disease 2019 (COVID-19) worsened the situation for child healthcare in low-resource settings due to overwhelmed and strained healthcare systems. Promoting the health and well-being of under-fives remains a priority of the United Nations and its member states, as evidenced by the setting of under-five mortality goals in both the expired Millennium Development Goals and the current Sustainable Development Goals. Globally, under-five mortality outcomes are meagrely improving, registering a 4 per cent improvement in 18 years. Zimbabwe is one of the countries with high under-five mortality rates, with the Midlands and Mashonaland West provinces having the worst under-five mortality rates, according to the 2019 Multiple Indicator Cluster Survey (MICS) report. Despite the evidence of emerging technologies helping to reduce under-five mortality rates in other regions and countries like the United States of America, the United Kingdom and South-West Nigeria, the potential of such technologies to reduce under-five mortality rates in Zimbabwe's public healthcare institutions has not been explored. Although Zimbabwe has registered improvements in under-five mortality rates over the years through such programmes as free healthcare for under-fives in public health facilities, child immunisation programmes, provision of nutritional supplements and prevention of mother-to-child transmission (PMTCT), the rates are still unacceptably high and above the SDG target of 23 per 1 000 live births, making Zimbabwe ranked amongst the fifty countries with the highest early childhood mortality in the world. The country's poor under-five mortality rates suggest that the existing methods need to be complemented by different approaches. Guided by three theoretical frameworks, the Diffusion of Innovation, the Unified Theory of Acceptance and Use of Technology and the Capabilities Approach, the researcher explored the potential role of emerging technologies in reducing under-five mortality in Makonde District, Zimbabwe. The key deliverables of this study included a framework for the adoption of emerging technologies to reduce under-five mortality in resource-constrained settings like Makonde district. An exploratory sequential mixed-methods design was used, in which 20 healthcare professionals from Makonde public health facilities participated in interviews and a focus group, while 90 healthcare professionals and 391 mothers of under-five children responded to questionnaires. The researcher used purposive and snowball sampling to identify interview and focus group participants, where experience and whether one works in the paediatric ward, works with children or pregnant women were critical considerations. Mothers of under-fives were randomly sampled. The study revealed that the participants arguably value under-fives the most and would accept any technology intended to improve their health and wellbeing. They perceive emerging technologies as helpful in areas like improving diagnosis, minimising loss to follow-ups and providing data-driven, evidence-based and personalised paediatrics. The impediments to adoption included the fear of medico-legal hazards, centralisation of digital health decision-making, network problems, resistance to change and demoralised workforce. There is generally poor knowledge of emerging technologies by healthcare professionals in Makonde District. The study proffers recommendations on what needs to be done for emerging technologies to be adopted in Makonde District's public healthcare institutions to reduce under-five mortality. An adoption framework is also presented.

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CHAPTER 1: Introduction

1.1 Introduction

Under-five mortality (U5M) remains high globally, with an average of 15 068 mortalities per day as of 2020, translating to 5.5 million under-fives dying in the year (UN IGME, 2021), up from 5.3 million in 2018 (UN IGME, 2019). The outbreak of the Coronavirus Disease 2019 (COVID-19) threatened the progress that had been made towards reducing under-five mortality as resources were redeployed to fight the pandemic (Batani & Maharaj, 2022b; Roberton et al., 2020) and healthcare institutions were overwhelmed by COVID-19 patients (Mbunge, Dzinamarira, Fashoto, & Batani, 2021; UN IGME, 2021). Some under-five children missed critical routine immunisations due to the indirect effects of COVID-19, such as breakdowns in supply chains, redeployment of healthcare personnel for COVID-19 purposes (Batani & Maharaj, 2022b) and national lockdowns, exposing children to preventable deaths (Roberton et al., 2020; Save the Children Fund, 2020). Without technology, tracking those under-fives who missed immunisation becomes a daunting task (Batani & Maharaj, 2022a).

There is an increasing global effort to promote child health and survival (UN IGME, 2020). However, the growing global drive and investment to accelerate child survival call for increased progress monitoring globally and nationally (UNICEF, 2019). Despite having been on the global agenda of the United Nations (UN) between 2000 and 2015 in the Millennium Development Goals (MDGs), U5M remains unacceptably high globally (Mbunge, Chemhaka, et al., 2022; UN IGME, 2020, 2021). This problem led to the UN setting new under-five mortality targets in the current Sustainable Development Goals (SDGs), which came into effect in 2015 and will remain valid through 2030 (The United Nations, 2015; World Health Organization, 2019). However, the outbreak of the Coronavirus Disease 2019 (COVID-19) threatens to jeopardise the achievement of the United Nations Sustainable Development Goal (SDG) 3.2 target on under-five mortality, with at least fifty countries at risk of failing to attain it (UN IGME, 2021). Although there is a dearth of evidence to suggest that COVID-19 killed many under-fives (RCPCH, 2020; Ruel & Headey, 2021; Save the Children Fund, 2020), its indirect effects like resource reassignment, lockdowns, overburdened healthcare systems, and disrupted medical supply chains had consequences on child health, such as missed or delayed immunisations (Gupta & Jawanda, 2020; RCPCH, 2020; Roberton et al., 2020; Save the Children Fund, 2020).

There has been a global under-five mortality decline of approximately 4 per cent in the 18 years ending 2018 (UN IGME, 2019), with an average annual improvement of about 0.22 per cent. A 4 per cent decline in under-five mortality over nearly two decades is a minor improvement that is insufficient to ensure the attainment of the SDG 3.2 target (Sachs et al., 2016; UNECA, 2015). Given the failure of many developing countries to achieve the MDGs' under-five mortality targets (UNDP Zimbabwe, 2015c), coupled with the threat posed by COVID-19's effects, there is a need to explore new ways of tackling the under-five mortality scourge to revive any hopes of achieving the SDGs targets on under-five mortality outcomes (Batani & Maharaj, 2022a; Mbunge, Chemhaka, et al., 2022). The hope of achieving the SDGs heavily lies on information and communication technology as the SDGs are stretch goals (Sachs et al., 2016). Emerging technologies demonstrated their critical role in healthcare during the COVID-19 pandemic, including in contact tracing, monitoring of mask-wearing, and distribution of medicines (Elliot Mbunge, John Batani, Godfrey Musuka, Itai Chitungo, Innocent Chingombe, Tafadzwa Dzinamarira, 2023), remote consultations and tracking disease spread (Gaobotse et al., 2022b; Mbunge, Dzinamarira, Fashoto, & Batani, 2021; UNESCO, 2020).

Under-five mortality rate (U5MR) is the number of children who die before their fifth birthday per every 1 000 children born alive, or the likelihood that a child dies before their fifth birthday (UN IGME, 2021). In this study, emerging technology means any information and communication technology (ICT) or digital technology, new or old, whose development or practical applications in Zimbabwe's public healthcare (especially paediatric care) are primarily unrealised. Generally, emerging technology is not synonymous with new technology since an established technology in one domain can be emerging in another environment or field (Halaweh, 2013; Millea et al., 2005).

One of the cross-cutting goals between the expired MDGs and current SDGs is reducing under-five mortality worldwide. MDG4 sought to minimise the under-five mortality rate by 66 per cent, while SDG3 targets to reduce under-five mortality to 24 per 1 000 live births (UNDP Zimbabwe, 2016). However, under-five mortality remains too high in Sub-Saharan Africa (UN IGME, 2021) and Zimbabwe (ZIMSTAT, 2019b). Zimbabwe had under-five mortality rates (U5MR) of 54 per 1 000 live births in 2020 (UN IGME, 2021) and 55 per 1 000 live births in 2019 (UN IGME, 2020) against a target of 23 per 1 000 live births (GSMA, 2016; ZIMSTAT, 2019b).

Zimbabwe's failure to achieve under-five mortality goals suggests that the approaches and techniques used are ineffective, and new approaches are required to complement the existing ones. In reviewing the MDGs' achievements and roadmap for achieving the SDGs, the Zimbabwean Government notes the important role that ICTs could play (Sibanda, 2016). This potentially important role that emerging technologies could play in achieving the SDGs is also echoed by the ITU (2018) and Sachs et al. (2016). Much hope for the realisation of the SDGs is placed on emerging technologies such as the Internet of Things (Herweijer et al., 2017; Sachs et al., 2016), artificial intelligence (AI), augmented and virtual reality, 3D printing, robots, blockchain, drones, cloud technologies and big data (Akhtar et al., 2018; Herweijer et al., 2017), upon which the fourth industrial revolution is hinged (Akhtar et al., 2018; GSMA, 2016; Herweijer et al., 2017). Although the SDGs cover several aspects, this study only focuses on one goal under SDG3, which aims to reduce under-five mortality.

Information technologies are being applied in healthcare to improve several aspects like diagnosis, treatment, and patient monitoring (Alansari et al., 2017; Davenport & Kalakota, 2019; Gaobotse et al., 2022b; Mbunge, Muchemwa, Jiyane, & Batani, 2021; C. Ross & Swetlitz, 2017). IoT, AI, telemedicine, telehealth, 3D printing, virtual reality, virtual clinics and big data analytics are some of the emerging technologies that are improving healthcare delivery. IoT is being used to monitor pregnant women to minimise stillbirths and miscarriages (Amala & Mythili, 2017), while AI is improving and automating diagnosis (Davenport & Kalakota, 2019; Xiong et al., 2018). Moreover, big data analytics, deep learning and other computational techniques are being used to provide data-driven paediatric care in other countries (Batani & Maharaj, 2022a; Bourgeois, 2022), such as to model precision medicine in paediatric acute liver failure (Zamora et al., 2016).

Despite the contributions such technologies are making in healthcare, the literature does not reveal any research exploring the potential role such technologies could play in reducing under-five mortality in Zimbabwe, nor why Zimbabwe's public healthcare institutions have not adopted the technologies to minimise under-five mortality. This study, therefore, sought to explore the potential role of emerging technologies in reducing under-five mortality in public health facilities in Makonde District in Zimbabwe by investigating why emerging technologies have not been adopted in the district's public healthcare institutions to reduce U5M, yet they have proven to work in other countries (Accenture Labs, 2019; Ilevbare, 2019; IWG, 2012). Specifically, the study sought to explore what needs to be done for emerging technologies to be adopted in Makonde District's public healthcare institutions to reduce

U5M and the perceived role of emerging technologies in reducing U5M in Makonde District's public healthcare institutions.

ICTs have already revolutionised people's lives in almost every sphere of life, and health is no exception. Technological innovations in healthcare keep raising hopes and prospects of a better life and access to healthcare services. Mobile phones have been used to improve child healthcare in countries like Zanzibar, where a mobile health intervention called wired-mothers has had a significant impact (WHO, 2014). Expansion of mobile phone penetration and network coverage can narrow the digital divide and minimise barriers to healthcare access (Nyamawe & Seif, 2014), while improving timely access to information (Batani et al., 2019). Existing ICT tools like Medic Mobile, RapidSMS and MOTECH suite have already demonstrated their ability to collect and exchange health information and deliver community-based health services (ITU, 2013). Emerging technologies such as Artificial Intelligence (AI), big data analytics, telemedicine, telehealth, m-Health, the Internet of Things and e-health are revolutionising healthcare delivery (Davenport & Kalakota, 2019; Fayez, 2018; Ristevski & Chen, 2018). However, Zimbabwe's public paediatric care lacks the adoption of such emerging technologies to reduce under-five mortality (Batani & Maharaj, 2022a).

1.2 Background to the Study

Zimbabwe is a landlocked Southern African country surrounded by South Africa, Botswana, Mozambique and Zambia. The country's total area is 390 757 km^2 and is divided into ten provinces and further subdivided into sixty-three districts (Ministry of Health and Child Care, 2016). According to the 2022 national census preliminary findings, Zimbabwe has a population of 15 178 979 (ZIMSTAT, 2022). Sections 76 and 77 of the country's constitution have provisions for health, in which access to essential health care services by citizens is stipulated as a right.

The country has a fully-fledged health ministry called the Ministry of Health and Child Care (MoHCC), formerly the Ministry of Health and Child Welfare (MoHCW). In 1980, the country adopted the Primary Health Care (PHC) approach, which has informed the country's health system structure since then (Ministry of Health and Child Care, 2016). Platforms for health delivery in the country are divided into primary, secondary, tertiary and quaternary facilities, where provincial and central health facilities constitute tertiary and quaternary, respectively (Ministry of Health and Child Care, 2016). The majority of the health facilities are at the PHC level. In addition to state health institutions, there are also mission and private ones. In 2015, Zimbabwe had a total of 1 848 health facilities, 11.58 per cent of which were hospitals, and 88.42 per cent were PHC facilities (Ministry of Health and Child Care, 2016). The country has a mobile phone and internet penetration rate of 93.5 per cent and 62.6 per cent, respectively(POTRAZ, 2021b). Moreover, out of the country's 219 post offices (77 of which are in rural areas), 69.41 per cent have internet connectivity (POTRAZ, 2019).

The Zimbabwean Government has committed itself to both the expired MDGs and current SDGs by appending its signatures. While the Zimbabwean Government did not do well in the MDGs, it is still committed to achieving the SDGs (Sibanda, 2016). Although there was an improvement with regard to access to health in Zimbabwe, the country failed to attain one of the targets of the MDGs (MDG4), which was to reduce U5M to 34 per 1 000 live births, succeeding only in reducing the mortality rate from 102 per 1 000 live births in 1999 to 74 per 1 000 live births in 2015 (Sibanda, 2016), which is still too high by both Zimbabwe's targets and the regional average.

Generally, Zimbabwe is committed to children's well-being and development. The Government of Zimbabwe has demonstrated this commitment by signing global agreements like the UN Convention on the Rights of the Child (UNCRC), intended to support the health of children globally and whose Section 24 emphasises the rights of children to enjoy the best achievable health (Zimbabwe National Statistics Agency, 2015). Moreover, the Zimbabwean Government has a free health policy for under-fives in all public healthcare institutions (Batani & Maharaj, 2022a).

While Zimbabwe's under-five mortality rates have been slowly improving, they are still unacceptably high and above the country's SDG targets (UN IGME, 2021). The United Nations in Zimbabwe (2014) concurs that the rate of improvement in under-five mortality in Zimbabwe has been slow. As stated by the Ministry of Health and Child Care (2016), Zimbabwe had set a target of under-five mortality of 43 per 1 000 live births as of 2014, yet the actual figure stood at 75 per 1 000 live births. Despite a general improvement in Zimbabwe's child health services, under-five mortality in the country is still far higher than the country's SDG target of 23 per 100 live births (Ministry of Health and Child Care, 2016). Consequently, Zimbabwe was among the fifty countries with the highest early childhood mortality in the world (UNICEF, 2010). This problem of high under-five mortality is not peculiar to Zimbabwe but is also faced by most Sub-Saharan African countries (UN IGME, 2021). Attempts have been made by the Government of Zimbabwe (GoZ) to minimise U5M by improving child health services, but the reductions have been marginal and have seen the country failing to achieve its targets even during the expired MDGs era till present. As a country committed to the achievement of the SDGs (Sibanda, 2016), the Ministry of Health and Child Care commits to SDG 3, which seeks to “Ensure healthy lives and promote well-being for all at all ages”, including the under-fives.

A study by Haley et al. (2017) revealed that factors contributing to high under-five mortality in Zimbabwe include critically low medical staff complement, a lack of access to training opportunities for medical staff and inadequate monitoring of patients at home. Another study by Batani and Maharaj (2022) revealed that poor road infrastructure, shortage of medicines, a lack of access to specialists and lack of knowledge and negligence by parents and guardians are some of the contributing factors to high under-five mortality rates in Zimbabwe. These factors could be addressed by emerging technologies like virtual clinics, drones, 3D printing (Gaobotse et al., 2022b; Mbunge, Muchemwa, Jiyane, & Batani, 2021), telemedicine, telehealth, AI, IoT and big data analytics (Accenture Labs, 2019; Dlodlo, 2013; West, 2015). One can argue that if equipped with the right technologies, healthcare institutions can remotely monitor patients in real-time and remind them of when to visit healthcare institutions and the appropriate times to take their medication (Haley et al., 2017). Moreover, medical staff can access current, accurate information about health conditions and treatment and the latest ideas on the treatment of particular ailments (West, 2015). Moreover, technology can help track disease outbreaks and the spread of epidemics (West, 2015).

Latest statistics show that the two provinces with the highest U5M in Zimbabwe are Midlands and Mashonaland West, which have an under-five mortality rate of 83 per 1 000 live births (ZIMSTAT, 2019b). Therefore, in selecting a study area, the researcher had to choose between the two and settled for Mashonaland West, in which Makonde District was chosen. This research’s study area is Makonde District, which is one of the communities with the highest infant mortality rates (71 per 1 000 live births) in the Mashonaland West province. A detailed background of the study is presented in chapter 2 (Context of the study).

1.3 Research Problem

Despite evidence of a positive role played by emerging technologies in reducing under-five mortality in countries like the United States of America, the United Kingdom, South-West Nigeria and Zanzibar (Accenture Labs, 2019; Ilevbare, 2019; IWG, 2012; WHO, 2014), the perceived potential role of emerging technologies in reducing under-five mortality in Zimbabwe has not been explored. The emerging technologies are yet to be adopted to minimise U5M in the country's public healthcare institutions. Although Zimbabwe has registered marginal improvements in under-five mortality rates over the years, the rates are still unacceptably high and above the country's SDG targets (Ministry of Health and Child Care, 2016; ZIMSTAT, 2019b). Zimbabwe's U5MR is 73 per 1 000 live births (ZIMSTAT, 2019b), against a target of 23 per 1 000 live births (Ministry of Health and Child Care, 2016). Consequently, Zimbabwe is among the fifty countries with the highest early childhood mortality in the world, along with many other Sub-Saharan African countries (UN IGME, 2019). The Zimbabwean Government failed to meet the MDG U5M targets (Sibanda, 2016; UNDP Zimbabwe, 2016), calling for new approaches to complement the existing ones in tackling the under-five mortality scourge (Mbunge, Chemhaka, et al., 2022).

Emerging technologies have proved to play a positive role in reducing U5M in other countries, such as the United States of America (Accenture Labs, 2019), the United Kingdom (IWG, 2012), South-West Nigeria (Ilevbare, 2019) and Zanzibar (WHO, 2014). IoT (Internet of Things) is being used in healthcare to improve service quality, lower service cost (Williams & Woodward, 2015), and provide reliable preventive care (Fayez, 2018); while improving quality of life, remotely monitoring adherence to medication and treatment by patients at home (Islam et al., 2015). It is also being used to monitor pregnancies before the child is even born (Amala & Mythili, 2017). The real-time and remote monitoring of pregnancies is done through monitoring physiological parameters like body temperature, oxygen saturation, heart rate and the number of kicks by the foetus per unit of time, leading to an early and real-time diagnosis of ailments (Islam et al., 2015) which is critical in reducing U5M.

On the other hand, Artificial Intelligence is being used in improving and automating diagnosis, recommending patient engagement and adherence (Davenport & Kalakota, 2019; Xiong et al., 2018), while mass media technologies are being used to disseminate important public health information, expand audience's reach (including those who live in underserved, remote, rural areas) and provide a critical link between health professionals and the public (Naveena, 2015; Sharma & Gupta, 2017).

In Ohio State, big data is being used in tackling U5M by identifying underlying drivers of U5M and enabling data-driven, targeted, preventive interventions and driving effective programmatic actions. By using big data and machine learning techniques, Ohio State is improving the quality and consistency of health service delivery to under-five children (Accenture Labs, 2019). Likewise, in South-West Nigeria, Safermom, an m-health application, is helping reduce U5M by empowering expectant and nursing mothers with targeted health information (Ilevbare, 2019). In this ICT intervention, mobile phones are being used to improve access to targeted health information by pregnant and nursing mothers, monitor and track pregnancy and development of babies, connect mothers with medical doctors and midwives, engaging and monitoring of mothers (Ilevbare, 2019; Olanrewaju, 2019). In Zanzibar, an m-health intervention called Wired-Mothers, which uses mobile phones to link mothers and health institutions, has had a positive impact in increasing access to antenatal care visits, deliveries under the care of skilled birth attendants and reducing perinatal mortality (WHO, 2014); while other innovations like pocket-sized ultrasound scanners and portable foetal monitors which work with computing devices are making their impact in improving maternal and child health (Edwards, 2019; IWG, 2012).

Results of implementing emerging technologies in other countries have demonstrated that they can contribute positively to reducing U5M. With the right emerging technologies, patients can be remotely monitored in real-time, get reminded to visit health institutions and take their medicine at appropriate times (Haley et al., 2017), while medical staff can access current, accurate information about health conditions and treatment, and latest ideas on the treatment of particular ailments (West, 2015). Moreover, technology can help track disease outbreaks and the spread of epidemics (West, 2015).

Despite the evidence of emerging technologies helping in reducing U5M in other countries like the USA (Accenture Labs, 2019), UK (IWG, 2012), Zanzibar (Nyamawe & Seif, 2014; WHO, 2014) and North-West Nigeria (Ilevbare, 2019; Olanrewaju, 2019), and their role in healthcare well-documented, the Zimbabwean Government has not widely adopted such emerging technologies in its public healthcare institutions to reduce U5M, yet the country is grappling with high U5M rates (Ministry of Health and Child Care, 2016; ZIMSTAT, 2019b). Moreover, there is a dearth of studies on the perceived role of emerging technologies in reducing under-five mortality in resource-constrained settings. This study, therefore, sought to answer the question, **"What is the perceived role of emerging technologies towards reducing under-five mortality in Makonde District's public healthcare institutions?"** The main objective was to develop an emerging technologies framework to help reduce under-five mortality by enhancing the adoption and utilisation of emerging technologies for under-five healthcare enhancement in public healthcare facilities in Makonde District.

1.4 Objective of the Study / Overall Objective

The main objective is to develop an emerging technologies adoption framework to help reduce under-five mortality in public healthcare facilities in Makonde District.

1.4.1 Research Sub-Objectives

This research intends to:

1. Investigate the preparedness to adopt emerging technologies in Makonde District to reduce under-five mortality in public healthcare institutions.
2. Identify emerging technologies that are available in Zimbabwe.
3. Identify factors that can affect the potential adoption of emerging technologies to reduce under-five mortality in the Makonde District's public healthcare institutions.
4. Identify the perceived potential role of emerging technologies in reducing U5M in Makonde District's public healthcare institutions.
5. Develop an emerging technologies framework to help reduce under-five mortality in public healthcare facilities in Makonde District.

1.5 Research Questions

The study sought to answer the following research questions:

Main Research Question

What is the perceived role of emerging technologies in reducing under-five mortality in Makonde District's public healthcare institutions?

Research Sub-Questions

1. What is the level of readiness to adopt emerging technologies for reducing under-five mortality in Makonde District public healthcare facilities?
    a. To what extent do healthcare professionals in Makonde District know about emerging technologies for reducing under-five mortality?
    b. To what extent are healthcare professionals in Makonde District willing to adopt emerging technologies to reduce under-five mortality?
2. What factors are affecting the potential adoption of emerging technologies by public healthcare institutions to reduce under-five mortality in Makonde District?
    a. What factors affect the potential adoption of emerging technologies for reducing under-five mortality by pregnant women and mothers of under-five children in Makonde District?

   b. What factors affect the potential adoption of emerging technologies to reduce under-five mortality by public health professionals in Makonde District?
   c. Which emerging technologies in healthcare are currently available in Zimbabwe?
3. What potential role can emerging technologies play in reducing under-five mortality in Makonde District?
   a. What is the perceived contribution of emerging technologies in disease prevention among under-five children in the Makonde District?
   b. What is the perceived contribution of emerging technologies in managing diseases among under-five children in the Makonde District?
   c. What is the perceived contribution of emerging technologies in improving healthcare quality for under-five children in the Makonde District?
   d. What needs to be done for emerging technologies to be adopted in Makonde District's public health institutions to reduce U5M?

1.6. Significance of the Study

This study is crucial as it seeks to provide a potential solution to reducing U5M in Makonde District and Zimbabwe by first exploring the perceived role of emerging technologies by public healthcare professionals. Makonde District is one of the districts with high U5M mortality in Zimbabwe (Zimbabwe National Statistics Agency, 2013); hence, reducing U5M mortality in Makonde District will, in turn, result in reduced U5M in Zimbabwe. Moreover, the findings of this study could inform policymaking, especially the national health strategy and national e-health strategy, as well as provide useful insights to Zimbabwe's public health partners and donors that may consider digital interventions to reduce under-five mortality rates in Makonde District. Since the idea of e-health is still comparatively nascent to healthcare centres in Zimbabwe (Furusa & Coleman, 2018), there is a need to inform e-health policy and implementation strategy through research. The study also directly feeds into the achievement of SDG 3, hence, contributing to Zimbabwe's attainment of the SDGs. It will also help improve the well-being of children and help the Ministry of Health and Child Care achieve one of its goals, which seeks to reduce U5M to 23 per 1 000 live births by 2030 (Ministry of Health and Child Care, 2016). The use of technology in healthcare reduces costs, as noted by Williams and Woodward (2015) and Fayez (2018); the findings of this study may lead to reduced costs in fighting U5M, which in turn may increase funds available for other critical areas such as the fight against HIV/AIDS and rebuilding the capacity of public healthcare post the COVID-19 pandemic. Finally, this study is expected to improve efficiency and effectiveness in the delivery of childcare services and minimise the impact of manpower shortages that the MoHCC is also struggling to curtail (Ministry of Health and Child Care, 2016).

1.7 Theoretical Lenses

This study is guided by three theoretical frameworks, which are combined to form a custom framework. The frameworks adopted in this study are the capability approach (CA), diffusion of innovation (DOI) and the unified theory of acceptance and use of technology (UTAUT). Although the aim of this study is to explore the potential role of emerging technologies in reducing U5M, that role cannot be achieved unless the emerging technologies have first been adopted; hence, the adoption and acceptance of technology theories (UTAUT and DOI). Ross et al. (2016) and Alberta Health Services (2010), as cited in Furusa and Coleman (2018, p.4), the adoption of technological innovations is a process influenced by multifaceted factors. A detailed explanation of the theoretical frameworks guiding this study is presented in chapter 4 (Theoretical Frameworks).

1.7.1 The Capability Approach

The capability approach (CA) is a theoretical framework generally attributed to Amartya Sen (Haenssgen & Ariana, 2018; Robeyns, 2005; Wells, 2012), regardless of some of its aspects being traceable back to earlier philosophers like Aristotle and Karl Marx (Robeyns, 2016). The CA is broad, flexible, and multi-disciplinary instead of a precise and confined theory of well-being (Robeyns, 2005, 2016); hence, this partly explains why it is named the 'capability approach' and not the 'capability theory' (Robeyns, 2016, p. 2). The framework was initially designed for evaluating the quality of people's lives (Haenssgen & Ariana, 2018) and the development process (Robeyns, 2006, p. 352), as well as providing a perspective on how development should be evaluated. The theory has also been widely used for analysing the effect of development processes and interventions on human life (Haenssgen & Ariana, 2018), as well as assessing the impact of ICT interventions on people's lives, focusing on how people's capabilities are being improved by technology (Gigler, 2015).

The direct focus of the CA is the achievable quality of life by individuals, which is examined with regard to the principal concepts of "functionings" (states of 'being' and 'doing') and "capabilities" (the set of actual valuable functionings that can actually access) (Wells, 2012 para. 19). Therefore, an individual's capability represents their effective freedom (Gigler, 2015; Wells, 2012). This approach argues that although an intervention may have potentially positive effects on human life, its actual value is determined by what the people actually do, that is, their capability to convert the potential benefits into actual benefits of the intervention. The word 'capability' is defined in the CA differently from its daily sense as it shows the actual opportunities one has to lead a life one values (Gasper, 2007).

The CA posits that capabilities are produced by inputs (resources) or the features of inputs, but the value of those resources is dependent upon a person's ability to transform them into valuable functionings, which rely on the individual's physiology, social norms and physical environment (Wells, 2012).

Wells (2012) illustrates the capabilities approach using a bicycle as a resource example. The value of a bicycle is dependent upon one's ability to transform it into valuable functionings (bicycling), which in turn relies upon the individual's personal physiology (such as health), social norms and physical environment (such as road quality) (Wells, 2012). Figure 1 shows the core relationships in the capability approach.

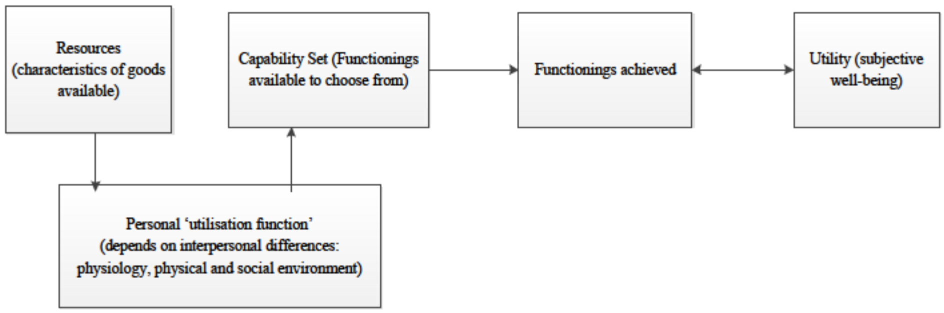

Figure 1: Core relationships in the capability approach. Source: (Wells, 2012)

The CA is used in this study to guide the exploration of the potential role of emerging technologies in reducing U5M in Makonde District, viewing the role in the context of valuable functionings which are dependent upon personal utilisation function. Since the utilisation function also includes factors that can affect the adoption of emerging technologies in Makonde District to reduce U5M, two technology adoption theories are further presented, which were eventually combined to form the extended CA which guided this study.

1.7.2 Diffusion of Innovation (DOI) Theory

Ensuring that people adopt an innovation is never an easy task regardless of the innovation's benefits being conspicuous and obvious (Rogers, 1983a). The DOI theory was propounded by Rogers (1983) and focused on how innovation spreads among people. He argued that the wide adoption of innovation often takes time, resulting in many people and organisations having the question of how to accelerate innovation adoption (Rogers, 1983a).

Rogers (1983, p. 5) defines diffusion as "the process by which innovation is communicated through certain channels over time among the members of a social system." Innovation is defined as anything, such as an idea, practice or object, that a potential adopter views as new (Rogers, 1983a). According to the DOI theory, an innovation has little to do with the time that has passed since its discovery; and an innovation's newness does not necessarily only involve new knowledge but also a potential adopter's development of attitude (favourable or not) towards it, which will eventually lead to adoption or rejection of the innovation (Rogers, 1983, p. 6). This definition of innovation resonates with the meaning of emerging technology as it is used herein. This theory asserts that technology adopters can be categorised into six classes depending on the time they take until they can adopt an innovation. These categories are innovators, early adopters, early majority, late minority and laggards (Rogers, 1983a). The DOI theory posits that before deciding to adopt or reject an innovation, people pass through the stages of knowledge and persuasion, after which they may decide to adopt or reject the innovation.

This theory is used in this study to guide in the answering of research questions:

3a. *To what extent do healthcare professionals in Makonde District know about emerging technologies for reducing under-five mortality?*

3b. *To what extent are healthcare professionals in Makonde District willing to adopt emerging technologies for reducing under-five mortality?* and

4. *What is the level of readiness to adopt emerging technologies for reducing under-five mortality in Makonde District public healthcare facilities?*

Relating these research questions to the DOI theory, they seek to investigate what healthcare professionals and mothers of under-fives know (knowledge variables) about emerging technologies for reducing U5M and the potential factors affecting emerging technologies adoption (persuasion variables).

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

Designed by Venkatesh et al. (2003), UTAUT is a common theory that has enjoyed wide use in explaining the acceptance of technology by individuals and the use of technology by organisations (Venkatesh et al., 2016). The theory has four theoretical constructs that are used in predicting technology adoption and usage; and these constructs are performance expectancy (the extent to which a potential technology adopter or user believes that technology use will enhance their performance), effort expectancy (the extent to which one views technology as simplifying their work), social influence (the extent to which one perceives as important other people's belief that they should use technology) and facilitating conditions, which is the extent to which a user believes that the necessary infrastructure, legislation and other conditions exist to facilitate the use of technology (Venkatesh et al., 2003, 2016).

The UTAT model was applied as a guiding theoretical lens for answering research question 4, *What factors can affect the potential adoption of emerging technologies for reducing under-five mortality in Makonde District?* and its sub-questions (research questions 4a and 4b).

1.8 Methodology

The guiding philosophy for this study was pragmatism, allowing the researcher to use multiple methods and techniques to enhance the study findings' reliability and validity. The researcher used the exploratory sequential mixed methods design in which data were collected in two sequential phases. The first phase was qualitative, while the second one was quantitative. The findings of the first phase informed the design of the second phase's data collection instruments. Triangulation was used to enhance the validity and trustworthiness of the findings. Questionnaires, focus groups, interviews and data from the District Health Information System (DHIS-2) provided the data used in this study. The researcher used a survey strategy and selected the respondents using purposive and random sampling techniques. Purposive sampling was used to select interviewees and focus group participants by targeting public healthcare professionals who specialised in paediatric care, such as the Provincial Paediatric Specialist. The researcher obtained ethical clearance from the University of KwaZulu-Natal's Human and Social Sciences Research Ethics Committee (HSSREC) (Protocol number: HSSREC/00002132/2020) and the Medical Research Council of Zimbabwe (MRCZ) (Protocol number: MRCZ/A/2782). Permission letters were obtained from the Mashonaland West Provincial Medical Director and the Makonde Rural District Council Chief Executive Officer (MRDC CEO). MRDC CEO had to clear study since all the public clinics in rural Makonde District fall under the Makonde Rural District Council (MRDC). Overall, 501 participants (110 public healthcare professionals and 391 mothers and guardians of under-fives) participated in this study. The Statistical Package for the Social

Sciences (SPSS) version 27 and Nvivo 12 facilitated the data analysis for this study. A detailed methodology is presented in chapter 5 of this thesis.

1.9 Dissertation/ Thesis Structure

The thesis is structured in the following manner.

1. Introduction – in chapter 1, the researcher presents an introduction to the research, including background on under-five mortality issues in Zimbabwe, research questions and objectives.
2. Study Context – this is the second chapter of this thesis that describes the research context in detail. It begins by giving an overview of Zimbabwe before narrowing down to Makonde District.
3. Literature Review – This is the third chapter of this thesis, in which the researcher presents a thorough investigation and interrogation of the literature to present the status quo of the literature in the area of the role and adoption of emerging technologies in healthcare in developing countries. The chapter also spells out the research gap.
4. Theoretical Frameworks – in this chapter, the researcher reviews relevant theoretical frameworks for technology adoption and capabilities and justifies the selection of the guiding frameworks to be used in this study. The researcher derived indicators used in the study from three theoretical frameworks: the Capabilities Approach, DOI and UTAUT.
5. Research Methodology – This chapter presents the materials, methods and techniques followed in this study. The philosophical perspectives guiding this study are also described and justified. The sample and population are described, the sampling techniques presented, and the reliability and validity issues elucidated. The researcher expatiates the data collection and analysis procedures, justifying every choice.
6. Presentation of Findings – This chapter presents the study's findings, structured by research questions.
7. Discussion of Findings – the chapter discusses the study's findings and presents the emerging technologies' adoption framework. The discussion is structured based on the research objectives.
8. Conclusions and recommendations – This is the final chapter of this thesis. It draws conclusions based on study findings and proffers appropriate recommendations.

1.10 Chapter Summary

In this chapter, the study was introduced. The importance of reducing under-five mortality was articulated as was evidence of emerging technologies positively contributing to reducing under-five mortality in the countries where they were adopted. Moreover, the purpose of the study was underscored, which is to investigate what is needed for the adoption of emerging technologies in Makonde District's public health institutions to reduce under-five mortality. Pursuant to the study purpose, research objectives and subsequent research questions were outlined. Moreover, the underlying theoretical frameworks were also presented, namely, the capability approach, diffusion of innovation and unified theory of acceptance and use of technology. It was established that Makonde District's public healthcare institutions are not using emerging technologies to reduce under-five mortality, yet such technologies have proven to work in other countries, and this study sought to explore what needs to be done for these health institutions to adopt emerging technologies. As a country whose U5MR is almost thrice the target, there is a need for Zimbabwe to adopt new and complementary methods to tackle the U5M problem. However, adopting new technologies would require studies into what needs to be done for successful adoption, which this study sought to do. Moreover, the study sought to explore the potential role of emerging technologies in reducing under-five mortality in Makonde District from the perspective of public healthcare professionals.

Additionally, an abridged methodology is also presented. It was explained that data was collected using a mixed methods approach, including questionnaires, focus group and interviews. Finally, the thesis structure is presented, showing the chapters in this thesis and what they cover. In the next chapter, the study's context is described in detail.

CHAPTER 2: The Study's Context

2.1 Introduction

In this chapter, a detailed account of the study's context is presented. This includes general information about Zimbabwe's profile, its healthcare system, healthcare system challenges, ICT environment, mobile communication outlook, national e-health strategy, under-five mortality trends and emerging technologies in Zimbabwe. The researcher then narrows down to Makonde District and discusses it, including presenting the map of Zimbabwe that shows where the district is located, its population distribution and other demographic data. Moreover, all the healthcare institutions in Makonde, as shown in the DHIS-2 tool, are presented. These are classified as public, private and mission.

2.2 Zimbabwe's General Profile

Zimbabwe is a landlocked Southern African country surrounded by South Africa, Botswana, Mozambique and Zambia. The country's total area is 390 757 km^2 and is divided into ten provinces and further subdivided into sixty-three districts (Ministry of Health and Child Care, 2016). Zimbabwe conducts a national census every decade, the latest of which was in 2022. According to findings of the 2012 national census, Zimbabwe had a population of 13 061 239, of which 67 per cent reside in rural areas while the remainder resides in urban areas (ZIMSTAT, 2012). This population increased by over 2 million to 15 178 979 in 2022 (ZIMSTAT, 2022). Sections 76 and 77 of the country's constitution have provisions for health, in which access to basic health care services by citizens is stipulated as a right. The country has sixteen official languages, namely Shona, Ndebele, English, Chewa, Tonga, Sotho, Chibarwe, Kalanga, Khoisan, Nambya, Ndau, Sign language, Xhosa, Shangani, Venda and Tonga (Constitution of Zimbabwe, 2013). However, Shona, Ndebele and English are the dominant languages.

In 2017, Zimbabwe had 2 830 secondary schools, with Manicaland having 436 followed by Mashonaland West with 379 (ZIMSTAT, 2019a). There are more primary schools (6 123) than secondary schools (2830), with Manicaland topping the number of primary schools (877) followed by Midlands (870) (ZIMSTAT, 2019a). Every province in the country has at least one university. Figure 2 shows the map of Zimbabwe, with the names of provinces written in uppercase. All the neighbouring countries of Zimbabwe are also shown.

Figure 2: Zimbabwe Administrative Map. Source: (Nations Online, 2017)

Table 1: Basic Demographic Indicators

Indicator	**Measurement**
Total Population	15 178 979
Population growth rate (annual)	1.1%
Sex Ratio (Males/100 females)	92
Male Population	7 289 558
Female population	7 889 421
Population Age Distribution	
Under 15 years	41%

15 to 64 years	55%
65 years and over	4%
Average household size	4
Rural population	61.4%
Urban population	38.6%

Source: National Census Report (ZIMSTAT, 2022)

Table 2: Population by province

Province	**Capital**	**Area (km^2)(City Population, 2018)**[1]	**Population (2022 Census)**[2]
Harare	Harare	872	2 427 209
Mashonaland West	Chinhoyi	57 441	1 893 578
Mashonaland Central	Bindura	28 347	1 384 891
Manicaland	Mutare	36 459	2 037 762
Bulawayo	Bulawayo	479	663 940
Mashonaland East	Marondera	32 230	1 731 181
Matebeleland South	Gwanda	54 172	760 345
Matebeleland North	Lupane	75 025	827 626
Midlands	Gweru	49 166	1 811 908
Masvingo	Masvingo	56 566	1 638 539

[1] City Population (2018)

[2] ZIMSTAT (2022)

2.3 Zimbabwe's Healthcare System

Zimbabwe has a fully-fledged health ministry called the Ministry of Health and Child Care (MoHCC), formerly the Ministry of Health and Child Welfare (MoHCW). In 1980, the country adopted the Primary Health Care (PHC) approach, which has informed the country's health system structure since then (Ministry of Health and Child Care, 2016). Platforms for health delivery in the country are divided into primary, secondary, tertiary and quaternary facilities, where provincial and central health facilities constitute tertiary and quaternary, respectively (Ministry of Health and Child Care, 2016). The majority of the health facilities are at the PHC level. In addition to state health institutions, there are also mission and private facilities. Zimbabwe has a total of 1 848 health facilities, 11.58 per cent of which were hospitals, and 88.42 per cent were PHC facilities (Ministry of Health and Child Care, 2016).

Table 3: Number of health facilities by type. Source: (ZIMSTAT, 2019a))

Hospitals/Clinics	**Number as of 2018**
Central Hospitals	6
Provincial Hospitals	7
District Hospitals	43
Mission Hospitals	71
Rural Hospitals	55
Infectious Diseases	6
Specialised hospitals	2
Others	22
Clinics and Rural Health Centres	1 577
Total	**1 789**

Table 4: Medical Institutions by Province **Source:** (ZIMSTAT, 2019a)

Province	**Rural Hospitals**	**Rural Health Centres/ Clinics**	**Total**
Manicaland	26	256	282
Mashonaland Central	6	153	159
Mashonaland East	13	202	215
Mashonaland West	16	182	198
Matebeleland North	8	135	143
Matebeleland South	13	113	126
Midlands	12	238	250
Harare	0	73*	73*
Bulawayo	0	50	50
Masvingo	7	175	182
Total			**1678**

*includes Chitungwiza

Table 5: Health Personnel in Establishment and in Post **Source:** (ZIMSTAT, 2019a)

Category	**In Post (2018)**
Top Management	52
Doctors	1 364
Nurses Grades	18 967
Environmental Health Department	1 530
Pharmacy	338
Radiology	262
Physiotherapy	395
Nutrition	841
Orthopaedic	26
Oral Health	223
Laboratory	393
Research Officers	16
Health Information	168
Health Promotion	50
Hospital Equipment	78
Administration General	5302
Programme Managers	65
Total	**30 070**

Despite the wide implementation of m-health in Zimbabwe, it is mainly for strengthening communication, and efforts are underway to introduce a comprehensive five-year e-health strategy in the country to promote, encourage, support and regulate digital innovations in healthcare (MoHCC, 2021).

Generally, Zimbabwe is committed to children's well-being and development. This commitment has been demonstrated by its government signing global agreements like the UN Convention on the Rights of the Child (UNCRC), intended to support the health of children the world over and whose Section 24 emphasises the rights of children to enjoy the best achievable health (Zimbabwe National Statistics Agency, 2015).

2.4 Zimbabwe's Healthcare System Challenges

Challenges in Zimbabwe's healthcare system have been well documented in a number of published articles by both the government and researchers. In its e-health strategy for the five-year period ending 2014, the-then Ministry of Health and Child Welfare pointed out a number of challenges faced in Zimbabwe's healthcare. These challenges include underfunding, unequal access to healthcare mainly by vulnerable groups, dilapidated infrastructure, recurrent stock-outs of essential supplies, poor quality of care in both public and private healthcare institutions, poor remuneration of public healthcare personnel, lack of incentives for working in remote areas, inadequate management, leadership capacity and human resource development capacity, weak health delivery system in terms of planning, budgeting and management, poor inter-sectoral action and collaborations in service delivery, lack of community involvement and participation in health issues and poor availability of costing data for some aspects (Ministry of Health and Child Welfare, 2009). Moreover, all of the provinces in the country are failing to meet the target health facility density of 2 health facilities per every population of 10 000(Ministry of Health and Child Care, 2016). However, there has been an increase in essential medical supplies, with 98 per cent of all health institutions having essential medicines by 2016, and a service readiness index of 78 per cent (Ministry of Health and Child Care, 2016).

2.5 Zimbabwe's ICT environment

2.5.1 National ICT policy

The current Zimbabwe national ICT policy was enacted in 2016 as a replacement for the first-ever national ICT policy that had existed for eleven years. Zimbabwe's first national ICT policy remained in effect from 2005 till it was replaced by the current one in 2016, after its first review between July and September 2012 (Ministry of ICT Postal and Courier Services, 2016). The replacement of the previous national ICT policy was necessitated by the realisation that it was obsolete given the so many changes that had occurred between 2005 and 2016.

Generally, the Zimbabwe national ICT policy seeks to promote rather than deter ICT development and uptake. One of the six objectives of the policy is to promote the growth of ICT access and usage in all spheres of life (including healthcare) while also promoting innovation and partnerships (Ministry of ICT Postal and Courier Services, 2016). The current Zimbabwe national ICT policy emphasises the following:

- The importance of ICT as a development enabler, such as improving access to basic information and health knowledge. It claims that the absence of ICT is worsening the healthcare situation of the poor due to a lack of access to health information.
- Development of ICT policy instruments and innovation incentives to guide, regulate and promote ICT innovations.
- Promoting development and implementation of ICT applications across all sectors, including healthcare. The policy places more importance on the development of local solutions that provide real and basic solutions relevant to local people.
- Promoting legislation for e-health. It recognises the important role ICT can play in healthcare and thus seeks to promote e-health legislation not to deter but promote and regulate e-health innovations.

Generally, the policy acknowledges that ICT is a development enabler that can potentially help Zimbabwe in realising its development goals. It also seeks to promote e-government to improve service delivery and accessibility to the people. However, the policy may need to be reviewed frequently, given how fast the ICT landscape is changing.

2.5.2 Mobile Telecommunications

The Postal and Telecommunications Regulatory Authority of Zimbabwe (POTRAZ) releases reports quarterly on the performance of the telecommunications and postal services sector in Zimbabwe. Zimbabwe has three mobile phone operators, namely Econet Wireless, NetOne and Telecel. The country has a mobile phone and internet penetration rate of 94.2 per cent (up from 90.6 per cent) and 59.1 per cent (down from 60.6 per cent), respectively, as of 31

March 2020 (POTRAZ, 2020). Moreover, out of the country's 219 post offices (77 of which are in rural areas), 69.41 per cent have internet connectivity (POTRAZ, 2019, 2020).

The 2020 first quarter report by POTRAZ (2020) shows the following highlights as of 31 March 2020:

- Zimbabwe has a total of 24,379,810 registered mobile phone subscribers, of which 13,724,522 are active.
- There was a 4 per cent increase in the number of active subscribers than the previous quarter.
- There was a 2.8 per cent growth in mobile internet and data to 6 661 terabytes (TB), compared to the previous quarter.
- The mobile penetration rate increased by 3.6% to reach 94.2% from 90.6%.
- The Internet penetration rate declined by 0.7% to reach 59.1% from 60.6%.

Econet Wireless has continued to dominate the market share in terms of the number of subscribers, followed by NetOne and then Telecel (POTRAZ, 2019, 2020). Although Econet Wireless is the youngest telecommunications company of all the three, having been launched in 1998 (Econet Wireless Zimbabwe, 2018), the company has outgrown NetOne and Telecel Zimbabwe, which were both launched in 1996. Registered in 1996, NetOne is the first GSM mobile telecommunications company to operate in Zimbabwe and is wholly owned by the Government of Zimbabwe (NetOne, 2020). Telecel Zimbabwe was also founded in 1996 (Pindula, 2018).

2.5.3 ICT in Healthcare in Zimbabwe

Zimbabwe's health sector has seen a number of partnerships with other organisations like the United Nations Development Programme (UNDP), the Global Fund and WHO not only in training and provision of medical supplies but also in e-health interventions. The Global Fund and UNDP Zimbabwe have supported ICT in healthcare in Zimbabwe in a number of ways, such as upgrading network infrastructure and providing hardware and staff development. The organisation upgraded internet access to 82 provincial and district hospitals and offices, provided 1 594 laptops, 83 desktop computers, servers and printers and funded the ICT skills training of 92 per cent of all health information officers in Zimbabwe (UNDP Zimbabwe, 2015a), essentially providing the requisite support for e-health.

Zimbabwe currently has a number of information systems in use in healthcare. These include the District Health Information System version 2 (DHIS-2) (UNDP Zimbabwe, 2020) for health information reporting, Integrated Disease Surveillance and Response (IDSR) information system, Inpatient Mortality and Morbidity Information System (IMMIS) (Ministry of Health and Child Care & University of Oslo, 2015), Human Resource Information System (HRIS) to keep track of health professionals and it can transfer data to the National Health Management Information System (NHMIS), electronic patient management system (ePMS) (UNDP Zimbabwe, 2015a), information systems for registration of medical practitioners with councils which citizens can query registration statuses of medical practitioners, the National Health Information System (NHIS) (Ministry of Health and Child Welfare, 2012) and Weekly Health Surveillance System (UNDP Zimbabwe, 2020). The IDSR and IMMIS have been hailed for improving data accuracy (Ministry of Health and Child Welfare, 2012). Moreover, there is a telemedicine application installed at the University of Zimbabwe School of Medicine for purposes of training students (Ministry of Health and Child Welfare, 2012) and another telemedicine application deployed in two Manicaland districts, Nyanga and Chimanimani, as pilot studies to facilitate remote consultation by nurses at remote clinics enabling them to consult doctors at district hospitals without need for patients to travel to district hospitals (Maruta, 2018).

The DHIS-2, which is free and open-source software, is widely used in the country for data collection but barely for quality assurance, analysis, interpretation and dissemination (Ministry of Health and Child Care & University of Oslo, 2015). The system is in use in all districts across the country, improving data access in the NHIS, with health facilities in remote areas where there is no internet connection using mobile phones to report to the national database (NHIS) (Ministry of Health and Child Welfare, 2012). The Weekly Disease Surveillance System feeds into the DHIS-2 system by transmitting disease surveillance data to help monitor and detect disease outbreaks, while a macro database interacts with the DHIS-2 nationally (UNDP Zimbabwe, 2020).

To improve TB and HIV data collection and management, the Ministry of Health and Child Care introduced the ePMS in 2014, effectively replacing the inefficient paper-based system that was in place prior (UNDP Zimbabwe, 2015a). The ePMS has improved data access and reporting since its deployment. There has been an upsurge in computer and internet availability in Zimbabwe's public healthcare institutions, with most level 2 and 3 facilities having adequate numbers of computers and internet connectivity (Ministry of Health and Child Care & University of Oslo, 2015); hence, providing fertile ground for e-health.

However, most of the data collected by these electronic health systems are not used, with only 5.5% of the data collected needed for calculating the National Health Indicators (Ministry of Health and Child Care & University of Oslo, 2015). Moreover, to the researcher's best knowledge, there are no e-health systems dedicated to reducing under-five mortality in Zimbabwe's public healthcare institutions.

Figure 3: E-health systems in Zimbabwe. Source: (UNDP Zimbabwe, 2020 p. 6)

2.5.4 National E-health Strategy

Zimbabwe had its first national e-health strategy spanning the period 2009 to 2014 (Ministry of Health and Child Welfare, 2009). Before its expiry, it was replaced by another one for the period 2012 to 2017 (Ministry of Health and Child Welfare, 2012). Zimbabwe recognises the importance of e-health as emphasised in the country's 2016-2020 national health strategy. Zimbabwe acknowledges that e-health can play improve efficiency in resource utilisation in healthcare in a number of ways, including minimising costs through telehealth, customisation and prioritisation of health interventions through electronic surveillance systems and minimising resource wastages through electronic medical record systems (Ministry of Health and Child Care, 2016). As one of the measures to promote ICT uptake, the country removed import duty on all ICT equipment, a move that can potentially promote e-health in the country.

2.5.5 E-health in Zimbabwe's Public Healthcare Institutions

Zimbabwe's commitment to e-health started as far back as prior to 1990. In 1985, Zimbabwe's Ministry of Health and Child Care (then Ministry of Health and Child Welfare) designed and piloted an electronic national health information and surveillance (NHIS) system, which was rolled out across the country three years later (Ministry of Health and Child Welfare, 2009) for data collection. The NHIS system was meant to support health care delivery by providing the information needed for measuring the performance of service delivery at each health facility in the country (Ministry of Health and Child Welfare, 2009). It was implemented to increase data availability for planning, implementation and monitoring of health programmes in the country.

Efforts by the Government of Zimbabwe to continue strengthening the NHIS system resulted in the creation of the Health Information Officer position at different levels, namely provincial, district and mission hospitals; and the introduction of a Health Information training course at the Harare Poly-Technical College (Ministry of Health and Child Welfare, 2009). A study to assess factors influencing the functioning of the NHIS system was commissioned in 2005 by the Ministry of Health and Child Welfare and the UNICEF, in which the following challenges were identified: lack of a central data repository to enable integration of health information system data sources, lack of datasets, inadequate ICT infrastructure, inadequate analysis and use of information, poor support systems, inadequately designed software, lack of data authentication system, poor support systems, inadequately designed software, inadequate staff complement for health information system, and private health practitioners and facilities not reporting to NHIS, among other challenges.

Using technology for the provision of healthcare services remains highly prioritised by several developed and developing countries since technology is now a health delivery enabling tool (Furusa & Coleman, 2018). Public healthcare institutions in Zimbabwe are using such electronic systems as the electronic Patient Management System (ePMS) (UNDP Zimbabwe, 2015a), District Health Information System (DHIS-2), Integrated Disease Surveillance and Response (IDSR) System, Inpatient Mortality and Morbidity Information

System (IMMIS), and Health Information Management System (HIMS) (Ministry of Health and Child Care & University of Oslo, 2015). The DHIS-2 system is deployed across all districts in the country; however, it is being used more as a data capturing tool than an analytics and quality assurance tool (Ministry of Health and Child Care & University of Oslo, 2015). The electronic patient management system is currently being used for collecting and managing patient data (HIV and TB), according to UNDP Zimbabwe (2015). The system manages "patient registrations, demographic details, past medical history, patient follow-up visits, laboratory investigations and prescription and drug dispensing (UNDP Zimbabwe, 2015a, p. 5).

With improved network connectivity and computer availability in Zimbabwe's public healthcare institutions, such electronic systems have significantly improved communication between and among the country's health institutions (Ministry of Health and Child Care & University of Oslo, 2015).

2.6 Under-Five Mortality Trends in Zimbabwe

While Zimbabwe's under-five mortality rates have been slowly improving, they are still unacceptably high and above the country's SDG targets (Ministry of Health and Child Care, 2016). The United Nations in Zimbabwe (2014) concurs that the rate of improvement in under-five mortality in Zimbabwe has been very slow. As stated by the Ministry of Health and Child Care (2016), Zimbabwe had set a target of under-five mortality of 43 per 1 000 live births as of 2014, yet the actual figure stood at 75 per 1 000 live births. Despite a general improvement in Zimbabwe's child health services, under-five mortality in the country is still far higher than the country's SDG target of 23 per 100 live births (Ministry of Health and Child Care, 2016). Consequently, Zimbabwe is among the fifty countries with the highest early childhood mortality in the world (UNICEF, 2010). UNICEF (2010) asserts that this problem of high under-five mortality is not peculiar to Zimbabwe but is also faced by most Sub-Saharan African countries. Attempts have been made by the Government of Zimbabwe (GoZ) to minimise U5M by improving child health services, but the reductions have been marginal and have seen the country failing to achieve its targets even during the expired MDGs era till present. As a country committed to the achievement of the SDGs (Sibanda, 2016), the Ministry of Health and Child Care commits to the SDG 3 which seeks to "Ensure healthy lives and promote well-being for all at all ages", including the under-fives.

Figure 4 shows the child mortality trends in Zimbabwe between 1988 and 2019, and it is conspicuous that under-mortality has been higher than all types of child mortality in Zimbabwe throughout the years under consideration as its graph is transposed over all other graphs. There was generally an improvement in U5M since 2000, but the improvements have not been significant, suggesting that there is a need to have new approaches to complement the current ones. At this rate of improvement, Zimbabwe will also fail to meet its 2030 SDG target of an under-five mortality rate of 24 per 1 000 live births. In fact, the latest statistics show a rise in U5MR from 69 in 2015 to 73 in 2019, as depicted in Figure 4.

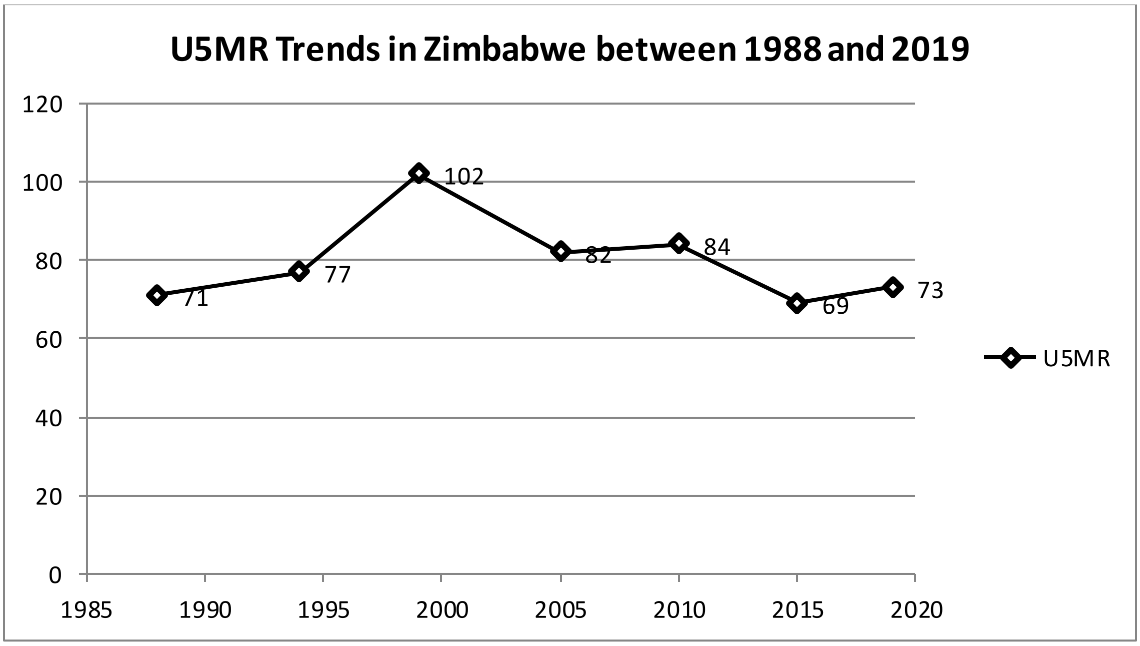

Figure 4: Under-Five Mortality Trends in Zimbabwe. Source: (Ministry of Health and Child Care (2016 p. 9), ZIMSTAT, 2019b (p. 72))

The 2019 U5MR is from the MICS Report by ZIMSTAT (2019b), while the rest are from the Ministry of Health and Child Care (2016).

The leading causes of under-five mortality are neonatal causes, diarrhoea, HIV/AIDS, injuries, measles, malaria and other diseases, as shown in Figure 5.

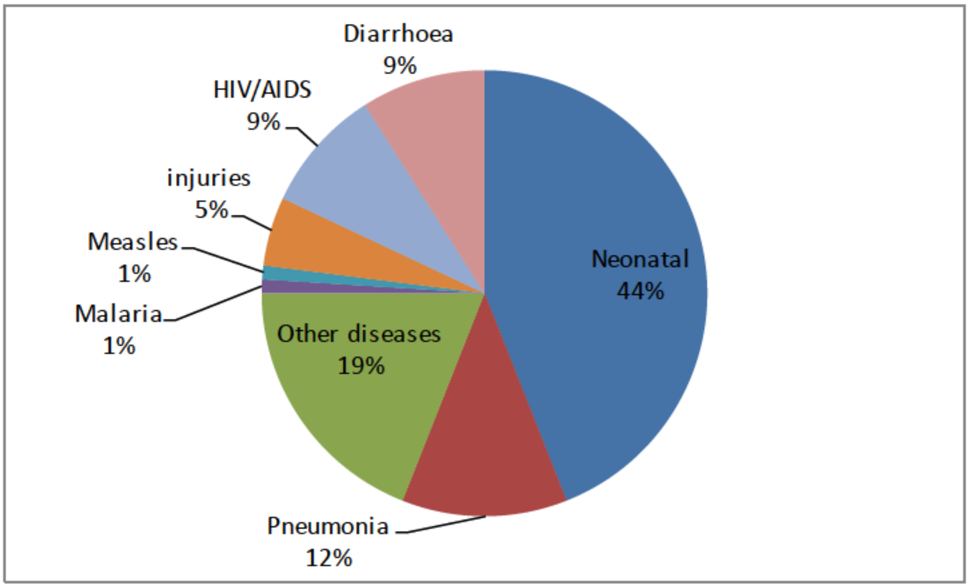

Figure 5: Causes of Under-Five Mortality in Zimbabwe. Source: (Ministry of Health and Child Care, 2016, p. 28)

2.7 Makonde District

Makonde is a district in the Mashonaland West province of Zimbabwe with a population of 209 947 (11.09 per cent of the provincial population) (ZIMSTAT, 2022). The district has rural and urban parts, with the majority of its population staying in the rural areas (Zimbabwe National Statistics Agency, 2013; ZIMSTAT, 2022). There are 2 967 households in Makonde, with an average household size of 4.4 (ZIMSTAT, 2022). It has a literacy rate of 95 per cent (96 per cent male and 93 per cent female) for people aged at least 15 years (Zimbabwe National Statistics Agency, 2013). 77.7 per cent of the population is employed, while the remainder are communal farmers (Zimbabwe National Statistics Agency, 2013).

Figure 6 shows the map of the Mashonaland West province and its districts. Makonde district borders with Sanyati, Hurungwe and Zvimba districts. Overall, the province has seven districts, Chegutu, Hurungwe, Kariba, Makonde, Mhondoro, Sanyati and Zvimba (ZHIS, 2022).

[3]Figure 6: Map of Mashonaland West Districts

[4]Table 6: Makonde District Key Population Indicators

Attribute	Male	Female	Overall
Population	77 492 (50.5%)	76 048 (49.5%)	153 540
Crude birth rate per 1 000			34.8
Crude death rate per 1 000			10.7
Rate of natural increase			2.4%
Percentage married			64.7%
Number of households			32 747

3 https://upload.wikimedia.org/wikipedia/commons/1/1d/Mashonaland_West_districts.png

4 http://www.zimstat.co.zw/dmdocuments/Census/CensusResults2012/Mash_West.pdf

Average household size			4.6
Literacy rate	96%	93%	95%
Total fertility rate (TFR)			4.6
Infant mortality rate per 1 000 live births			71
Maternal mortality rate			615

Source: (Zimbabwe National Statistics Agency, 2013)

The data presented in Table 6 is based on the previous census that was conducted in 2012, according to which Makonde District is the third highest populated district in Mashonaland West province. While there was a national census conducted in 2022, only the preliminary results had been published by the time of submission of this thesis, and those results did not include the aspects reported in Table 6. Overall, the district accounts for 11.09 per cent of the province's population. Sadly, it has the third highest maternal mortality rate (MMR) of 615, after Hurungwe and Mhondoro-Ngezi districts, with MMRs of 631 and 661, respectively (Zimbabwe National Statistics Agency, 2013). The district also has a high infant mortality rate of 71 per 1 000 live births (Zimbabwe National Statistics Agency, 2013), while the province is currently at 83 per 1 000 live births (ZIMSTAT, 2019b).

The district has government, council, private, and mission health centres.

Table 7: Health Facilities in Makonde District

	Public Facilities	**Private Facilities**	**Mission Facilities**	**Total**
Number of registered health facilities (ZHIS, 2022)	36	6	3	45
Number of beds (John et al., 2011)	422	St Rupert's 85	191	606

The district has 36 public healthcare institutions according to the DHIS-2 system, which are listed in Appendix XVII.

All healthcare institutions within Makonde District are under the responsibility of the District Health Executive (DHE) team, whose mandate is to plan and coordinate all district health facilities (Muchekeza et al., 2012). The members of the DHE team are the District Medical Officer (DMO), District Nursing Officer (DNO), District Environmental Health Officer (DEHO), District Health Services Administrator (DHSA), pharmacist and accountant (Muchekeza et al., 2012). Ideally, the District Hospitals are the workstations of the DHE team though the members go around the district monitoring health activities. However, in the case of Makonde District, they are stationed at Chinhoyi Provincial Hospital (CPH) since Makonde District does not have a government district hospital and Chinhoyi is in Makonde District. The DMO heads the DHE team, and the team reports to the Provincial Health Executive (PHE) (Spark Health Africa, 2020). The PHE consists of the Provincial Medical Officer (PMD), Provincial Nursing Officer (PNO), Provincial Environmental Health Officer (PEHO), Provincial Health Services Administrator (PHSA), Provincial Accountant and Pharmacist.

The clinics in the rural Makonde District are under Makonde Rural District Council (RDC), which is headed by the Chief Executive Officer (CEO). Each clinic is ideally manned by at least a registered general nurse (RGN), primary care nurse (PCN), environmental health technician (EHT), nurse aide, senior field orderly (SFO) and a general hand (GH). However, some clinics are understaffed as some of the vacancies have not been filled; for example, Nyamugomba and Mutala Clinics did not have an EHT at the time of data collection for this study. Some of the RGNs in Makonde clinics have midwifery qualifications.

Some of the clinics are in resettlement areas where people were resettled after the land redistribution exercise that began in 2000. In some areas, the road network is bad due to lack of maintenance, such that people take longer to get to the referral hospital situated in Chinhoyi, even though the distance may not be long. Due to bad roads, lack of recreational amenities, poor living and working conditions and other unfavourable conditions, the district has, over time, struggled to retain healthcare professionals (Nyandoro et al., 2016).

2.8 Emerging Technologies in Zimbabwe

Zimbabwe has already started adopting the Internet of Things in some areas, such as security and fleet management. Econet Wireless Zimbabwe is already offering IoT-based home security and fleet management solutions, named Econet ConnectedHome and Econet ConnectedCar, respectively (Econet Wireless Zimbabwe, 2014, 2020). These are used to remotely monitor cars and homes, mainly for security reasons. The existence of such IoT solutions in Zimbabwe demonstrates that the country can implement and adopt IoT-based solutions. However, the literature does not show any health institutions in Zimbabwe where IoT has been implemented as yet.

Artificial Intelligence (AI) is also another emerging technology in Zimbabwe that has not yet realised its full potential. A number of applications of AI in the country include security (such as biometric authentication), chatbots or virtual assistants and various research. Many universities in the country are also offering AI as a course to students who are mainly studying ICT and Engineering degrees, such as the Chinhoyi University of Technology. Since most AI algorithms require high processing power, there is a high-performance computing (HPC) centre at the University of Zimbabwe to allow any researchers across the country who may need high-performance computing for their research. However, there is no published literature or reports showing that there are any AI applications deployed in the public health domain in Zimbabwe.

Social media platforms, such as WhatsApp, Twitter and Facebook, are making information dissemination easier in the country, and the Ministry of Health and Child Care has taken advantage of such platforms. The Ministry of Health and Child Care already has a presence on Twitter and Facebook, making it easier to send updates to the people and, in some instances, get feedback.

Short Messaging Systems (SMSs) have become useful for disseminating health information in Zimbabwe (Dimaguila, 2015). The ministry often sends important messages to the people using SMSs to facilitate two-way follow-up communication for circumcision (Marongwe et al., 2022). During the COVID-19 period, the Ministry of Health and Child Care introduced a toll-free number to help people report suspected cases for free (UNICEF Zimbabwe, 2020).

The Government of Zimbabwe has also introduced community radio stations to help disseminate location-specific information, among other reasons. These radio stations can be useful tools for sharing important health information, like disease outbreaks and preventive measures. Examples of some community radio stations include Diamond FM, Nyaminyami FM, Great Zimbabwe University Radio Station and CapiTalk FM. Zimbabwe's public healthcare receives donations from various donors to spearhead digital health projects (Dimaguila, 2015). However, some of these projects end at piloting state and are deployed to a few public health facilities, such as the telemedicine in Nyanga (Moyo & Madziyire, 2020; Ndhlovu, 2021) and Neotree in Chinhoyi (Batani & Maharaj, 2022a).

2.9 Causes of Under-Five Mortality in Zimbabwe

Under-five mortality is defined as the likelihood of a child dying before they reach five years of age. According to the Zimbabwe National Statistics Agency (2015), the major causes of under-five mortality in Zimbabwe can be grouped into neonatal period causes (premature birth complications, birth asphyxia, and neonatal sepsis), HIV/AIDS and others (pneumonia, diarrhoea, measles, malaria and malnutrition). As stated by the Zimbabwe National Statistics Agency (2015), HIV/AIDS accounted for 22 per cent of under-five mortality in Zimbabwe, whereas the neonatal period accounted for 29 per cent of the deaths. In rural areas, some under-fives die due to delayed access to healthcare services because of poor road infrastructure, terrain and sometimes lack of funds to visit specialists when referred (Batani & Maharaj, 2022a).

2.10 Efforts by Zimbabwe to Reduce Under-Five Mortality

In addition to being a signatory to the UN's SDGs and other international treaties that advocate for improvement in child health access and services, the Government of Zimbabwe (GoZ) developed a National Child Survival Strategy for Zimbabwe to deliver its commitment (Zimbabwe National Statistics Agency, 2015). With the assistance of international partners, Zimbabwe has been able to provide fully subsidised health services to expectant mothers and under-five children through such programmes as the Urban Voucher Program and Results-Based Financing (RBF), funded by the Global Financing Facility (World Bank, 2019). Moreover, the prevention of mother-to-child transmission (PMTCT) program intends to reduce HIV transmission from mothers to children (Musarandega et al., 2020). The World Bank, along with its multi-donors, has financed free health services for under-fives and pregnant mothers through the Results-Based Financing programme (The World Bank, 2016).

2.11 Chapter Summary

In this chapter, the study's context was presented, starting with Zimbabwe's general profile and overview of its healthcare system. The chapter also presents Zimbabwe's healthcare system's challenges, the country's ICT environment, under-five mortality trends, emerging technologies in Zimbabwe and a description of Makonde District, which is the study area.

The researcher discussed the ICT environment, the national ICT policy, mobile telecommunications, ICT in healthcare, national e-health strategy and e-health in Zimbabwe's public healthcare. Generally, the ICT indicators for Zimbabwe are good, especially internet and mobile phone penetration, which are above 60% and 90%, respectively (POTRAZ, 2019, 2020).

Detailed information about Makonde District is provided, such as the available healthcare institutions. The distribution of these facilities among the public, private and mission is also presented. Normally, when people face a problem, they attempt to solve it. Likewise, several efforts have been made by Zimbabwe's government to address the problem of under-five mortality in the country, including in the Makonde District. These efforts were also discussed in this chapter, and the researcher indicated that they are insufficient and have failed to address the problem, requiring complementing measures.

The next chapter is dedicated to a literature review and focuses on under-five mortality trends in Zimbabwe, an overview of emerging technologies in healthcare, an overview of emerging technologies for child health, an overview of electronic health, factors affecting digital technologies adoption in healthcare and the role of emerging technologies in child health. The related studies are reviewed, and the research gap is explained before summarising the chapter.

CHAPTER 3: Literature Review

3.1 Introduction

Various emerging technologies are being applied in the healthcare domain to improve service delivery, quality and overall experience while reducing healthcare costs (Batani & Maharaj, 2022a; Mbunge, Dzinamarira, Fashoto, & Batani, 2021). COVID-19 has seen a plethora of digital innovations in the healthcare domain (Farao, 2020; Moore & Hawarden, 2020) and an increased uptake of such technologies by medical practitioners (Grossman et al., 2020). Such technologies include the various sub-types of artificial intelligence (such as deep learning (DL) and machine learning(ML)) (Janiesch et al., 2021), big data analytics, internet of medical things (IoMT), 3D printing (Khan et al., 2021; Shilo et al., 2018), virtual reality, virtual clinics (Gilbert et al., 2020), cloud computing, telehealth and telemedicine (Grossman et al., 2020; Mbunge, Muchemwa, et al., 2022). In this chapter, the researcher reviews the literature on emerging technologies in healthcare, emerging technologies for child health, uses of emerging technologies in healthcare and factors affecting emerging technologies adoption in healthcare. Moreover, the researcher expatiates the role of emerging technologies in child health and articulates the research gap that this study sought to fill. The reviewed literature was informed by the research questions and objectives.

3.2 Under-Five Mortality Trends

In this section, the researcher presents under-five mortality trends globally, regionally and nationally. This helps to show where Zimbabwe currently stands in terms of under-five mortality from a global perspective.

3.2.1 Global Under-Five Mortality Trends

Although there has been a global improvement in child health and under-five mortality rates from 1990 to the present, under-five mortality remains high and a cause for concern globally (UN IGME, 2019, 2020, 2021). According to the statistics published by the UN IGME (2010), the majority of child deaths occur before the age of five. In 2018, for instance, the world registered about 5.3 million (85% of all child deaths for the year) deaths of under-five children and about 1 million deaths of those children above the age of 5 but not above 14 years of age (UN IGME, 2019). In 2020, approximately 5.5 million under-five children died globally (UN IGME, 2021).

On a global scale, there was a 59 per cent decrease in under-five mortality between 1990 and 2018 (UN IGME, 2019). Though a 59 per cent decrease is a significant improvement, under-five mortality is still high, with the Sub-Saharan African region being the hardest-hit region (Mbunge, Chemhaka, et al., 2022; UN IGME, 2019, 2021). The UN IGME (2019) postulates that most under-five deaths are due to curable or preventable diseases. This implies that most of these deaths of under-five children the world over could be avoided.

In the quest to improve child health and reduce under-five mortality, the United Nations set SDG targets, such as SDG 3. The SDG target for under-five mortality is 25 per 1 000 live births (UN IGME, 2019). The world has registered an improvement in under-five mortality between 1990 and 2018, with a decrease of about 7.2 million deaths (UN IGME, 2019). However, many children are still dying, with a global daily average of 15 000 under-five deaths in 2018 (UN IGME, 2019), translating to 625 under-five children dying every hour. These numbers were estimated to have increased to 5.5 million in 2020 (UN IGME, 2021).

While the annual under-five mortality declined between 1990 and 2018, the annual rate of reduction has increased by merely 2 per cent (from approximately 2 per cent between 1990 and 2000 to approximately 4 per cent between 2000 and 2018) (UN IGME, 2019). Such statistics are affected by countries and regions with high under-five mortality rates; hence reducing the rate in those countries will reduce the overall under-five mortality rate globally. Such attempts include the aim of this research, in which the researcher seeks to explore the potential contributions of emerging technologies in reducing under-five mortality in Zimbabwe. At least fifty countries are on the verge of failing to achieve the SDG under-five mortality targets by 2030 (UN IGME, 2021).

3.2.2 Under-Five Mortality in Africa

Under-five mortality remains relatively higher in Africa compared to the global average (Mbunge, Chemhaka, et al., 2022; UN IGME, 2021). In Uganda, for instance, the under-five mortality rate was 137 per 1 000 live births in 2005 (Ayiko et al., 2009), while for Nigeria, it is approximately 167 per 1 000 live births, translating to about one death in every six under-five children (Adedini & Odimegwu, 2014). The Sub-Saharan African region has the highest under-five mortality rates within both the African continent and the entire planet (Haley et al., 2017; UN IGME, 2021). Africa has an average U5MR of 72 per 1 000 live births (UN IGME, 2021).

3.2.3 Under-Five Mortality in Sub-Saharan Africa

The Sub-Saharan African region has always had the highest under-five mortality rates (Amouzou & Hill, 2004; UN IGME, 2019), with the 1990 under-five mortality rate being 180 deaths per 1 000 live births, while the developed counterparts had an under-five mortality rate of only 9 per 1 000 live births in the same year (Ayiko et al., 2009; UN IGME, 2020). A comprehensive list of the countries classified as Sub-Sahara is presented in Table 8. The UN IGME (2019) reports that Sub-Saharan Africa (SSA) has registered an improvement in under-five mortality since the year 2000, though the improvements have not been as significant as those registered by eastern and south-eastern Asia. Under-fives in SSA are a fifteen-fold more likely to die than their counterparts in developed countries (UN IGME, 2021).

Sub-Saharan Africa remains the region with the highest under-five mortality rate in the world (Mbunge, Chemhaka, et al., 2022), with an under-five mortality rate of 78 per 1 000 live births as of 2018, against a global average of 39 deaths per 1 000 live births (UN IGME, 2019). In 2020, the under-five mortality rate of Sub-Saharan Africa was estimated at 74 per 1 000 live births, a value that is fourteen times higher than Europe and Northern America and nineteen times higher than New Zealand and Australia, which have an U5MR of 4 per 1 000 live births (UN IGME, 2021). This means that children in Sub-Saharan Africa have higher chances of dying before age five (UN IGME, 2021). The SSA's average U5MR is double the global average of 37 per 1 000 live births. There are six countries in Sub-Saharan Africa with an under-five mortality rate of at least 100 per 1 000 live births.

In 2018, Sub-Saharan Africa contributed to 52 per cent of global under-five deaths (UN IGME, 2019). In 2020, the value increased to 54 per cent of the global under-five deaths (UN IGME, 2021), suggesting that the region is making the least progress relative to others. Zimbabwe is one of the countries in the Sub-Saharan Africa region. In 2020, the region had an average under-five mortality rate of 74 per 1 000 live births, which was the highest of all regions (UN IGME, 2021). The SSA region also has the worst neonatal mortality in the world, making it the region with the worst child health outcomes (Chadoka-Mutanda & Odimegwu, 2017; UN IGME, 2020, 2021). Of the 43 million under-fives estimated to die before 2030, SSA is projected to account for 58 per cent (UN IGME, 2021). Moreover, about 75 per cent of SSA countries are at high risk of failing to attain the under-five mortality targets of the UN SDGs (UN IGME, 2021).

Generally, there is a downward trend in the under-five mortality rates of the SSA region, from 181 in 1990 to 74 in 2020, although it is still the highest rate globally (UN IGME, 2021).

The estimated under-five mortality rates for SSA countries are presented in Table 8. These values are estimates by the UN IGME for the three years 2018 to 2020. It is evident from Table 8 that most SSA countries have poor U5MR outcomes, save for Cabo Verde, Seychelles and Mauritius, which have maintained rates below the SDG target. Some countries still have rates above 100, such as Somalia, Chad and the Central African Republic. Zimbabwe, though its U5MR is below 100, still has a high U5MR relative to the SDG and MoHCC's targets. The Zimbabwe National Statistics Agency carried out a national survey in 2019 (the Multiple Indicator Cluster Survey or MICS for short), with support from the European Union, UK Aid, Sweden Embassy to Zimbabwe, UNFPA and UNICEF (ZIMSTAT, 2019b). The MICS findings indicate that Zimbabwe's U5MR (73) is higher than the UN IGME (2019)'s estimates (55). Since the UN IGME (2019) value was an estimate, the researcher preferred the ZIMSTAT (2019b)'s survey findings.

Table 8: Under-five mortality rates for SSA countries

Country	**U5MR per 1 000 live births by year**		
	2018 (UN IGME, 2019)	**2019** (UN IGME, 2020, pp. 40–48)	**2020 (UN IGME, 2021)**
Angola	77	75	71
Benin	93	90	86
Botswana	36	42	45
Burkina Faso	76	88	85
Burundi	58	56	54
Cabo Verde	19	15	14
Cameroon	76	75	72
Central African Republic	116	110	103
Chad	119	114	110
Comoros	67	63	61
Congo	50	48	45
Côte d'Ivoire	81	79	78

Democratic Republic of the Congo	88	85	81
Djibouti	95	57	56
Equatorial Guinea	85	82	78
Eritrea	42	40	39
Eswatini (formerly Swaziland)	54	49	47
Ethiopia	55	51	49
Gabon	45	42	42
Gambia	58	52	49
Ghana	48	46	45
Guinea	101	99	96
Guinea-Bissau	81	78	77
Kenya	41	43	42
Lesotho	81	86	90
Liberia	71	85	78
Madagascar	54	51	50
Malawi	50	42	39
Mali	98	94	91
Mauritania	76	73	71
Mauritius	16	16	17
Mozambique	73	74	71
Namibia	40	42	40
Niger	84	80	78
Nigeria	120	117	114
Rwanda	35	34	40
Sao Tome and Principe	31	30	16
Senegal	44	45	38

Seychelles	14	14	14
Sierra Leone	105	109	108
Somalia	122	117	115
South Africa	34	34	32
South Sudan	99	96	98
Togo	70	67	64
Uganda	46	46	53
Tanzania	53	50	49
Zambia	58	62	61
Zimbabwe	46	55 (73 (ZIMSTAT, 2019b)	54

3.3 The Impact of COVID-19 on Under-Five Mortality

Researchers and healthcare professionals feared that the emergence of COVID-19 was going to significantly increase child mortality (Roberton et al., 2020). A scenario modelling study conducted in 2020 suggested that child mortality would increase by about 235 500 cases in half a year due to COVID-19 (Roberton et al., 2020). There were fears that the pandemic would reverse the achievements made in improving child mortality outcomes (WHO, 2020).

However, the empirical evidence suggested that under-fives were the least affected in terms of mortality from COVID-19 (UN IGME, 2021; UNICEF, 2020b). Nonetheless, the indirect effects of COVID-19 on under-five mortality could be detrimental and threaten the achievement of the UN SDG's under-five mortality targets (Hirschhorn et al., 2020; WHO, 2020). The indirect effects of the COVID-19 pandemic include overwhelmed healthcare services (United Nations, 2020), disruption of child healthcare services (WHO, 2020), diversion of health resources, and reassignment of healthcare personnel for COVID-19 purposes affect the delivery of critical child health services and threatens the gains made over years towards reducing U5M (UNFPA Maldives, 2020; Yigezu et al., 2020).

Moreover, the COVID-19-induced national lockdowns and movements restrictions affected child access to healthcare services (Organisation for Economic Co-operation and Development (OECD), 2020) and increased home deliveries as some women feared contracting COVID-19 from healthcare centres (Yigezu et al., 2020). Job losses and supply chain constraints because of COVID-19 led to malnourishment in children, increasing their exposure to diseases and wasting (UNICEF, 2020a). Additionally, some children missed out on important vaccinations, exposing them to diseases (The Royal College of Paediatrics and Child Health (RHCP), 2020). Identifying those children who missed out on immunisation could be a daunting task without using information technology (Batani & Maharaj, 2022a).

3.4 Overview of Emerging Technologies in Healthcare

Emerging technology is not synonymous with *new technology* since an established technology in one domain can be an emerging technology in another (Halaweh, 2013; Millea et al., 2005). In fact, whether technology is emerging or not depends on the context (place, domain or application) in which it is being considered (Halaweh, 2013). In this study, the term emerging technology means any new or old information technology whose development or practical applications in Zimbabwe's public healthcare are mainly unrealised.

There are several emerging technologies in healthcare, such as AI, IoT, 3D printing, virtual reality and big data analytics (Holst et al., 2020; Mbunge, 2020; Mbunge, Dzinamarira, Fashoto, & Batani, 2021). The following sections present a literature review pertinent to emerging technologies in healthcare from a global perspective.

3.4.1 IoT in Healthcare

The advent of the Internet revolutionised virtually every sphere of people's lives, including education, entertainment, communication, health, transport and work, among others. With global healthcare systems strained due to COVID-19, emerging technologies like IoT could help improve efficiency and access to care (Raza et al., 2021). The Internet of Things uses the existing internet infrastructure to connect everyday objects (things) to the Internet using sensors, wireless sensor networks (WSN) and Bluetooth-enabled devices, with powerful servers for data analysis and knowledge extraction (Khodadadi et al., 2016). IoT is a collection of devices and systems that link sensors and actuators to the Internet (Fremantle, 2015). Schneider (2018) concedes that defining IoT precisely is difficult, though he defines it as a network of virtually everything and anything which is uniquely identifiable in a network and/ or has some computing capabilities.

IoT-based innovations are increasingly emerging in healthcare in areas like remote collection of patient health data (Castiglione et al., 2021) and monitoring of adherence to medication and treatment (Islam et al., 2015). IoT-based applications have been developed to monitor health parameters for pregnant women and foetuses remotely, leading to reduced maternal, prenatal and under-five mortality (Amala & Mythili, 2017; Marques et al., 2021). Furthermore, IoT is being used to provide input data to patient care systems to discover new disease information that feeds into early disease detection and critical decision-making to improve quality of life (Jagadeeswari et al., 2018).

Benefits of IoT in healthcare include higher service quality, lower service cost, reliable preventive care (Fayez, 2018; Islam et al., 2015), personalisation of healthcare (Jagadeeswari et al., 2018), remote monitoring of patients' health, adherence to medication and treatment by patients at home, enriching users' experience and improving the quality of life (Islam et al., 2015).

The application of IoT in healthcare benefits not only patients but also service providers. Healthcare providers benefit in many ways, including reduced device downtime through remote service provision, correct identification of optimal times for supplies replenishment to enable smooth and uninterrupted operation, and efficient scheduling of inadequate resources (Islam et al., 2015). Several IoT-based applications, devices and solutions have already been deployed in healthcare. According to Blake (2015), as cited in Fayez (2018), more than thirty per cent of all global IoT-based applications are in healthcare. The Internet of Things, among other recent technological advances in healthcare, has lowered costs, enhanced service quality and improved the management of healthcare globally (Williams & Woodward, 2015).

A study by Amala and Mythili (2017) in India showed that IoT-based applications could help monitor pregnancies by monitoring foetal kicks and essential physiological parameters like oxygen saturation, temperature and heart rate. Moreover, Marques et al. (2021) developed a system for foetal monitoring by combining IoT and AI. COVID-19 requirements, like social distancing, contact tracing and surveillance, led to the rapid development of IoT-based applications globally (Singh et al., 2020). Literature shows that IoT can promote child health and well-being before even the child is born (Marques et al., 2021). This is achievable through IoT-based systems that monitor pregnancies, and this is especially important in rural areas of developing countries where the majority of women give birth at home where they cannot get specialised attention (Amala & Mythili, 2017). The real-time and remote monitoring of pregnancies is done through the monitoring of parameters like body temperature, oxygen saturation, heart rate and the number of kicks per unit of time for the foetus. IoT helps promote child health through real-time remote monitoring, early diagnosis of ailments and monitoring of compliance with treatment (Islam et al., 2015).

When babies are still young and unable to talk, it is difficult for parents or guardians to tell whether they are well or not unless they cry excessively or the parents notice some abnormalities. In such cases, using the IoT can help to tell if a child is healthy or not based on the parameter readings collected by sensors (Amala & Mythili, 2017; Taiwo & Ezugwu, 2020). Medical specialists can monitor the health of children remotely in real-time (Castiglione et al., 2021) and attend to them before it is too late.

Though the internet of things improves patient care and access to and efficiency of healthcare, it also has undesirable effects. Researchers have raised ethical issues concerning the use of the internet of things during COVID-19 (Mbunge, Fashoto, Akinnuwesi, et al., 2021). Such issues include oversurveillance and repurposing, where some government agencies tracked some people for purposes other than healthcare (Gaobotse et al., 2022b; Mbunge, Fashoto, Akinnuwesi, et al., 2021). Moreover, wearable devices that may be used for continuous patient monitoring may have short battery life, which can create challenges in countries where there are constant electricity outages or when patients visit un-electrified rural areas (Mbunge, Muchemwa, Jiyane, & Batani, 2021).

3.4.1.1 Sensors and Wearable Devices

There is a surge in the use of sensors globally to improve service delivery and user experience. Healthcare is one such domain in which the use of sensors is surging (Mbunge, Muchemwa, Jiyane, & Batani, 2021). In healthcare, sensors are widely used for real-time patient data collection as they can covert health data into observable electrical signals (Haleem et al., 2021; Hasan & Negulescu, 2020; Kumar et al., 2020). Physiological parameters like heart rate, oxygen saturation, blood pressure, body temperature (Amala & Mythili, 2017), body weight, serum levels of different stress levels and blood sugar levels can be remotely and continuously measured using sensors and sensory smart gadgets (Mbunge, Muchemwa, Jiyane, & Batani, 2021). If interfaced with software applications to analyse the physiological data, sensors can provide pervasive, customised and ubiquitous healthcare. Real-time monitoring of patients' physiological parameters can significantly improve the quality of healthcare to neonates, foetuses and under-fives as medical professionals can quickly identify when the children are sick (Amala & Mythili, 2017; Joshi et al., 2016). Monitoring the physiological parameters of neonates in real-time is crucial given that the neonates cannot talk to say when they are sick.

There are unlimited possibilities that sensors and sensing devices can potentially bring to the healthcare domain, one of which is the provision of virtual and pervasive healthcare (Mbunge, Muchemwa, Jiyane, & Batani, 2021). Researchers, scientists and engineers have already demonstrated that sensors can be integrated with smart devices like smartphones, smart wearable devices and the internet of medical things. There is evidence of sensors' indispensability in monitoring people's activities for medical purposes, helping with medical diagnosis and monitoring (Gaobotse et al., 2022b; Haleem et al., 2021; Hatamie et al., 2020; Mbunge, Jiyane, et al., 2022; Mbunge, Muchemwa, Jiyane, & Batani, 2021).

However, some sensor-based patient monitoring systems generate lots of false alarms which are non-actionable (O'Mara Sage et al., 2019). Moreover, patient acceptance of monitoring systems is hindered by religiosity (O'Mara Sage et al., 2019) and ethical and security concerns (Dai et al., 2020). A study that was conducted by O'Mara Sage et al. (2019) in Sub-Saharan Africa and South Asia on the feasibility of child health and mortality prevention surveillance revealed that implementation guidelines must be site-specific as the factors that influence adoption are not universal.

3.4.2 Artificial Intelligence (AI)

AI is a collection of technologies that seek to make computers intelligent and its subtypes are machine learning, artificial neural networks, and deep learning (A. Zhang et al., 2020). The increase in data volumes (through IoT and an increase in digital devices) in healthcare have led to a rise in the use of AI for healthcare provision (Davenport & Kalakota, 2019) since AI algorithms thrive on massive datasets to train the algorithms. There are various uses of AI in healthcare, such as improving and automating diagnosis (Davenport & Kalakota, 2019; Xiong et al., 2018) and recommending patient engagement, adherence and administration (Davenport & Kalakota, 2019).

AI algorithms have already proven to be more effective than radiologists in detecting malignant tumours and "guiding researchers on how to construct cohorts for costly clinical trials" (Davenport & Kalakota, 2019, p. 94). Deep learning is helping clinicians detect clinically relevant features in imaging data beyond the capability of a human eye (Vial et al., 2018). Several expert systems have been developed in the medical domain, such as the

MYCIN, and AI has proved so useful in precision medicine that it is beyond question if AI can be useful in healthcare (Zamora et al., 2016). Lee et al.,(2018) developed a ML model that integrated big data to perform precision medicine in a cancer type called acute myeloid leukaemia. Their argument was that cancers tend to respond differently to the same treatment among different patients, hence, the need to use ML to identify the most suitable treatment plans to each patient (Lee et al., 2018). They reported an area under the curve value of 53.967 per cent, a sensitivity value they claimed outperformed most of the existing approaches. Moreover, AI was used for drug repurposing during COVID-19 (Zhou et al., 2020). As COVID-19 was at its peak, medical scientists sought to create vaccines and drugs quickly to save lives. One approach they tried was drug repurposing, where drugs originally meant to treat certain ailments would be tried for other diseases and conditions (Zhou et al., 2020). Researchers have applied ML approaches to highlight ways to repurpose drugs for paediatric cancers (Hovestadt et al., 2013; Zhou et al., 2020). For instance, Northcott et al. (2017) used support vector machines (a ML algorithm) for molecular classification and disease diagnosis.

Apart from diagnosis tools such as the EMGuidance in South Africa, healthcare institutions are using medical chatbots to provide ubiquitous access to health information and answer general queries on public health (Mbunge, Batani, et al., 2022). The Neotree, a digital health system that guides healthcare professionals on the treatment of diseases and conditions in neonates, has been piloted in Zimbabwe and Malawi with positive results (Gannon et al., 2021; Neotree, 2021). However, the deployment of Neotree in Zimbabwe is not nationwide (Gannon et al., 2021). Moreover, though the system applies AI, it does not analyse the collected routine data to inform paediatric car, nor is it integrated with other health information systems to provide evidence-based and data-driven paediatric care (Batani & Maharaj, 2022a). Even so, healthcare professionals who have used Neotree have reported that it is effective and has helped them save the lives of neonates, supporting the claims that AI can help save lives (Gannon et al., 2021).

Though AI-driven healthcare applications seem to be gaining traction of late, research in this area began over fifty years ago. Research on applying AI to disease diagnosis and treatment began as far back as the 1970s when Stanford University developed a rule-based expert system called MYCIN for bacterial infection diagnosis (Xie et al., 2015). Since then, several studies have suggested that AI could outperform human experts in executing some healthcare tasks, such as tumour detection, a task in which deep learning has performed well (Davenport & Kalakota, 2019). The potential of AI in healthcare has attracted the attention of both researchers and technology companies like IBM. IBM researchers developed an AI-driven tool called Watson, which combines ML and natural language processing (NLP) capabilities to provide several services, including disease diagnosis (C. Ross & Swetlitz, 2017).

The benefits of AI in precision medicine, such as improved accuracy and efficiency in disease diagnosis (Manikandan et al., 2020), have seen governments investing in research in the area (The UK Government, 2021b). Machine learning has succeeded in precision medicine, where it has been applied to predict the best treatment protocols for patients based on their attributes (Lee et al., 2018). AI played a significant role in the COVID-19 vaccines development, including designing drugs and vaccines (Thomas et al., 2022), genome sequencing, developing drugs and discovering vaccines (Abubaker Bagabir et al., 2022). Artificial intelligence helps enhance efficacy, minimise the duration of drug design and costs as well as helps analyse complex and huge data sets of clinical trials (R. Gupta et al., 2021). Integrating AI in computer-aided drug design helps reduce the time taken to design, develop and test vaccines and drugs through modelling, as well as enhance accuracy.

However, rule-based healthcare systems lack adaptability as they require hand-tuning, unlike deep learning (Davenport & Kalakota, 2019). Moreover, ethical issues have been raised regarding using AI in healthcare (Mbunge, Fashoto, Akinnuwesi, et al., 2021; Mbunge, Millham, Sibiya, Fashoto, et al., 2021). The issues include algorithmic bias and who becomes accountable when a human expert obtained advice from an AI tool (Davenport & Kalakota, 2019). The adoption of AI in daily clinical practise is still low, probably due to the issues raised by healthcare professionals, such as ethics and accountability (Davenport & Kalakota, 2019).

3.4.3 Big Data Analytics

Big data refers to vast and complex data which cannot be easily analysed and managed with traditional software and hardware (Kankanhalli et al., 2016; Raghupathi & Raghupathi, 2014). Big data analytics comprises controlling data quality, integrating heterogeneous data, analysing, modelling, interpreting and validating (Ristevski & Chen, 2018). Through big data analytics, huge datasets of thousands or hundreds of thousands of patients can be analysed, and clusters and correlations identified to develop predictive models using data mining techniques (Ristevski & Chen, 2018).

Digital technologies have increased the volume of patient data generated, creating opportunities for discoveries in the healthcare domain (Mbunge, Akinnuwesi, Fashoto, Metfula, et al., 2021a; Ye, 2020). The increased connectedness and proliferation of wearable devices, sensors, telemedicine, electronic medical records (EMR), the medical internet of things and other emerging technologies have resulted in the generation of huge volumes of medical data (Mbunge, Muchemwa, et al., 2022). The big data can be analysed to identify trends and utilised for disease detection, prevention, management and personalised care (Mbunge, Muchemwa, Jiyane, & Batani, 2021). Combined with AI and other emerging technologies, big data analytics was used during the COVID-19 pandemic to model and predict the spread of the virus, and analyse disease trends and vaccine effects (R. Gupta et al., 2021).

The Ohio state employed big data analytics to save children's lives by analysing more than 200 datasets to uncover hidden trends (Accenture Labs, 2019) and inform paediatric care (Gout et al., 2021). Evidence-based paediatric care achieved through big data analytics is also crucial in precision medicine to identify the most appropriate treatment plan for each patient (Zamora et al., 2016), leading to the personalisation of care (Omotosho et al., 2019). Oftentimes, big data and AI are integrated to enhance and complement their performance (Lee et al., 2018).

However, the unlocked value of this data may be overshadowed by ethical issues regarding how the data was collected and used (Mbunge, Fashoto, Akinnuwesi, et al., 2021; Royakkers et al., 2018). AI algorithms that could be used to analyse big data may perpetuate societal disparities, segregation and biases as those may naturally be reflected in the datasets.

3.4.4 3D Printing

3D is one of the emerging technologies in healthcare that is improving efficiency, enabling personalisation and customisation of healthcare (Shilo et al., 2018; Ventola, 2014). 3D printing is premised on additive technology, where layers of material are gradually added to create 3D objects (Shilo et al., 2018). This technology is rapidly evolving in the health sector, among other sectors and has the potential to revolutionise the health domain (Shilo et al., 2018).

Some of the uses of this technology in health include surgery pre-planning, virtual planning and customization of surgery and surgical guides, patient-specific implants (Shilo et al., 2018), bio-printing of organs and tissues, tissue and organ fabrication, creating customised prosthetics, pharmaceutical research on drug dose and forms, delivery and detection (Ventola, 2014). 3D printing technology has numerous advantages in healthcare, including customisation and personalisation of healthcare (products, drugs and equipment), cost-effectiveness, and increased productivity (Ventola, 2014).

The COVID-19-induced strain on healthcare systems and disruptions to the supply chain created shortages of clinical supplies (Roberton et al., 2020). To combat the shortages, 3D printing was used (Longhitano et al., 2021). Nonetheless, some of the 3D-printed medical devices may fail to pass the required standards as they were not subjected to thorough testing since there was an urgent need to fill a gap (Longhitano et al., 2021). Thus, the continued use of such devices may raise ethical concerns (Kitchin, 2020).

3.4.5 Mass Media Technologies

Mass media refers to communication technologies intended to reach many people, such as electronic/digital billboards, radios, televisions and social media. Mass media technologies have been shown to improve people's behaviour, perceptions and attitudes towards health issues (B. J. Saunders & Goddard, 2002). Promoting health entails not only curative measures and patient treatment but also prevention. The adage "prevention is better than cure" emphasises the importance of preventing diseases rather than relying on getting a cure after falling sick. Mass media plays an important role in disease prevention by educating the public on health matters and disease prevention methods (Balamurugan, 2018; Naveena, 2015; B. J. Saunders & Goddard, 2002; Sharma & Gupta, 2017).

Mass media in healthcare is useful in the dissemination of important health information to the public, expansion of audience reach (including those who live in underserved, remote, rural areas) and provision of a critical link between health professionals and the public (Naveena, 2015; Sharma & Gupta, 2017). In this era of social media, fake news and misinformation, mass media helps debunk misinformation and disinformation by spreading official information. Several governments used mass media to provide official information on COVID-19, enabling people to access official and authentic information (Mbunge, Batani, et al., 2022). Attitude shift and behavioural change are important in preventing diseases. Mass media helps persuade target audiences to change behaviours and adopt new ones that minimise the spread of diseases (Naveena, 2015; Sharma & Gupta, 2017).

Moreover, people can be reminded of critical information (such as important dates for visiting health facilities for pregnant and nursing mothers), updated on new diseases and disease outbreaks, disease prevention, and whom to seek medical help from (Balamurugan, 2018; Naveena, 2015; Sharma & Gupta, 2017). Educating the public about health issues is one of the most important constituents of public health and health promotion (Sharma & Gupta, 2017), and mass media is helpful in that respect.

In the context of promoting child health, mass media can be useful in awareness creation, disseminating essential information to mothers and guardians, influencing parents' behaviours and attitudes about child health (Naveena, 2015; Sharma & Gupta, 2017) and generally educating parents about child health and care(B. J. Saunders & Goddard, 2002). In Zimbabwe, the government is expanding community radio stations to empower local communities (Pikirayi, 2018), and one such radio station currently operating in Mashonaland West Province is Nyami Nyami. There are also national radio stations, a national television (TV), and several social media platforms such as WhatsApp, Facebook, Twitter and Instagram. These may potentially be used as sources of health information to improve the health of under-five children.

3.4.6 Telemedicine and Telehealth

There are different definitions of telemedicine in the literature, but they all point to the use of ICTs to provide patient care remotely. Telemedicine is the use of telecommunication technologies and software applications to deliver healthcare services remotely (Albarrak et al., 2021; Bashshur et al., 2020). The World Health Organisation (WHO) defines telemedicine as the cost-effective use of ICTs to support healthcare services, health surveillance, education, knowledge and research (Albarrak et al., 2021; WHO, 2015). Telehealth goes beyond telemedicine in that it includes health education, research, patient outreach and other applications in which ICTs are used to support healthcare services (Schut et al., 2020; WHO, 2006). Thus, though the terms telehealth and telemedicine are sometimes used interchangeably, they are distinctively different in that they use related but different technologies. Telemedicine uses information technology as the underlying technology, while telehealth uses telecommunication technologies (Bashshur et al., 2020).

WHO's definition of telemedicine implies that telemedicine reduces costs, among other benefits like assisting in health promotion (Schut et al., 2020), remote disease diagnosis and monitoring (Adeola & Evans, 2018). With a shortage of specialist healthcare professionals in rural areas, telehealth and telemedicine could play a critical role in improving access to specialist care remotely (Vidal-Alaball et al., 2020). These technologies also played a critical role in ensuring that patient care continued with minimal or no physical contact during the COVID-19 pandemic (Mbunge, Akinnuwesi, Fashoto, Metfula, et al., 2021a). For instance, the Royal National Orthopaedic Hospital delivered at least seven per cent of its outpatient consultations through telephone (Gilbert et al., 2020). However, the deployment of telemedicine and telehealth in Sub-Saharan Africa has mainly been for pilot testing, not at full-scale, countrywide (Moyo & Madziyire, 2020; Ndhlovu, 2021).

Though telemedicine and telehealth have promising benefits in healthcare, their access in low-resource settings perpetuates the digital divide between rural and urban areas (Doraiswamy et al., 2020). There is disproportionate access to digital resources between urban and rural areas in resource-constrained areas, including unstable network connections, poor computer skills (Furusa & Coleman, 2018) and erratic power supply (Batani, 2017; Chitungo et al., 2021). Developing countries often face a plethora of challenges that hinder nation-wide deployments of telemedicine and telehealth, such as a lack of the requisite ICT infrastructure (Dodoo et al., 2021), financial barriers (E. W. Coleman & Delea, 2013), security and privacy issues (Mbunge, Muchemwa, Jiyane, & Batani, 2021). Consequently, most Sub-Saharan African countries rely on health information systems to capture, store and process health information as the required infrastructure is cheaper than that for telemedicine and telehealth (Dodoo et al., 2021).

3.4.7 Virtual Clinics

Virtual clinics provide an alternative to physical consultations amidst the COVID-19 pandemic, reducing travel and waiting times (Gilbert et al., 2020). Health Service Excellence (2021, p. 3) defines virtual clinics as "planned contact by a healthcare professional with a patient/client for the purposes of clinical consultation, assessment, monitoring/management of healthcare conditions, provision of advice, and/or treatment planning". The clinical practice experienced a plethora of COVID-19-induced changes, one of which is the introduction of virtual or remote clinics (Charnell et al., 2020; Gilbert et al., 2020). Some benefits of virtual clinics have been reported, such as cost efficiency and patient satisfaction. However, those engaged in virtual clinics reported challenges in optimal patient-centric care (Charnell et al., 2020). Despite the reported challenges, it is evident that virtual clinics help provide remote patient consultations where it is not feasible to do so physically (Gilbert et al., 2020).

Virtual clinics became popular at the peak of the COVID-19 pandemic as healthcare professionals sought ways of providing care to patients, yet minimising physical contact. For instance, the Royal National Orthopaedic Hospital (RNOH) in the United Kingdom sought to reduce contact consultations of outpatient visits to twenty per cent (Gilbert et al., 2020). China's Ping An Good Doctor, an AI-powdered, unstaffed clinic that includes an intelligent medicine cabinet to dispense medicines, is one of the examples of virtual clinics (Lovett, 2018). Remote clinics became popular during the COVID-19 pandemic to minimise physical contact while delivering essential healthcare services to patients, such as consultation.

3.4.8 5G Technology

A purely digital health ecosystem, such as healthcare 5.0, involves the transfer of massive data between the healthcare providers and patients, such as the real-time collection of patients' physiological data (Amala & Mythili, 2017; Mbunge, Muchemwa, Jiyane, & Batani, 2021). Providing remote patient care using emerging technologies like nanotechnology, robotics, cloud computing, smart devices, and AI needs seamless and high data transfer rates to enable the real-time collection, storage, monitoring and tracing of health data (Mbunge, Akinnuwesi, Fashoto, Metfula, et al., 2021b; Mbunge, Muchemwa, Jiyane, & Batani, 2021). These requirements call for a stable, high-bandwidth wireless network. The 5G technology provides these capabilities with its high data transmission rate and ability to handle high data transmission volumes (Siriwardhana et al., 2021).

Some of the features that make 5G technology ideal for healthcare applications include high security in data transmission, high rate connectivity and ultra-low network latency, providing a paradigm shift in the current mobile networks (Mbunge, Muchemwa, Jiyane, & Batani, 2021; Siriwardhana et al., 2021). Security is a critical requirement in digital health (Emilio et al., 2021; Mbunge, 2020; Ristevski & Chen, 2018). Studies such as by Furusa and Coleman (2018), Mohanta et al. (2019) and Odekunle et al. (2017) have demonstrated that security and privacy are some of the factors affecting the adoption and use of digital health; hence, the use of a secure network could possibly persuade healthcare professionals and patients alike to adopt and use the technologies.

With technologies like sensor-based intelligent health systems, healthcare professionals can monitor under-five children's health remotely and in real-time. The high data transmission rates provided by the 5G technology enable secure and real-time remote patient care, treatment and consultation (Mbunge, Akinnuwesi, Fashoto, Metfula, et al., 2021a; Siriwardhana et al., 2021). However, the high transmission rates could translate to high bandwidth requirements (Shukurillaevich et al., 2019).

3.4.9 Robotics

The field of robotics has come of time, with numerous applications in fields like manufacturing. Of late, robotics have permeated the healthcare domain to improve the quality of care by aiding diagnosis, performing repetitive tasks and delivering medical supplies (Mbunge, Muchemwa, Jiyane, & Batani, 2021). Some healthcare providers are using robots and drones to deliver medication to patients and deliver medical supplies to healthcare facilities during the COVID-19 pandemic (Firouzi et al., 2021; Zeng et al., 2020).

Robots can help with healthcare provision in various ways. For example, autonomous robots are helping healthcare practitioners with repetitive tasks (Mbunge, Muchemwa, Jiyane, & Batani, 2021). The various examples of robots invented through continued digital automation include autonomous robots (Mbunge, Muchemwa, Jiyane, & Batani, 2021), telerobots, collaborative robots and social robots (Khan et al., 2021; Seidita et al., 2021; Tavakoli et al., 2020). These significantly improve the quality of care by conducting surgical operations, disease diagnosis and detection (Di Lallo et al., 2021). The use of robots in healthcare can potentially benefit under-five children to continue getting critical health services during the pandemic times, despite the re-assignment of some clinicians to attend to COVID-19 cases (Hirschhorn et al., 2020; Roberton et al., 2020). Robots and drones were used to help manage patients, record data, broadcast messages and deliver drugs and food to patients' rooms in hospital wards, for example, in Spain (PAL Robotics, 2020) and Rwanda (Musanabaganwa et al., 2020).

3.4.10 Blockchain Technology

Blockchain technology's popularity has soared in the financial services sector due to its high security when trading in distributed, peer-to-peer networks, eliminating the need for third parties (Agbo et al., 2019). This technology uses an append-only data structure called the blockchain to store data publicly and chronologically (Ahir et al., 2020), with the ability to store an ever-growing list of transactions (Mbunge, Muchemwa, Jiyane, & Batani, 2021). Just like the healthcare domain, the financial sector requires high security of data. Blockchain technology provides that security, making it a popular technology in electronic monetary transactions like cryptocurrency. With the rise in electronic health records, various benefits and potential could be unlocked by patient data sharing. However, the rise in digitisation of health records has not necessarily translated to an increase in patient data sharing due to security and privacy concerns (Gordon & Catalini, 2018).

There are at least two key features of blockchain that make it a secure technology, namely, non-repudiability (due to replication on multiple entities) and immutability (inability to computationally modify or manipulate any committed transactions) (Gordon & Catalini, 2018). These security features make blockchain an ideal technology to address the issues of security and privacy in digital health (Dai et al., 2020; Mbunge, Muchemwa, Jiyane, & Batani, 2021), which are often cited as barriers to the adoption of digital health (Balachandran & Prasad, 2017; Dai et al., 2020; Kitchin, 2020). Gordon and Catalini (2018), for example, argue that implementing blockchain in digital health enhances security by enhancing access rules, data liquidity, aggregation and immutability, patient identity and privacy.

The use of blockchain technology in digital health is not just a proof-of-concept but has widely been implemented in electronic medical records (EMR) (Mettler, 2016), medical insurance claims (Attaran, 2020), remote patient monitoring and pharmaceutical supply chain systems (Ben Fekih & Lahami, 2020). Blockchain was used during COVID-19 to secure digital vaccination certificates (Mbunge, Dzinamarira, Fashoto, & Batani, 2021) to improve their integrity, verifiability and traceability (Bhushan et al., 2020). Sharing patient data among healthcare providers can improve patient care through data-driven and evidence-based paediatric care as well as enhance continuity of care (Batani & Maharaj, 2022a). However, Downing et al. (2017) contend that sharing patient data across healthcare providers requires all the involved parties to make data sharing concessions and governance rules before the actual sharing starts.

3.4.11 Drone Technology

Drones are pilotless aircrafts or umanned aerial vehicles (Balasingam, 2017). They have been around for over a century, having been first used in the military since the late 19th Century and early 20th Century (Shaw, 2014). However, their usage has transcended the military domain to others, such as public safety and healthcare (Balasingam, 2017).

During the COVID-19 pandemic, the healthcare domain has witnessed a surge in the usage of digital technologies like autonomous machines, such as robots and drones (Mbunge, Muchemwa, Jiyane, & Batani, 2021). Many activities went online, like education, shopping, and work. Some countries have used drones to enforce the observance of COVID-19 protocols like movement restrictions (Khan et al., 2021), disinfection of contaminated places and delivery of critical supplies like food and medicines (Restás et al., 2021; Zeng et al., 2020). Using drones for critical supplies delivery could help in disaster-struck and inaccessible areas. After the 2010 Haiti earthquate, drones were used to deliver medicines in Haiti and the Dominican Republic (Choi-Fitzpatrick et al., 2016). Moreover, Matternet used drones in Papua New Guinea to deliver tuberculosis samples from remote, hard-to-reach rural areas to urban areas, minimising the delivery time (Medicins Sans Frontiers Inc., 2015). They have also been used in the Dominican Republic, New Guinea and Switzerland (Choi-Fitzpatrick et al., 2016).

3.4.12 Cloud computing

Cloud computing is a technology or model of delivering computing resources, including data, over the Internet and virtual servers to maintain the data and applications (Sunyaev, 2020) There are different models of cloud computing, such as infrastructure as a service (IaaS), platform as a service (PaaS) and software as a service (SaaS), depending on what a cloud user is outsourcing (infrastructure, platform or software) (Balachandran & Prasad, 2017).

There are several advantages of cloud computing in healthcare, including high efficiency and lower patient data storage and management costs, providing flexible and ubiquitous access to patient data (Griebel et al., 2015; Kumari et al., 2018; Mbunge, Muchemwa, Jiyane, & Batani, 2021). Moreover, it enables editing and sharing of patient data among healthcare facilities, remote treatment and diagnosis (Mbunge, Muchemwa, Jiyane, & Batani, 2021). Cloud-based health applications have already been deployed. Lu et al. (2018) created a smart, cloud-based helmet that monitors certain parameters for miners, such as anxiety, fatigue and concentration.

However, using cloud computing for healthcare applications requires ensuring the security and privacy of patient data. Anonymisation, encryption, blockchain (Bhavin et al., 2021; Tsafack et al., 2020) and developing robust application programming interfaces can improve the security of cloud-based healthcare systems (Mbunge, Muchemwa, Jiyane, & Batani, 2021).

3.5 Overview of Emerging Technologies for Child Health

While the general emerging technologies in healthcare are improving the healthcare of people of all ages, some applications are specifically designed for improving child (born and unborn) health. The need for different health applications for children from adults emanates from the fact that the physiologies of children and adults are different, and so are the interpretations of even the most basic clinical observations like blood pressure, heart rate and respiratory rate (Shiffman et al., 2001). Paediatrics applications include those that are meant to monitor the health of pregnant women and children, such as Wired Mothers (WHO, 2014), IoT-based healthcare monitoring systems for children (Amala & Mythili, 2017) and electronic-integrated management of childhood illnesses (Blaya et al., 2010), among others. Moreover, paediatrics applications should also include graphical growth monitoring, which is unnecessary for adults (Shiffman et al., 2001).

However, the technologies used for both children's and adults' health innovations are mainly the same, though the particular applications and systems will differ. Emerging technologies for child health include telemedicine, telehealth, electronic health records, big data, digital engagement (Busenbark, 2017), and wireless sensor networks (Amala & Mythili, 2017). Researchers have developed applications specifically for child health, such as the Neotree for neonates' health management (Gannon et al., 2021; Neotree, 2021), noninvasive sensors for continuous monitoring of physiological parameters (Chung et al., 2020) and mobile applications for monitoring treatment adherence (Morse et al., 2020). Moreover, computational technique-based tools have been developed to utilise paediatric data and provide data-driven paediatrics (Bourgeois, 2022; Gout et al., 2021; Zamora et al., 2016). Emerging technologies have been used in paediatrics to aid in diagnosing acute liver failure (Squires, 2008), model precision medicine for acute liver failure (Zamora et al., 2016), to conduct virtual consultations (Charnell et al., 2020) through paediatric telemedicine and telehealth (Curfman et al., 2021; Lakshin et al., 2021) and to manage paediatric tuberculosis using internet of things applications (Li et al., 2019).

3.6The Use of Emerging Technologies in Child Health

Patients and healthcare professionals are using emerging technologies in diverse ways, including remote data collection (Mohanta et al., 2019), booking appointments (Malik et al., 2017), diagnosis support (Zamora et al., 2016), remote patient treatment and monitoring, tracking disease outbreaks, medical data sharing and communication. In this section, the researcher explains some of the uses of emerging technologies in child health.

3.6.1Remote Health Data Collection

The surge in mobile devices presents an opportunity for remote health data collection. Instead of collecting data only when patients visit for consultation, medical practitioners can collect such data remotely and ubiquitously using IoT sensors (Fouad et al., 2020), telemonitoring and social media feeds (Messinger et al., 2020). Artificial intelligence, through predictive analytics, can discover knowledge from huge patient datasets to help in personalising healthcare and managing diseases (Messinger et al., 2020). Collecting patient data remotely could help to continuously and remotely monitor under-fives with special conditions, alerting healthcare institutions if there is an emergency.

3.6.2 Education and Awareness

Educating the public about health issues is one of the crucial elements of public health and health promotion (Sharma & Gupta, 2017). Through education and awareness programmes, healthcare institutions can persuade target audiences to change behaviours, remind them of critical health information and update them on new diseases and where to seek medical help (Balamurugan, 2018). Sharma and Gupta (2017) concur that education and awareness influence behaviour and change attitudes toward health and healthy behaviours; for instance, healthcare institutions can educate pregnant women on the importance of having regular check-ups throughout the duration of a pregnancy. As a result of education, the public can have access to accurate and current information regarding health conditions and treatment (West, 2015).

3.6.3 Booking Appointments

Since most people have busy schedules, they prefer booking appointments online with medical practitioners to avoid spending more time waiting in queues (Malik et al., 2017). Emerging technologies are helping patients to make appointments remotely by choosing dates and times that suit their schedules; and also enabling healthcare professionals to send appointment reminders to patients (McDonnell, 2017). With a shortage of paediatric specialists in most resource-constrained settings (Furusa & Coleman, 2018), booking appointments remotely could save patients' time and money by visiting healthcare institutions when they are sure they will see specialists. Pre-booking could be critical to patients who travel long distances to healthcare facilities or take long due to poor road networks and terrains (Batani & Maharaj, 2022a; Nyandoro et al., 2016).

3.6.4 Supporting disease diagnosis

Emerging technologies are supporting disease diagnosis. In some instances, emerging technologies are outperforming the human experts in disease diagnosis; for instance, AI is being used in diagnosis and treatment recommendation and is already outperforming radiologists at spotting malignant tumours (Davenport & Kalakota, 2019). Deep learning is helping medical experts in detecting clinically relevant features in imaging data beyond what the human eye can perceive (Vial et al., 2018). AI has already proven its remarkable capability to be useful in the healthcare domain, but the biggest challenge is ensuring its adoption in daily clinical practice (Davenport & Kalakota, 2019, p. 97). Moreover, emerging technologies can support health workers in carrying out clinician duties in the absence of doctors, can help keep track of patients and enable remote consultations (Blaya et al., 2010).

3.6.5 Remote Patients Treatment and Monitoring

Remote patient monitoring comprises using digital devices, mobile applications, websites or sensors to collect patient data when they are outside of physical healthcare institutions for transmission to a remote location where it can be monitored and acted on by medical practitioners (Portnoy et al., 2020). According to Jutras and Duckett (1957), as cited in Marlene et al. (2002, p. 2), telemedicine refers to the use of telecommunication technology for providing healthcare services, "clinical information and education" remotely; for instance, transmitting medical images. Through telemedicine, healthcare professionals can remotely monitor, treat and diagnose patients. Healthcare institutions can monitor the growth of children remotely, including graphic monitoring to quickly visualise children's growth (Shiffman et al., 2001).

3.6.6 Communication with Patients/ Sending Medical Information

Communication between pregnant women or mothers of under-five children and healthcare institutions can enhance health in many ways. These ways include reminding patients of critical health information through reminder systems (Bervell & Al-samarraie, 2019; Blaya et al., 2010). Healthcare institutions can disseminate important health information to the public and expand audience reach, including underserved rural areas, through mass media (Naveena, 2015). National health authorities and the World Health Organisation used interative medical virtual assistants (medical chatbots) to provide health information to the public using WhatsApp and other social media platforms (Firouzi et al., 2021; Fotheringham & Wiles, 2022). Interactive information exchange between patients and healthcare providers could help with health education and debunking misinformation and myths.

3.6.7 Tracking Disease Outbreaks

Medical researchers and healthcare institutions are using emerging technologies to track disease outbreaks (Carneiro & Mylonakis, 2009; Mbunge, 2020; Schmidt, 2012; West, 2015). Some people attempt self-diagnosis by searching on the Internet, and that search provides a data point that medical researchers could use to track disease outbreaks and respond to pandemics (Schmidt, 2012). Some people report symptoms via social media, and healthcare institutions can also use that information to track disease outbreaks, thereby transforming disease surveillance (Schmidt, 2012). It is possible to track disease outbreaks in real-time (Carneiro & Mylonakis, 2009) and plot outbreak maps (Schmidt, 2012). Emerging technologies can detect disease outbreaks faster than traditional Centres for Disease Control and Surveillance Systems (Carneiro & Mylonakis, 2009; Mbunge, Akinnuwesi, Fashoto, Metfula, et al., 2021a).

3.6.8 Communication with Fellow Health Professionals

Communication between and among professionals in the same domain is vital as it allows them to share new ideas and insights. Emerging technologies in healthcare can help medical professionals share the latest ideas on treating particular problems (West, 2015). They facilitate communication between healthcare institutions (Blaya et al., 2010). Moreover, healthcare professionals could exchange notes on how to handle certain conditions that might be challenging (Batani & Maharaj, 2022a). Communication among healthcare professionals can be helpful in remote areas to allow nurses to consult paediatric specialists who are normally housed in healthcare institutions that are in urban areas as they shun rural and remote areas (Nyandoro et al., 2016).

3.6.9 Training of Health Professionals

Continuous professional development is of paramount importance in virtually any domain, including healthcare. With new diseases, conditions and practises emerging, it is critical that healthcare professionals keep abreast. However, it is crucial to ensure that healthcare professionals remain onsite by limiting travel for both training and meetings (Bishi et al., 2017). Through technology, healthcare professionals can attend training sessions virtually while onsite. Ensuring that healthcare professionals remain on site is even more critical in developing countries like Zimbabwe, where there is a shortage of medical doctors (Ministry of Health and Child Care & University of Oslo, 2015; Ministry of Health and Child Care, 2016; Ministry of Health and Child Welfare, 2013).

3.6.10 Patient Medical Data Sharing

Emerging technologies are used to share patient medical data across institutions and healthcare professionals through electronic health cards (EHR), electronic patient records and health portals (Blaya et al., 2010). This sharing of patient data enables medical professionals currently attending to patients to have the patient's medical history. Moreover, the availability of huge patient datasets could facilitate data-driven and evidence-based paediatric care by applying deep learning and big data analytics (Batani & Maharaj, 2022a). However, the sharing of patient data is associated with security and ethical issues (Balachandran & Prasad, 2017), requiring patient consent, implementing security measures and ensuring the data is not repurposed (Mbunge, Batani, et al., 2022).

3.6.11 Treatment Support

Emerging technologies are supporting the treatment of patients both remotely and physically. Ventola (2014) explains how 3D printing shortens the duration of surgical operations, improves precision and is used for personalised medicine by choosing appropriate therapies based on a patient's genetic makeup, facilitating personalisation of care. Moreover, it is useful in customising and personalising medical products, drugs and equipment (Mbunge, Muchemwa, Jiyane, & Batani, 2021; Ventola, 2014). Virtual reality is helping clinicians treat psychiatric disorders like anxiety (Maples-Keller et al., 2017). Healthcare professionals who have used the Neotree (a digital system for neonates' treatment guidance) in Zimbabwe have reported that the system helped them save children's lives by suggesting appropriate treatment plans (Batani & Maharaj, 2022a; Gannon et al., 2021).

3.7 Emerging Technologies Interventions to Reduce U5M in Sub-Saharan Africa

Notwithstanding many challenges faced by Africa, such as unreliable power supply, lack of, and poor infrastructure, the continent has already embarked on its emerging technologies journey such as IoT (Liquid Telecom, 2017). Currently, the main uses of emerging technologies in healthcare in Sub-Saharan Africa are in the areas of reminders, treatment adherence, monitoring, training and recruitment, patient records management, information provision for treatment and disease prevention, case reporting, decision support, acquiring patient data and disease control and prevention (Bervell & Al-samarraie, 2019). A number of innovations have been deployed to improve access to healthcare and pregnancy and child health monitoring in the region.

In Zanzibar, a mobile health system called Wired-mothers that links women to health facilities during their most critical period before and after giving birth increased the number of women receiving healthcare significantly (Nyamawe & Seif, 2014; WHO, 2014). Moreover, Tanzania's 'Healthy Pregnancy Healthy Baby' text messaging system, Malawi's 'Chipatala Cha Pa Foni' (also called ICT for Maternal, Newborn and Child Health) and

Ghana's MamaYe, a website for fighting child mortality through educating, empowering and uniting stakeholders' efforts, are some of the technologies being used to improve pregnant women's and children's health (Nyamawe & Seif, 2014).

Tanzania is using JamboMama to provide remote pregnancy moniroting, albeit not in real-time (Healthy Newborn Network, 2017). Moreover, Tanzania is also using Nurse Assistant App, a digital clinical decision system to advise healthcare professionals on how to handle certain conditions and diseases according to the national and global standards and procedures (van Pelt et al., 2021). Other digital health interventions for maternal and child health in Tanzania include the Healthy Pregnancy Healthy Baby SMS system by MAMA and a mobile phone tool for community health workers in the Singida District (Nyamawe & Seif, 2014).

South Africa is using MomConnect (Barron et al., 2016; Grobbelaar & Uriona-Maldonado, 2019; Peter et al., 2018), ChildConnect (Mostert et al., 2021), Mobile Alliance for Maternal Action (MAMA) text messaging (J. Coleman et al., 2020), MUM & BABY (Matee, 2020) and DrConnect (Moore & Hawarden, 2020) to provide child and maternal health services digitally. MomConnect is used to connect pregnant women to health facilities by sending them stage-relevant information by free SMS, pre- and post-natal, until the child is a year old (Barron et al., 2016). The MAMA text messaging is used to send reminders for antenatal appointment visits, adherence to child care and educating women on public healthcare issues about children (J. Coleman et al., 2020), while the MUM & BABY has been used for maternal health education and communication (Matee, 2020). ChildConnect has also been used for health education provision to mothers and caregivers, facilitating mobile learning (Mostert et al., 2021). DrConnect is a remote medical consultation application that enables virtual consultations of scheduling (Moore & Hawarden, 2020).

Mobile ultrasound, Africa Wired and VScan have been used in Nigeria to provide portable and mobile ultrasound scanning (Ikpeme et al., 2017; Rao & Dona, 2017). Ghana, Tanzania, Malawi, Nigeria, Sierra Leone and Ethiopia have also implemented a web portal (MamaYe) for maternal and child health information dissemination (WHO, 2013). Moreover, Ghana and Tanzania have implemented an electronic clinical decision support system to support antenatal care by facilitating adherence to clinical practice guidelines, bridging the "know-do" gap of healthcare professionals (Blank et al., 2013; Sukums et al., 2015).

Though many Sub-Saharan African countries have adopted digital interventions to promote maternal and child health, most of the systems are SMS-based. Thus, the healthcare institutions miss on the possibility of applying computational methods to analyse the data generated and provide data-driven and evidence-based paediatric care (Batani & Maharaj, 2022a; Bourgeois, 2022). Moreover, common challenges like inadequate ICT infrastructure (Matee, 2020), understaffed healthcare facilities and underfunding have clouded the implementation of these interventions.

3.8 Factors Impeding Emerging Technologies Adoption in Healthcare

Impediments to the adoption of emerging technologies in healthcare have been categorised differently by different researchers though the actual barriers are similar. Some researchers have grouped the impediments into three, namely, product-related factors, social influence factors and security-related factors (AlHogai, 2018), while others have categorised them into internal and external factors (Furusa & Coleman, 2018). In the following subsections, these impediments are presented without categorisation.

3.8.1 Privacy and Security Issues

Patient data security is one of the critical ethical values in the healthcare domain, and concerns over potential data security breaches have impeded the adoption of emerging technologies in healthcare (Furusa & Coleman, 2018). Though consumers may realise and appreciate the potential benefits of technology in healthcare, their inertia to adopt it will arise from fear of potential data breaches, data security and privacy issues (Dinev et al., 2016; Kart et al., 2007; Robinson, 2008). These issues of privacy and data security are even more critical in healthcare, where patient privacy and data security are so critical that their breaching may lead to legal action. Besides the security that must be provided by applications, networks through which data traverse must also be secured, or at least the data must be secured. AlHogai (2018) points out that data insecurity may be due to insecure and untrusted networks through which data are transmitted; hence data in transit become vulnerable to attacks.

3.8.2 Lack of Infrastructure

The deployment and adoption of technological solutions require relevant infrastructure, thus, ICT infrastructure is a necessity for the deployment of emerging technologies in healthcare (Adeola & Evans, 2018). A study conducted by Furusa and Coleman (2018) revealed that a lack of infrastructure to support digital health systems impedes the adoption of electronic health, and sometimes there is over-reliance on personal digital devices. Some technological innovations, such as IoT-based ones, require considerable investments in requisite infrastructure, which may not be readily available, especially in low-resourced countries

(Liquid Telecom, 2017). The required infrastructure include gadgets, networks and software. However, Zimbabwe's public healthcare benefits from donors and partners, such as the Global Fund and World Bank, who fund various public health initiatives, including digital interventions (Chawurura et al., 2019).

3.8.3 Lack of Government Support

Government support in terms of legislation, provision of resources and incentivising the use of emerging technologies in healthcare can promote the adoption of digital health. In contrast, the lack of such support can impede digital health adoption. For the successful adoption of emerging technologies in the health domain, there is a need for approval by regulators (Davenport & Kalakota, 2019). Marginalised societies are being excluded from reaping the benefits of using information technologies (Gigler, 2015). Governments can support the adoption of emerging technologies in healthcare by removing import duties on ICT devices (Ministry of Health and Child Care, 2016). Zimbabwe's public health has been underfunded for many years (Furusa & Coleman, 2018; Haley et al., 2017; Nyandoro et al., 2016).

3.8.4 Organisational Policies

Organisational policies can enhance or impede technology adoption. For instance, social and institutional structures that perpetuate existing socioeconomic inequalities between the rich and the poor, can result in the poor failing to get the requisite devices to also be connected (Gigler, 2015). Being a technology-driven organisation requires policies and standards that support technology adoption, thus, a lack of such policies can impede technology adoption (Ndlanzi, 2021). A study conducted in Nigeria revealed that poor organisational and management policies hamper the adoption of technology in healthcare institutions (Zayyad & Toycan, 2018). This finding was confirmed by another study conducted in Saudi Arabia, which revealed that the nonexistence of health information governance policies hamper digital health adoption (Alanezi, 2021).

3.8.5 Lack of ICT skills

Users of electronic systems require digital skills for effective use of the systems. In a study conducted by Furusa and Coleman (2018), a lack of ICT skills was found to be one of the impediments to the adoption of technology by healthcare practitioners. Several studies have also revealed that a lack of ICT skills among healthcare professionals and patients alike is a hindrance to digital health adoption (Alanezi, 2021; Batani & Maharaj, 2022a; Bishi et al., 2017).

3.8.6 Poor Systems Integration

If a new technology is to be introduced in healthcare, it must be well integrated with existing electronic health systems, such as electronic health records (EHR) systems, for successful adoption (Davenport & Kalakota, 2019). Studies have shown that the failure to integrate new technologies with existing ones often impedes the adoption of new digital health technologies (Gaobotse et al., 2022a; Mbunge, Muchemwa, Jiyane, & Batani, 2021).

3.8.7 Lack of Standardisation

Emerging technology systems must be standardised to ensure that similar applications work in a similar way and can easily be taught to healthcare professionals (Davenport & Kalakota, 2019). A lack of standardisation between devices and technology hampers interoperability (Ben Fekih & Lahami, 2020; Dodoo et al., 2021). There is generally a lack of standards for developing electronic health tools (Ben Fekih & Lahami, 2020). Standardisation improves data sharing among healthcare insitutions to improve patient care (Gaobotse et al., 2022b).

3.8.8 Lack of Intrinsic Motivation

Intrinsic motivation is when a person acts because they derive satisfaction from the behaviour itself (van Velsen et al., 2019). Intrinsic motivation is a sufficient reason for people to adopt technology, and if usefulness is not immediately apparent, enjoyment may be an important factor (Adeola & Evans, 2018). van Velsen et al. (2019)'s findings concur with those of Adeola and Evans (2018) that a lack of intrinsic motivation can hinder the adoption of technology by healthcare professionals.

3.9 Overview of E-Health

E-health is short for electronic health. According to WHO (2005 p. 109), the term e-health refers to "the cost-effective and secure use of information and communications technologies in support of health and health-related fields, including health-care services, health surveillance, health literature, and health education, knowledge and research", while Blaya et al. (2010) simply define it as the use of ICT for managing patient care. E-health can also be written as eHealth, the form in which it is written by WHO (2005). Some categories of e-health include laboratory information systems, pharmacy information systems, patient registration and scheduling, clinical decision support systems, patient reminder systems, research/data collection, monitoring, evaluation and patient tracking systems (Blaya et al., 2010).

Telehealth and telemedicine are the other concepts closely related to e-health. In fact, these three are considered overlapping electronic healthcare (Marlene et al., 2002). Both telehealth and telemedicine existed before the Internet as the underlying technology was telecommunication technology, which existed before the Internet, the technology used in e-health (Marlene et al., 2002; Riva, 2004). Although telehealth and telemedicine are older than e-health, telemedicine and telehealth are now seen as subsets of e-health (Marlene et al., 2002; Riva, 2004), to the extent that Riva (2004) defines e-health as integrating telehealth technologies with the Internet. E-health administered over mobile devices and/or mobile applications is called mobile health (m-health or mHealth). Emerging technologies interventions for reducing under-five mortality therefore fall under the broad e-health category.

3.10 Emerging Technologies in Zimbabwe's Public Health

Telemedicine applications in Zimbabwe's public healthcare are very limited. There is a telemedicine application installed at the University of Zimbabwe's School of Medicine for purposes of training students (Ministry of Health and Child Welfare, 2012) and another telemedicine application deployed in two Manicaland districts, Nyanga and Chimanimani, as pilot studies to facilitate remote consultation by nurses at remote clinics enabling them to consult doctors at district hospitals without need for patients to travel to district hospitals (Maruta, 2018). The majority of digital health systems in Zimbabwe are mainly for administrative purposes and not necessarily patient care, diagnosis or treatment support. These include the electronic patient management system, national health information system, human resource management information system, electronic logistics management information system, and the district health information system 2 (UNDP Zimbabwe, 2015a, 2020).

The other examples include the Integrated Disease Surveillance and Response (IDSR) information system, Inpatient Mortality and Morbidity Information System (IMMIS), information systems for registration of medical practitioners with councils which citizens can query registration statuses of medical practitioners, the National Health Information System (NHIS) (Ministry of Health and Child Welfare, 2012) and Weekly Health Surveillance System (UNDP Zimbabwe, 2020). The IDSR and IMMIS have been hailed for improving data accuracy (Ministry of Health and Child Welfare, 2012).

The DHIS-2, which is free and open source software, is widely used in the country for data collection but barely for quality assurance, analysis, interpretation and dissemination (Ministry of Health and Child Care & University of Oslo, 2015). The system is in use in all districts across the country, improving data access in the NHIS, with health facilities in remote areas where there is no internet connection using mobile phones to report to the national database (NHIS) (Ministry of Health and Child Welfare, 2012). The Weekly Disease Surveillance System feeds into the DHIS-2 system by transmitting disease surveillance data to help monitor and detect disease outbreaks, while a macro database interacts with the DHIS-2 nationally (UNDP Zimbabwe, 2020).

To improve TB and HIV data collection and management, the Ministry of Health and Child Care introduced the ePMS in 2014, effectively replacing the inefficient paper-based system that was in place prior (UNDP Zimbabwe, 2015a). The ePMS has improved data access and reporting since its deployment. Zimbabwe recently piloted the Neotree in a few public hospitals to help healthcare professionals manage neonates' health (Gannon et al., 2021).

There has been an upsurge in computer and internet availability in Zimbabwe's public healthcare institutions, with most level 2 and 3 facilities having adequate numbers of computers and internet connectivity (Ministry of Health and Child Care & University of Oslo, 2015); hence, providing fertile ground for e-health.

However, most of the data collected by these electronic health systems are not used, with only 5.5% of the data collected needed for calculating the National Health Indicators (Ministry of Health and Child Care & University of Oslo, 2015). The lack of data utilisation means the country is missing out on the benefits of data-driven healthcare (Geller, 2020) to provide timely and evidence-based healthcare (Wariri et al., 2021).

3.11The Role of Emerging Technologies in Child Health

Emerging technologies are enhancing healthcare delivery to under-five children in a number of ways, such as precision medicine (Zamora et al., 2016), diarrhoea prediction (Mbunge, Chemhaka, et al., 2022) and acute paediatric cancer treatment (Gout et al., 2021). Before the children are even born, emerging technologies are useful in monitoring pregnancies and foetuses (Amala & Mythili, 2017). In this section, the researcher discusses the role of emerging technologies in child health.

Wearable technology provides continuous monitoring of child health. Through wearable technology, it is possible to constantly monitor children's heart rate, oxygen saturation, blood pressure, body temperature and respiratory rate, thus, helping to detect any sudden critical health conditions (Hasan & Negulescu, 2020). The ability to collect data remotely helps detect when children are sick, especially in the non-speaking age groups and while the children are asleep (Hasan & Negulescu, 2020). AI, through predictive analytics, can be applied to discover knowledge from the huge patient data sets to help in personalising healthcare and managing diseases (Messinger et al., 2020). Healthcare professionals can collect health data remotely using sensors (Fouad et al., 2020) and telemonitoring (Messinger et al., 2020).

Educating parents and guardians about the essential elements of child disease prevention, management and control (Sharma & Gupta, 2017) is one of the ways to fight the U5M problem. Public healthcare institutions can conduct awareness programmes to change the behaviours of parents and guardians, remind them of critical health information, and update them about new children's diseases and where to seek medical help (Balamurugan, 2018; Sharma & Gupta, 2017). As a result of education, the public can have access to accurate and current information regarding health conditions and treatment (West, 2015). Health authorities and healthcare institutions can use mass media, social media, text messages and electronic billboards to educate people about diseases affecting under-five children, how to manage, prevent and control them.

Emerging technologies are also playing an important role in supporting disease diagnosis (Mbunge, Akinnuwesi, Fashoto, Metfula, et al., 2021b). AI, for example, is being used in diagnosis and treatment recommendations and is already outperforming radiologists at spotting malignant tumours (Davenport & Kalakota, 2019). Deep learning is helping medical experts in detecting clinically relevant features in imaging data beyond what the human eye can perceive (Vial et al., 2018). AI has already proven its remarkable capability to be useful in the healthcare domain, but the biggest challenge is ensuring its adoption in daily clinical practice (Davenport & Kalakota, 2019, p. 97). Moreover, emerging technologies can support health workers in carrying out clinician duties in the absence of doctors, can help keep track of patients and enable remote consultations (Blaya et al., 2010).

Moreover, emerging technologies are enhancing communication between parents of under-five children and healthcare institutions. This communication enhances the health of under-five children in many ways, including reminding parents of critical health information about their children through reminder systems (Bervell & Al-samarraie, 2019; Blaya et al., 2010). Healthcare institutions can disseminate important health information to the public and expand audience reach, including underserved rural areas, through mass media (Naveena, 2015), such as radio, television (TV), social media and electronic billboards.

Emerging technologies are also useful in tracking disease outbreaks affecting under-five children. Medical researchers and healthcare institutions are using emerging technologies to track disease outbreaks (Carneiro & Mylonakis, 2009; Schmidt, 2012). Some people attempt self-diagnosis by searching on the Internet, and that search provides a data point that medical researchers can use to track disease outbreaks and respond to pandemics (Schmidt, 2012). Some people report symptoms via social media, and healthcare institutions can also use that information to track disease outbreaks, thereby transforming disease surveillance (Schmidt, 2012). It is possible to track disease outbreaks in real-time (Carneiro & Mylonakis, 2009) and plot outbreak maps (Schmidt, 2012). Emerging technologies can detect disease outbreaks faster than traditional Centres for Disease Control and Surveillance Systems (Carneiro & Mylonakis, 2009). Detecting disease outbreaks can help healthcare professionals and authorities in fighting such diseases by focusing on particular areas.

Healthcare institutions are also using emerging technologies to share patient medical data of under-five children across institutions and healthcare professionals through electronic health cards (EHR), electronic patient records and health portals (Blaya et al., 2010). This sharing of patient data enables medical professionals currently attending to patients to have the patients' medical history and build on the previous medication administered to the patient.

3.12 Related Studies

Although still a relatively new idea whose implementation has not been fully achieved (Furusa & Coleman, 2018), e-health is already being implemented in Zimbabwe, with a number of systems like DHIS-2, ePMS and NHIS already in operation (Ministry of Health and Child Care & University of Oslo, 2015; UNDP Zimbabwe, 2015b, 2020). As e-health tools trickle into Zimbabwe's public healthcare, several researchers have shown an interest in areas like factors affecting their adoption (Furusa & Coleman, 2018), how to transition digital health innovation into daily clinical practice (Marongwe et al., 2022), ethics for integrating emerging digital systems in public healthcare in Zimbabwe (Mbunge, Fashoto, Akinnuwesi, et al., 2021) and enhancing neonatal health in Zimbabwe's public healthcare institutions using digital technology (Gannon et al., 2021).

Previous studies have shown that there are a number of factors influencing the adoption and full utilisation of e-health in Zimbabwe's public healthcare. Some of the common factors from previous research include inadequate ICT infrastructure, understaffing and poor support systems (Furusa & Coleman, 2018; Ministry of Health and Child Care & University of Oslo, 2015). However, the Zimbabwean Government keeps receiving assistance from developmental partners to help improve infrastructure availability and skills development of personnel in health information systems (Chawurura et al., 2019). These partners have provided hardware, training and internet connectivity to a number of public health institutions in Zimbabwe (UNDP Zimbabwe, 2015b, 2015a, 2020; World Bank, 2019).

Furusa and Coleman (2018) categorised the factors affecting digital health adoption by doctors in Zimbabwe's public health into two-internal and external factors. Internal factors include ICT infrastructure and e-health technologies, ICT skills and knowledge, technical support, security concerns, lack of basic medical facilities, demographic factors such as age, and doctor-patient relationships. Furusa and Coleman (2018) argue that if these factors are addressed, there is a huge potential for e-health to be successful in the country. However, as indicated in the preceding paragraph, there are already international development partners who are working in Zimbabwe to promote e-health. Nonetheless, some of these partners' digital health interventions end at piloting stages, or are not deployed nationwide (Moyo & Madziyire, 2020; Ndhlovu, 2021).

Even for those e-health systems that are currently deployed, their full potential is not being enjoyed because of such factors as a lack of a central data repository to enable integration of health information system data sources, lack of datasets (Mbunge, Muchemwa, Jiyane, & Batani, 2021), inadequate analysis and use of information, poor support systems, inadequately designed software, a lack of data authentication system and poor support systems (Ministry of Health and Child Care & University of Oslo, 2015). This could mean that one of the areas to be improved in order to improve e-health utilisation is policy. The claim by the Ministry of Health and ChildCare and the University of Oslo (2015) that some private health practitioners and facilities are not reporting to the NHIS serves to show that there could be a need to design new policies or improve enforcement and monitoring of the current policies to ensure compliance.

Security and privacy have always been key issues in e-health applications and systems. This is because, by its nature, the health data of patients is private and confidential (Abid et al., 2022), and any technological innovation that infringes on them is bound to face resistance. Furusa and Coleman (2018) have already found security to be one of the factors impeding e-health adoption by some medical professionals in Zimbabwe.

While the researcher did not find any studies done on the potential role of emerging technologies in reducing under-five mortality, some related studies on the role of ICT in healthcare were found. Table 10 shows a summary of the studies related to this study, and below it is a review of those studies.

Table 9: Summary of related studies

Researchers	**Title**	**Location**	**Methodology**	**Findings**
(Nyamawe & Seif, 2014)	The Role of ICT in Reducing Maternal and Neonatal Mortality Rate in Tanzania	Tanzania	The methodology was not explicitly described, though the aim was to explore "the role of ICT in reducing maternal and neonatal mortality rate, review existing solutions to discover what is lacking and provide necessary recommendations" (Nyamawe & Seif, 2014, p. 39)	The study focused on mobile phones, though its title broadly looks at ICT. They found that mobile phones resulted in improved maternal and neonatal mortality rates through improved communication between expectant and nursing mothers and health professionals by sending reminders and enabling mothers to make emergency calls for medical assistance. They also found out that the major contributors to high

				neonatal and maternal mortality rates are delays in getting medical assistance, lack of education, lack of skilled clinical attendants
(Shiferaw & Zolfo, 2012)	The role of information communication technology (ICT) towards universal health coverage: the first steps of a telemedicine project in Ethiopia	Ethiopia	descriptive case study on failed adoption and implementation of telemedicine in Ethiopia	Successful implementation of telemedicine depends on technological factors, e-government readiness, enabling policies, multi-sector involvement, and capacity-building processes. "There is no perfect 'one size fits all' technology and the use of combined interoperable applications, according to the local context, is highly recommended"

				(Shiferaw & Zolfo, 2012, p. 1)
(Steele et al., 2003)	Virtual Reality as a Pediatric Pain Modulation Technique: A Case Study	Australia	Experiment	Virtual reality may reduce post-surgical pain in children
(Ndayiziga miye & Maharaj, 2016)	Potential adoption of mobile health technologies for public healthcare in Burundi	Burundi	Survey, descriptive	The role of m-health in Burundi includes disease management, enhancing the quality of healthcare service, enabling real-time access to medical data and increased speed of communication among health professionals. Factors affecting m-health adoption in Burundi include unreliable network connectivity and lack of ICT knowledge, among others.

Nyamawe and Seif (2014) conducted a study on the role of ICT in reducing maternal and neonatal mortality in Tanzania. Although based on the topic, they were supposed to investigate the role of ICTs; they narrowly focused on mobile technologies. It is not clear how the research was conducted as the methodology section is missing in their paper. However, their study found that mobile phones resulted in improved maternal and neonatal mortality rates in Tanzania through improved communication between expectant and nursing mothers and health professionals by sending reminders and enabling mothers to make emergency calls for medical assistance. They also found out that the major contributors to high neonatal and maternal mortality rates are delays in getting medical assistance, lack of education and lack of skilled clinical attendants. While neonatal is a subset of under-five, the challenges and main killers of neonatal may not be the same as of under-five children who are beyond the neonatal phase as the physiology changes with age (Shiffman et al., 2001).

Shiferaw and Zolfo (2012) conducted a study on the role of information communication technology (ICT) towards universal health coverage: the first steps of a telemedicine project in Ethiopia. They adopted a descriptive case study to investigate failed adoption and implementation of telemedicine in Ethiopia and found out that successful implementation of telemedicine depends on technological factors, e-government readiness, enabling policies, multi-sector involvement, and capacity-building processes. Even though their study was on the role of ICT, they also investigated factors affecting its adoption and successful implementation. This makes sense since, for the realisation of ICT capabilities to occur, the technology has to be adopted and implemented first. The researchers found out that "there is no perfect 'one size fits all' technology, and the use of combined interoperable applications, according to the local context, is highly recommended" (Shiferaw & Zolfo, 2012, p. 1). This finding suggests that a copy-and-paste approach to technology adoption and implementation may not work if the context is different. Likewise, the role that technology can potentially play may from one context to another (Shiferaw & Zolfo, 2012). Moreover, their results confirm the significance of compatibility of innovation being critical to its potential adoption (Rogers, 2003, 1995).

Steele et al. (2003) carried out a study on virtual reality as a paediatric pain modulation technique, using an experimental methodology in Australia. The study adopted a case study approach with the intention to experiment on whether virtual reality could play an analgesic role in reducing pain in children; and the study indeed confirmed virtual reality may reduce post-surgical pain in children (Steele et al., 2003).

Jagadeeswari et al. (2018) carried out research on the role of medical IoT and big data in personalised healthcare, mainly targeting the elderly. Their findings are that IoT can be a source of real-time patient data, which, combined with big data, can be used for monitoring, discovering new patterns from huge datasets, early disease detection, quick decision-making, and generally improving the quality of healthcare service. Their study appears to have been a general one, based on a literature review with no geographical boundaries. However, their findings concurred with Fong and Chung (2013) and Mohanta (2019) on personalisation of healthcare and remote data collection.

Ndayizigamiye (2016) conducted a study in Burundi on the potential adoption of mobile health technologies for public healthcare in the country. He used a descriptive survey study. Some of the findings of his study are that the role of m-health in Burundi includes disease management, enhancing the quality of healthcare service, enabling real-time access to medical data and increased speed of communication among health professionals; while the factors affecting m-health adoption in Burundi include unreliable network connectivity and lack of ICT knowledge, among others. This study was guided by three theoretical frameworks (DOI, UTAUT and CA).

As mentioned by Shiferaw and Zolfo (2012), the successful adoption and implementation of any technological innovation are dependent upon the context since context differs, and the new technology must be integrated with compatible systems and applications for successful deployment. By the time of submitting this thesis, the researcher had not seen any published literature on the potential role of emerging technologies in reducing under-five mortality in Zimbabwe generally and in Makonde District specifically. While the role of ICT in healthcare is generally researched and published, the role of emerging technologies in reducing under-five mortality does not enjoy the same exposure in the literature.

3.13 Research Gap

Though the role of ICT in various areas like COVID-19 containment (Firouzi et al., 2021; Okereke et al., 2021; Siriwardhana et al., 2021), reducing maternal and neonatal mortality (Nyamawe & Seif, 2014) and universal health coverage (Shiferaw & Zolfo, 2012) have been studied, there is a dearth of studies on the role of emerging technologies in reducing under-five mortality in resource-constrained areas. Despite emerging technologies giving the hope for the attainment of the SDGs (Sachs et al., 2016) including reducing under-five mortality (James & Acharya, 2021; Mbunge, Chemhaka, et al., 2022), there is a lack of literature on the role of emerging technologies, as perceived by healthcare professionals, in reducing under-five mortality in resource-poor settings. Thus, this study sought to investigate the role of emerging technologies in reducing under-five mortality in resource-constrained areas, using Makonde District as the study site. However, the findings are expected to be applicable to similar settings across Africa and developing countries.

The following information about the role and adoption of emerging technologies to enhance under-five children's health and reduce U5M in Makonde District's public healthcare institutions is unknown: the level of readiness to adopt emerging technologies to reduce under-five mortality, the extent to which public healthcare professionals know about emerging technologies for reducing under-five mortality, the extent to which public healthcare professionals are willing to adopt emerging technologies to reduce under-five mortality, the factors impeding the potential adoption of emerging technologies by public healthcare institutions to reduce under-five mortality in Makonde District and the potential role emerging technologies can play in reducing under-five mortality in Makonde District's public healthcare institutions. In this research, therefore, the researcher intended to explore the potential role of emerging technologies in reducing under-five mortality in public healthcare facilities in Zimbabwe.

3.14 Chapter Summary

In this chapter, the researcher reviewed the literature on emerging technologies in healthcare, the use of emerging technologies in child health, emerging technologies interventions to fight U5M in Sub-Saharan Africa, factors impeding the adoption of emerging technologies in healthcare, emerging technologies in Zimbabwe, the role of emerging technologies in child health, related studies and the research gap that this study sought to fill. The chapter also presented the global, African and Sub-Saharan African under-five mortality trends. Generally, there is a global reduction of under-five mortality rates since 1990, though Sub-Saharan Africa still has the worse under-five mortality outcomes.

The term emerging technology is not synonymous with new technology since an established technology in one context could be emerging in another domain, area or application (Halaweh, 2013; Millea et al., 2005). In the healthcare domain, healthcare professionals can use emerging technologies to monitor health parameters remotely, educate people about methods of disease prevention and control, remote treatment and monitoring of patients, track disease outbreaks, enhance communication (Schmidt, 2012) and support patient treatment and diagnosis (Fouad et al., 2020; Messinger et al., 2020; Ventola, 2014).

The chapter also presented the impact of COVID-19 on under-five mortality. Although, there was no sufficient evidence to suggest that COVID-19 disproportionately directly affected under-fives compared to adults, the pandemic indirectly affected children's access to healthcare through national lockdowns, personnel and resource reassignment and missed immunisations. Moreover, it was revealed that the emerging technologies in healthcare include artificial intelligence, the internet of things, big data analytics, 3D-printing, mass media, telemedicine, telehealth, virtual clinics, sensors and wearable devices, 5G technology, robotics, block chain and cloud computing.

The uses of emerging technologies in enhancing child health include remote data collection, education and awareness, booking appointments, supporting disease diagnosis, treating patients remotely, communicating with fellow healthcare professionals, tracking disease outbreaks, training of healthcare professionals, sharing patient medical data among healthcare institutions and treatment support. Moreover, factors that affect the adoption of emerging technologies were also discussed. These include privacy and secuiry concerns, a lack of infrastructure, government support and ICT skills, organisationational policies, poor systems integration and a lack of standardisation and instrinsic motivation.

An overview of e-health has also been discussed and the emerging technologies in Zimbabwe identified. The researcher also discussed the role of ICT in promoting child health. Moreover, the related studies were presented as well as the research gap. The next chapter discusses the theoretical frameworks that guided this study.

CHAPTER 4: Theoretical Frameworks

4.1 Introduction

In this chapter, the researcher reviews theoretical frameworks used in this study. These theoretical frameworks are the capabilities approach (CA) (Sen, 1981), diffusion of innovation (DOI) (Rogers, 1983b) and the Unified Theory of Acceptance and Use of Technology (UTAUT) model (Venkatesh et al., 2003). Each of these models is adapted to suit this study, and a customised framework is presented to guide this study.

4.2 Theoretical Frameworks

Various technology adoption theories exist. However, these theories are derived from the two basic theories, namely, the Technology Acceptance Model (TAM) and the Theory of Planned Behaviour (Koul & Eydgahi, 2017). According to Ross et al. (2016) and Alberta Health Services (2010), as cited in Furusa and Coleman (2018, p. 4), the adoption of information technology is a complex process influenced by various internal and external factors. In this section, the researcher presents theoretical frameworks that guided this study, and is inspired by the work of Ndayizigamiye and Maharaj (2016), with proper acknowledgement where necessary, without reproducing their work.

4.2.1 Capability Approach (CA)

The capability approach (CA) is a theoretical framework generally attributed to Amartya Sen (Haenssgen & Ariana, 2018; Robeyns, 2005; Wells, 2012), regardless of some of its aspects being traceable back to earlier philosophers like Aristotle and Karl Marx (Robeyns, 2016). The CA is broad, flexible and multi-disciplinary as opposed to a precise and confined theory of well-being (Robeyns, 2005, 2016); hence, this partly explains why it is named the 'capability approach' and not the 'capability theory' (Robeyns, 2016, p. 2). The framework was initially designed for evaluating the quality of people's lives (Haenssgen & Ariana, 2018) and the development process (Robeyns, 2006, p. 352). In addition to providing a perspective on how development should be evaluated, the theory has also been widely used for analysing how development processes and interventions impact people's lives (Haenssgen & Ariana, 2018).

The CA's direct focus is the currently achievable quality of life by individuals, which is examined with regard to the core concepts of 'functionings' (states of 'being' and 'doing') and 'capabilities' (a group of valuable functionings that one actually has access to)(Wells, 2012 para. 19). Therefore, an individual's capability represents their effective freedom (Wells, 2012). The argument of this approach is that although an intervention may have potentially positive effects on human life, its actual value is determined by what the people actually do, that is, their capability to convert the potential benefits into actual benefits of the intervention. The word 'capability' is defined in the CA differently from its daily sense. In the CA, the word capability reflects the actual opportunities and individual abilities that one has for them to lead the life they value (Gasper, 2007; Zheng & Stahl, 2011).

The CA posits that capabilities are produced by inputs (resources) or the features of inputs; but the value of those resources is dependent upon a person's ability to transform them into valuable functionings, which relies on the individual's physiology, social norms and physical environment (Wells, 2012). Thus, the approach argues that possessing a life-changing tool or technology is insufficient if one cannot utilise it to enjoy the benefits (Krupp-Schleubner & Bartels, 2018).

Wells (2012) illustrated the capability approach using a bicycle (resource) as an example. The value of a bicycle (resource) is dependent upon one's ability to transform it into valuable functionings (bicycling), which in turn relies upon the individual's personal physiology (such as health), social norms and physical environment (such as road quality)(Wells, 2012). Figure 7 shows the core relationships in the capability approach.

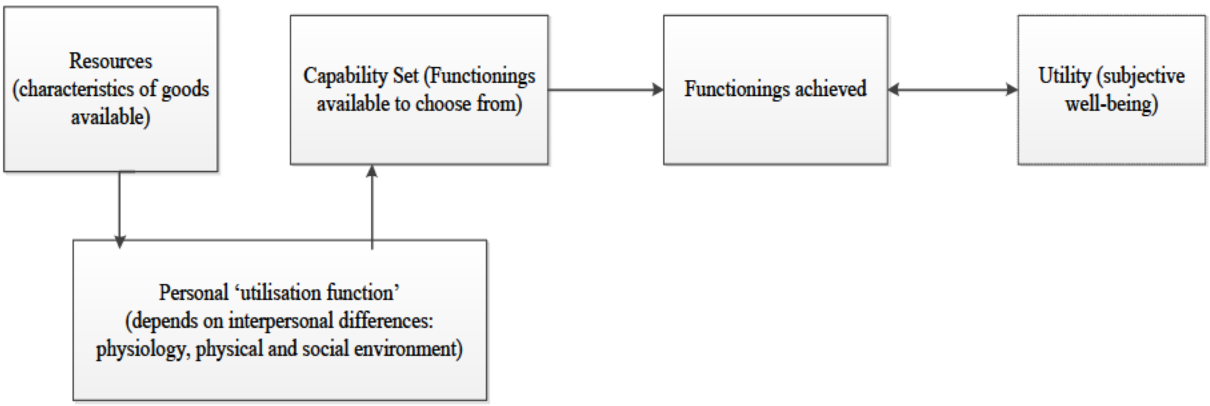

Figure 7: Core relationships in the capability approach. Source (Wells, 2012)

The CA is being applied in the design and adoption of ICTs (Zheng & Stahl, 2011). In the context of CA, ICT is viewed as a resource (input) that enables capabilities and enhances freedoms. However, its actual value depends on the users' capability to utilise it, such computer literacy and infrastructural context(Haenssgen & Ariana, 2018). Technology possesses inherent characteristics capable of expanding human capabilities, thus fulfilling the fundamental purpose of other inputs in the CA (Haenssgen & Ariana, 2018).

4.2.1.1 Adaption of CA to this study

Emerging technologies capability set includes diagnosis support, treatment support (Davenport & Kalakota, 2019; Islam et al., 2015; Williams & Woodward, 2015), monitoring of patients (Amala & Mythili, 2017; Islam et al., 2015), tracking disease outbreaks (Ristevski & Chen, 2018), education and awareness (Balamurugan, 2018; Naveena, 2015; B. J. Saunders & Goddard, 2002; Sharma & Gupta, 2017), reminding patients of important information, communication among staff and with patients (Sharma & Gupta, 2017), training of health professionals, preventive care (Fayez, 2018) and personalised healthcare (Davenport & Kalakota, 2019; Shilo et al., 2018; Ventola, 2014). The 'functionings', that is, what the healthcare professionals and mothers of under-five children may value doing to realise 'functionings achieved' is accepting the emerging technologies' capabilities by adopting the technologies. The emerging technologies are the inputs. The substantive freedoms were reduced under-five mortality in Makonde District through improved disease control and management, disease prevention and improved quality of healthcare for under-five children. Happier families can also be subjective well-being. The customised CA is presented in Figure 8.

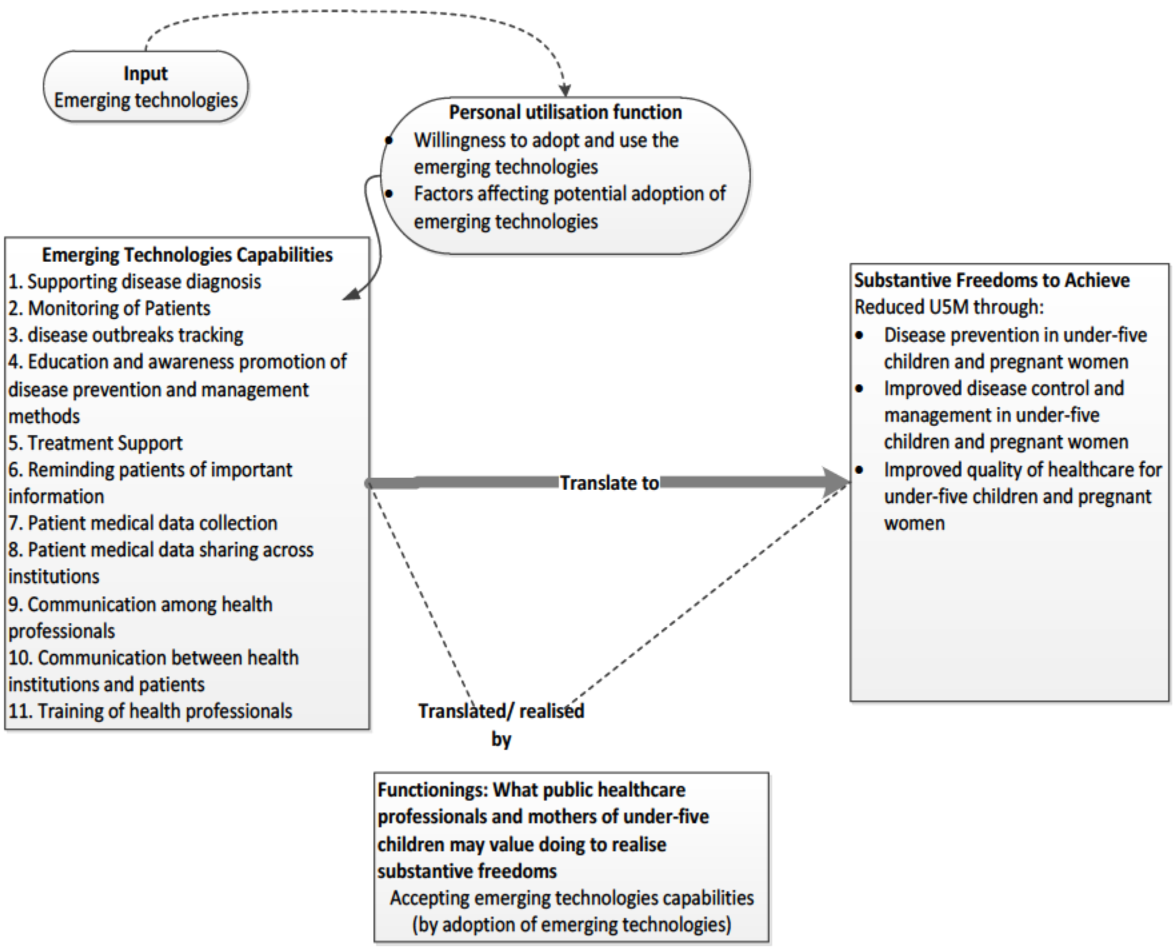

Figure 8: Customised Capability Approach

4.2.2 Diffusion of Innovation (DOI) Theory

Ensuring the adoption of an idea or innovation is no easy task, even if its benefits are obvious (Rogers, 1983a). This theory was propounded by Rogers (1983) and focused on innovations and their spreading (diffusion) among users. He argues that wide adoption of innovation often takes time, resulting in many people and organisations having the question about how to accelerate innovation adoption (Rogers, 1983a).

Rogers (1983, p. 5) defines diffusion of innovation as the process by which innovation spreads via different channels over time amongst the members of a social system. Innovation is defined as a creation, idea or practice that potential adopters view as new (Rogers, 1983a). The theory posits that from a human behaviour perspective, innovation has little to do with the time that has passed since its discovery. An innovation's newness does not necessarily only involve new knowledge but also a potential adopter's development of attitude (favourable or not) towards it, which will eventually lead to adoption or rejection of the innovation (Rogers, 1983, p. 6). Innovation adopters can be categorised into innovators, early adopters, early majority, late minority and laggards (Rogers, 1983a), depending on the time they take to adopt technological innovations or whether they are the initiators of the innovation themselves.

The DOI theory posits that before deciding to adopt or reject an innovation, people pass through knowledge and persuasion stages, after which they may choose to adopt or reject the innovation. Figure 9 depicts the DOI theory diagrammatically. The different variables that affect innovation diffusion are presented.

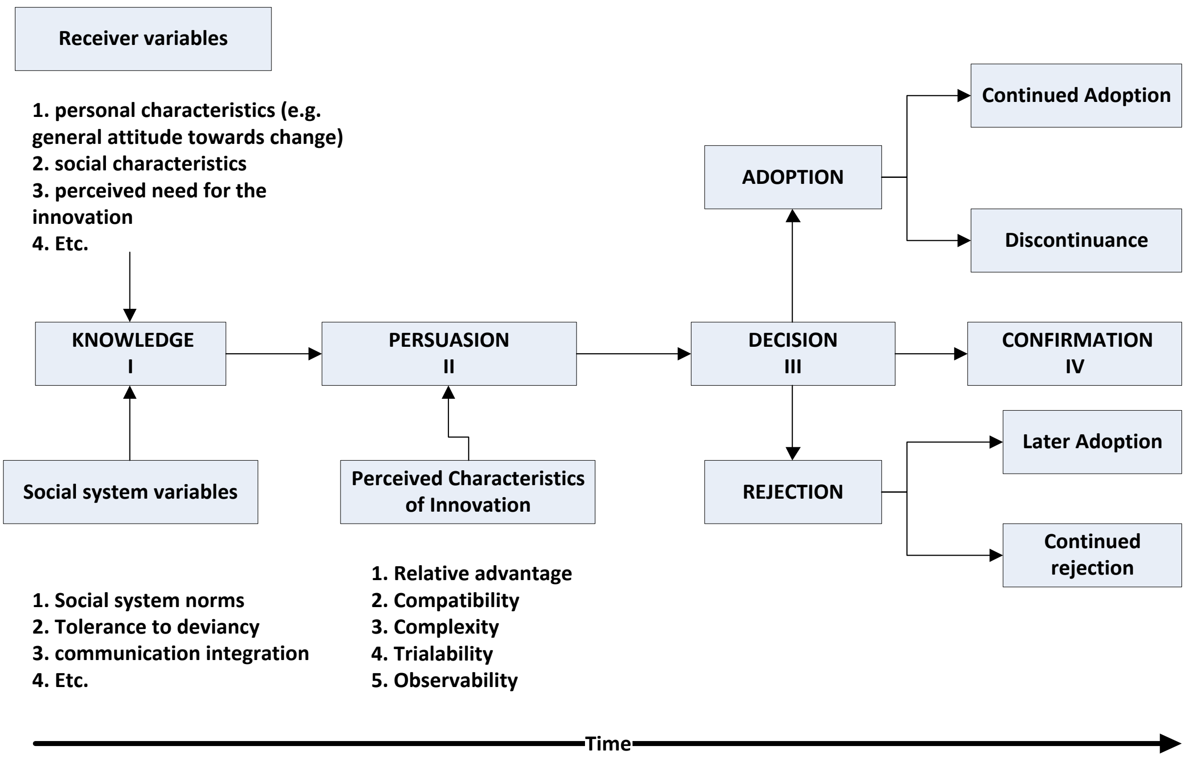

Figure 9: The Diffusion of Innovation Theory. Source: (Rogers, 2003))

As depicted in Figure 9, the process of innovation diffusion begins with knowledge, then persuasion, decision and confirmation. Before one can make a decision on whether or not to adopt an innovation, one first needs to know about the innovation. Potential adopters can have knowledge about a new innovation from those who may know it before them (Cain & Mittman, 2002). The knowledge phase is influenced by the social system and receiver variables, whereas the perceived characteristics of the innovation influence the persuasion phase.

Table 10 presents definitions of each of the perceived characteristics of innovation as defined by Rogers (1983, p. 15).

Table 10: Perceived Characteristics of Innovation

Characteristic	Definition
Relative advantage	The extent to "which an innovation is perceived as better than the idea it succeeds."
Compatibility	The extent to "which an innovation is perceived to be consistent with the existing values, past experiences and needs of potential adopters."
Complexity	The extent to "which an innovation is perceived as difficult to understand and use."
Trialability	The extent to "which may be experimented with on a limited basis."
Observability	The extent to which "the results of an innovation are visible to others" (Rogers, 1983, p. 16).

A study by Saaksjarvi (2003) revealed that compatibility is one of the most critical factors in predicting a potential technology adoption or rejection by a user. This was also confirmed by Furusa and Coleman (2018) and Mbunge, Muchemwa, Jiyaneand Batani (2021).

Within the population of innovation adopters, innovators are the fewest (2.5 per cent), while the majority tend to be between the early and late majority, who constitute 68 per cent (Rogers, 1995), as shown in Figure 10.

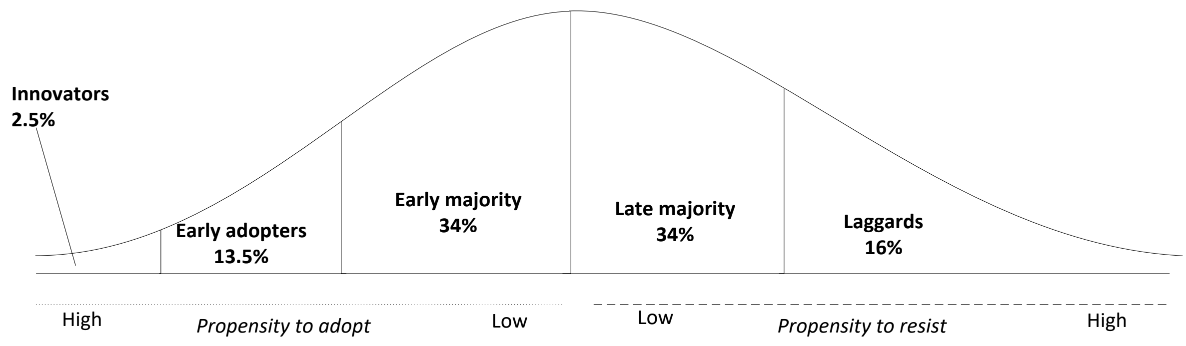

Figure 10: Innovation Adoption Curve. Source: (Rogers, 1983)

4.2.2.1 Applying the DOI theory to this study

Research questions 3 (*What is the level of readiness to adopt emerging technologies for reducing under-five mortality in Makonde District public healthcare facilities?*) and 4 (*What factors can affect the potential adoption of emerging technologies for reducing under-five mortality in Makonde District?*) seek to establish how much health professionals know about emerging technologies and their potential use for reducing U5M (specifically research question 3a (*To what extent do healthcare professionals in Makonde District know about emerging technologies for reducing under-five mortality?)* and 3b (*To what extent are healthcare professionals in Makonde District willing to adopt emerging technologies for reducing under-five mortality?*), and the factors that can potentially affect the adoption of emerging technologies by both healthcare professionals and mothers of under-five children and pregnant women. Relating these research questions to the DOI theory, they seek to investigate what healthcare professionals and under-five children's mothers know (knowledge variables) about emerging technologies for reducing U5M and the potential factors affecting emerging technologies adoption (persuasion variables).

Apart from being motivated by the nature of the research questions of this study, the choice of DOI is also influenced by the fact that it has been successfully applied in prior studies in e-health. One of the first researchers to apply it to the healthcare domain is Scott (1990). Taking Scott (1990)'s work as their basis, Grigsby et al. (2002) also applied the DOI theory to the medical care domain, but specifically focussing on the adoption of telehealth services.

Table 11: Persuasion Variables used in research instruments

Persuasion variables				
Relative advantage	**Compatibility**	**Complexity**	**Trialability**	**Observability**
Automated diagnosis (Davenport & Kalakota, 2019)	Compatibility with the working style of the organisation, and the duties of the involved people	User-friendliness	Experimenting with, or testing, the emerging technologies (to have a feel of how it works) before adoption (Rogers, 1995)	Results demonstrability- need to see tangible results of emerging technologies reducing U5M before adoption
Improved efficiency (Shilo et al., 2018; Ventola, 2014)	Compatibility with experience with ICT devices and applications	Difficulty to learn	Willingness to adopt emerging technologies without trying them	Results visibility- need to be shown where emerging technologies have worked before adopting
Higher service quality (Fayez, 2018; Islam et al., 2015)	Compatibility with duties of healthcare professionals	Difficulty to use	Adopting the technologies because they have worked in other countries	
Improved awareness of disease prevention among under-five children and their patients/guardians	Compatibility with work ethics of health professionals		Adopting the technologies first and evaluating the results later	

(Balamurugan, 2018; Naveena, 2015; Sharma & Gupta, 2017)				
Expansion of audience reach (Naveena, 2015; Sharma & Gupta, 2017)				
Improved communication and collaboration among practitioners				
Provision of a critical link between health professionals and the public (Naveena, 2015; B. J. Saunders & Goddard, 2002; Sharma & Gupta, 2017)				

Table 12: Knowledge Variables used in the research instruments

Knowledge Variables
Use of emerging technologies to reduce under-five mortality through:
1. Remote patients monitoring
2. Computerised diagnosis/ diagnosis support (computer-aided diagnosis)
3. Tracking disease outbreaks
4. Pervasive and personalised health
5. Remote health data collection
6. Health education and awareness
7. Remote patients treatment
8. Training of healthcare professionals (remote/ technology-assisted training and learning)
9. Communication with parents/guardians of under-five children sending important medical information

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

Designed by Venkatesh et al. (2003), UTAUT is a common theory that has enjoyed wide use in information systems, among other disciplines (Venkatesh et al., 2016). According to Venkatesh, Thong and Xu (2016), the UTAUT is used to explain the acceptance of technology by individuals and the use of technology by organisations. According to the UTAUT model, the actual use of technology depends on the intention to use the technology, which in turn is influenced by factors like performance and effort expectancy, facilitating conditions and social influence (Koul & Eydgahi, 2017). The theory has four theoretical constructs that are used in predicting technology adoption and usage; and these constructs are performance expectancy (the extent to which a potential technology adopter or user believes that technology use will enhance their performance), effort expectancy (the extent to which one views technology as simplifying their work), social influence (the extent to which one perceives as important other people's belief that they should use a technology) and facilitating conditions, which is the extent to which a user believes that the necessary infrastructure, legislation and other conditions exist to facilitate the use of a technology (Venkatesh et al., 2003, 2016). Figure 11 shows a diagrammatic representation of the UTAUT model.

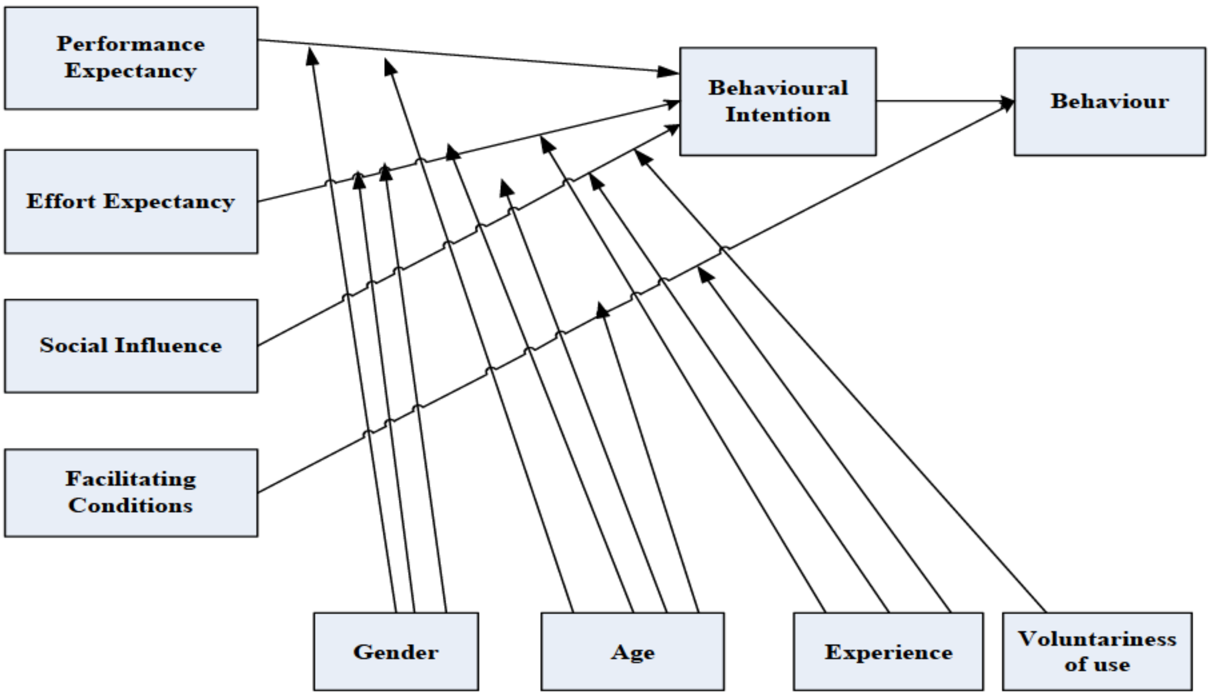

Figure 11: UTAUT Model. Source: (Venkatesh et al., 2003))

4.2.3.1 Applying UTAUT to this study

The UTAUT model was applied as a guiding theoretical lens for answering research question 4, "*What factors can affect the potential adoption of emerging technologies for reducing under-five mortality in Makonde District?*" and its sub-questions (research questions 4a and b).

Table 13: Applying UTAUT to this study

Facilitating Conditions
Internet penetration rate
Confidentiality (privacy) of patient data
Organisational policies (Batani & Maharaj, 2022a)
Government policy/Legislation
Affordability of the technologies
Availability of supporting infrastructure (Batani et al., 2019)
Reliability of infrastructure
Mobile phone penetration rate
Affordability of computing devices
Performance Expectancy
Improved efficiency (Shilo et al., 2018; Ventola, 2014)
Expansion of audience reach (Naveena, 2015; Sharma & Gupta, 2017)
Higher service quality (Fayez, 2018; Islam et al., 2015)
automated diagnosis (Davenport & Kalakota, 2019)
Accuracy of diagnosis
Effort Expectancy

Ease of use of emerging technologies applications

4.3 Customised Consolidated Framework

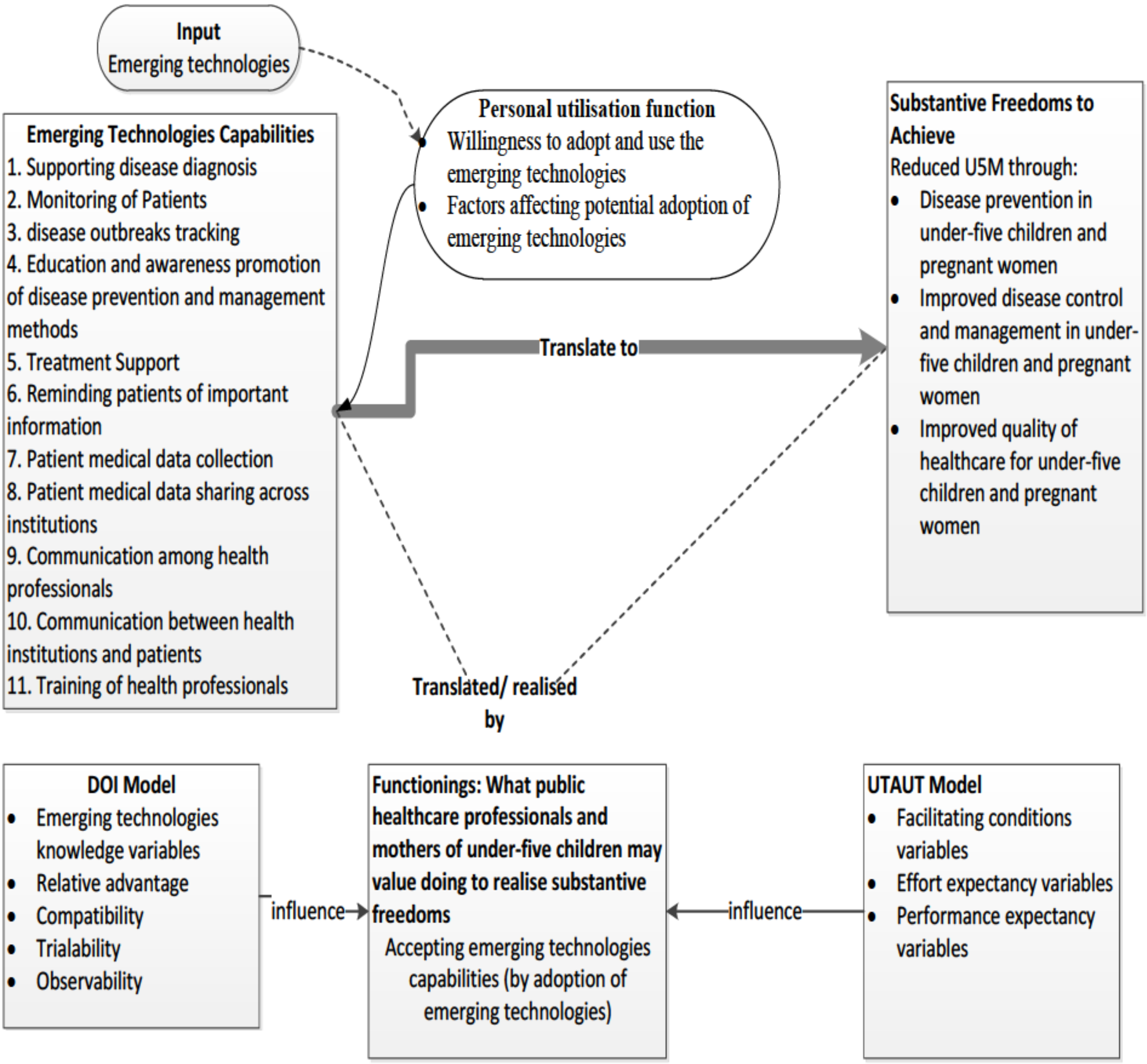

Figure 12: Extended CA Model. (Adapted from Ndayizigamiye & Maharaj (2016))

The framework in Figure 12 guided this study, where emerging technologies' adoption readiness and factors affecting the adoption of emerging technologies were explored with the guidance of the UTAUT and DOI theories, and the perceived role of emerging technologies in reducing U5MRs was explored with the guidance of the Capabilities Approach. In this model, emerging technologies are the input, while the personalisation function determines the willingness to use the technologies and the factors affecting their adoption. The capabilities of emerging technologies translate to substantive freedoms, such as reduced U5MRs through enhanced disease management, control, prevention and quality of care. However, the DOI and UTAUT factors influence what users value doing, which in this study, is adopting and using emerging technologies to reduce U5MRs.

The customised consolidated framework presented in Figure 12 builds on the idea of Ndayizigamiye and Maharaj (2016). However, the presentation of the framework is different and the adapted framework includes input and personalisation function, which are not there in Ndayizigamiye and Maharaj (2016)'s framework but are there in the CA. Thus, their idea was used as a point of departure. The functionings, substantive freedoms and capabilities are specific to this study.

Regardless of the potential benefits of emerging technologies in healthcare, as shown by the literature, their potential role in reducing under-five mortality in Makonde District will depend on whether the health professionals and patients (in this case, the mothers or guardians of under-five children acting on behalf of their children) decide to adopt the technologies or not. The two theoretical frameworks adapted to explain the potential adoption of emerging technologies for reducing U5M in Makonde District's public healthcare institutions are UTAUT and DOI, with their variables and customisation already explained. The Capability Approach model was used to describe the potential role of emerging technologies in reducing U5M in Makonde District public healthcare institutions. While the constructs and variables of this study have been pre-established from literature, the instruments were recalibrated after the qualitative data collection phase to reflect the partial findings of the research before triangulating in the quantitative data collection phase.

4.4 Conceptual Framework

Figure 13 shows the proposed conceptual framework for this study. While the capabilities of emerging technologies may result in the potential role of emerging technologies in reducing under-five mortality, those capabilities may only be turned into achieved functionings by what the potential adopters of the emerging technologies value doing. The potential adopters will decide whether to adopt the technologies; hence, the need to also investigate factors that may affect their decision to adopt or reject the emerging technologies. Factors affecting potential adoption and level of readiness were investigated guided by two technology adoption models (DOI and UTAUT), while the capabilities and potential role of emerging technologies in reducing U5M in Makonde were investigated guided by the capability approach (CA).

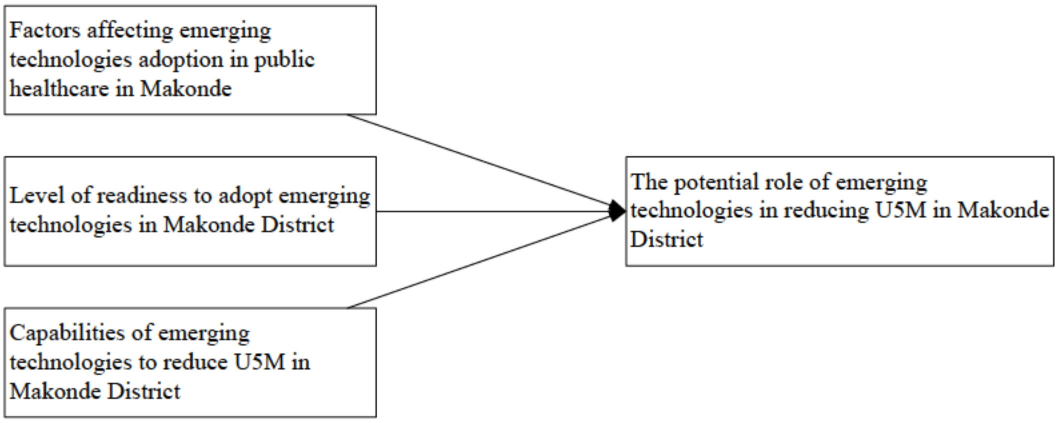

Figure 13: Conceptual Framework

4.5 Mapping the Theoretical Framework to the Target Population, Data to be Collected, Research Questions and Research Objectives

The theoretical framework guided the development of the research instruments, the questions asked, and the constructs considered. The main constituents of the extended capabilities approach used in this study are capabilities, functionings, substantive freedoms, personal utilisation function and influences on functionings. Table 14 shows the correlation among the theoretical framework, target population, the data to be collected, research questions and the research objectives.

Table 14: Mapping the theoretical framework to the target population, data to be collected, research questions and objectives

Theoretical Framework	**Target Population**	**Data to be Collected**	**Research Questions (RQs) and Research Objectives (ROs)**
	• Public healthcare professionals in Makonde District	**Capabilities**	

	• PMD Mashonaland West Province • DMO Makonde District • Mothers/ guardians of under-fives in Makonde District	Perceived potential role of emerging technologies in reducing U5M in Makonde District Readiness to adopt emerging technologies	RQ3, RQ2(a), RQ2(b), RO4, RO5 RQ1, RO1
Extended (Customised) Capabilities Approach (CA)	• PHIO Mashonaland West • Provincial ICT Officer (PICTO) Mashonaland West • District Health Information Officer (DHIO) Makonde District • Public healthcare professionals in Makonde District • PMD Mashonaland West Province • DMO Makonde District • Mothers/ guardians of under-5 children in Makonde District	**Personal Utilisation Function and Influences on Functionings** Factors affecting the potential adoption of emerging technologies in Makonde District's public healthcare institutions to reduce U5M Available emerging technologies in Zimbabwe	RQ1, RQ2, RO1, RO2
	• Public healthcare professionals in Makonde District	**Substantive Freedoms** The perceived role of emerging technologies in improving disease management, disease prevention and disease diagnosis	RQ3, RO4, RO5

4.6 Chapter Summary

The chapter discussed theories upon which this study premises before presenting the theoretical framework of this study. The constituent theories of this study's theoretical framework are the diffusion of innovation, the capabilities approach and the unified theory of acceptance and use of technology theories. These theories were customised and applied to the study.

In exploring the potential role of emerging technologies in reducing under-five mortality in the Makonde District, the researcher had to also understand the determinants of the adoption of such technologies. In light of this, the researcher derived indicators from technology adoption theories (DOI and UTAUT) and combined them with the capabilities approach to create the extended capabilities approach upon which this study was based. The framework uses an existing one (Ndayizigamiye & Maharaj, 2016) as a departure point, with some adaptations to suit the study. Each of these theories was aligned with the data that was collected, the research questions and objectives and the data sources. The conceptual framework comprises the factors affecting emerging technologies' adoption in public healthcare institutions in Makonde District, the level of readiness to adopt the technologies and the capabilities of emerging technologies in reducing under-five mortality. These fed into the potential role of emerging technologies in reducing under-five mortality in Makonde District's public healthcare institutions. The next chapter discusses the methods and tools that were used in this study and the philosophical stances that guided the research.

CHAPTER 5: Research Methodology

5.1 Introduction

A research methodology is a set of processes used to collect and analyse a research study's data (Walliman, 2000). This chapter describes the methods, tools, principles, techniques and procedures that the researcher followed in conducting this research. The discussion includes research design, philosophical assumptions, research strategy, research choices, data sources and the study population, sampling design, data collection and analysis, sampling, reliability and validity, and ethical considerations. Figure 14 depicts the steps followed in conducting this study, while Figure 15 summarises the research methodology for this study.

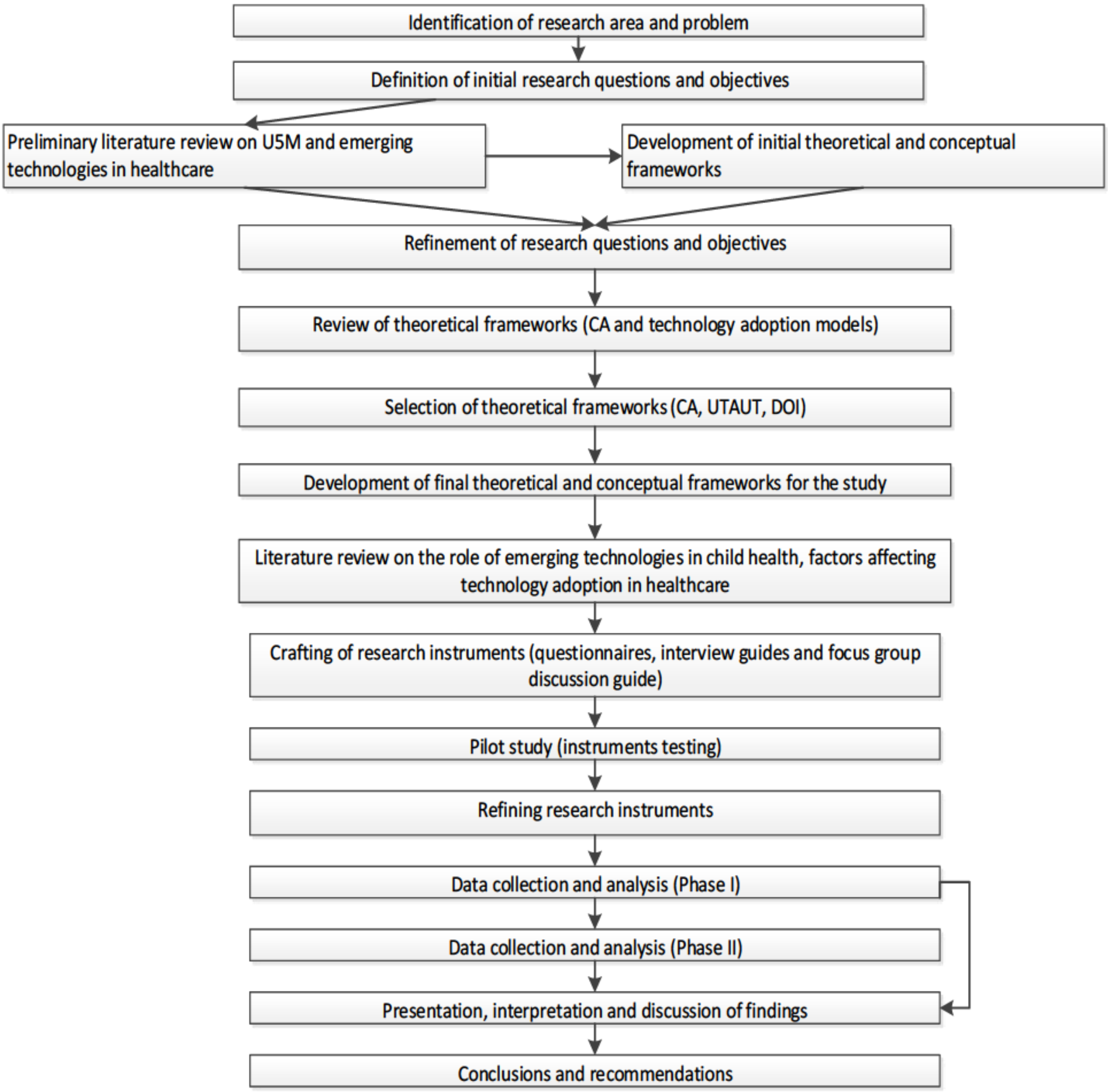

Figure 14: Study Approach

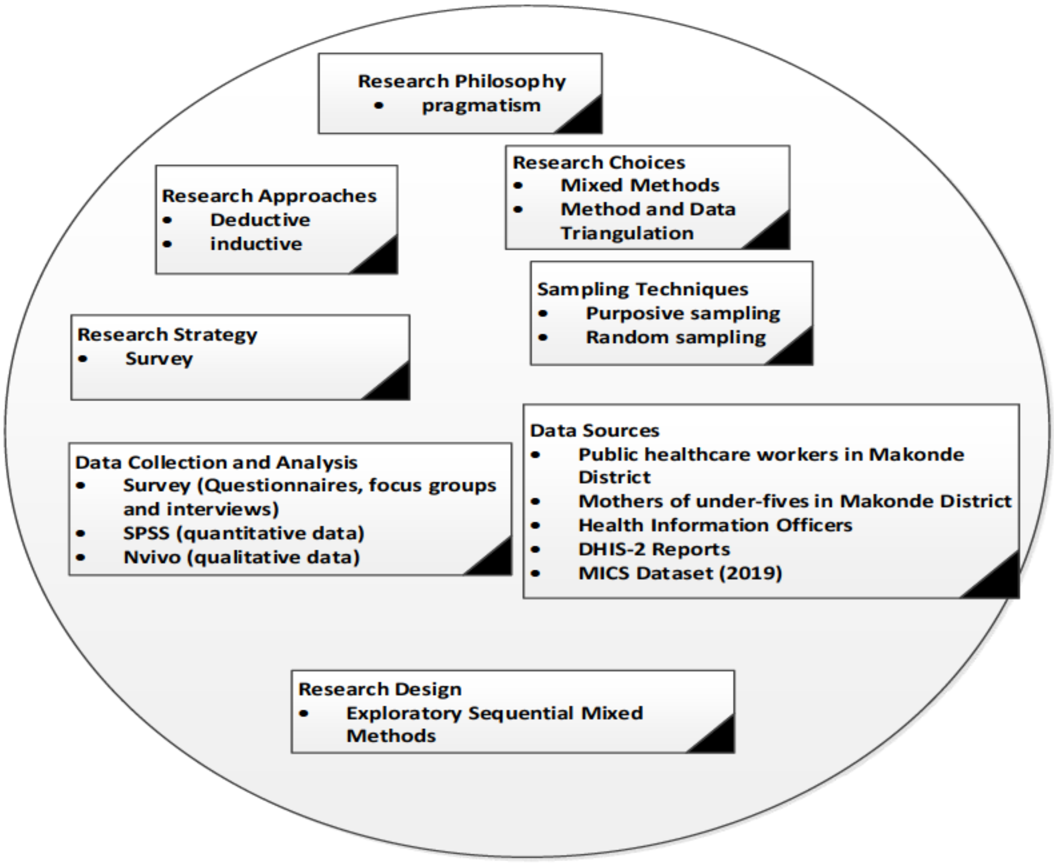

Figure 15: Summarised Research Methodology

5.2 Research Paradigms

A research paradigm is also called a research philosophy (Alshehri, 2012), meaning a set of shared beliefs that guide researchers' choices and practices throughout the research process, including data collection, analysis, interpretation of findings and knowledge generation (Morgan, 2007). It is a system of beliefs and theoretical frameworks comprising assumptions about four components: ontology, epistemology, methodology, and *methods* (Rehman & Alharthi, 2016). Each of these components is described detailedly in the following sections. The words paradigm and philosophy are often used synonymously in research (M. Saunders et al., 2019).

5.2.1 Ontology

"Ontology and epistemology are to research what 'footings' are to a house: they form the foundations of the whole edifice" (Grix, 2004, p. 59).

Ontology refers to beliefs regarding the nature of reality (Merriam, 2009) or the "nature of our beliefs about reality" (Richards, 2003, p. 33). Every researcher has assumptions and beliefs about reality, including its existence and what people can know about it (Rehman & Alharthi, 2016). Ontological assumptions are broadly classified into two- objective and subjective, where objective ontology contends that reality is measurable, testable and independently existent regardless of whether or not we can observe, experience or perceive it (Ndayizigamiye & Maharaj, 2016; O'Gorman & McIntosh, 2015). This ontology type assumes the possibility of establishing and explaining universal principles and facts through replicable and vigorous techniques (Ndayizigamiye & Maharaj, 2016). On the other hand, the subjective ontological perspective assumes the existence of multiple realities which are context-bound (Merriam, 2009).

5.2.2 Epistemology

Epistemology is "the study of knowledge" (O'Gorman & McIntosh, 2015, p. 59). It refers to beliefs regarding the nature of knowledge (Merriam, 2009). Epistemology refers to "assumptions about knowledge, what constitutes acceptable, valid and legitimate knowledge" (M. Saunders et al., 2019, p. 133). Epistemology aims to identify ways of developing valid knowledge. There are two primary epistemological viewpoints, positivism and interpretivism. The former aims to explain principles, while the latter seeks to understand relationships (Ndayizigamiye & Maharaj, 2016). Positivism is mainly associated with quantitative methods, while interpretivism is primarily related to qualitative methods.

Any philosophy selected by a researcher sets out some dictates that affect how the researcher will conduct their research. The researcher's beliefs regarding the nature of knowledge (epistemology) and that of reality (ontology) also influence the selection of research philosophies (Merriam, 2009). Saunders et al. (2019) state that research philosophies include pragmatism, critical realism, post-modernism, interpretivism and positivism. Table 15 summarises the four main research philosophies, namely positivism, interpretivism, critical realism and postmodern (post-cultural), according to Merriam (2015). Research has many philosophical stances, but this section describes only five. Pragmatism underpinned and guided this study.

Table 15: Epistemological perspectives[5]

	Positivist/ Post-positivist	*Interpretive/ Constructivist*	*Critical*	*Postmodern/ post-cultural*
Purpose	Predict, control, generalise	Describe, understand, interpret	Change, emancipate, empower	Deconstruct, problematise, question, interrupt
Types	Experimental, survey, quasi-experimental	"Phenomenology, ethnography, hermeneutic, grounded theory, naturalistic/ qualitative	Neo-Marxist, feminist, participatory action research, critical race theory, critical ethnography	Postcolonial, post-cultural, postmodern, queer theory
Reality	Objective, external, out there	Multiple realities, context-bound" (Merriam, 2009, p. 11)	Numerous realities are placed in political, social, and cultural contexts (one truth is privileged)	Questions assumption that there is a place where truth resides

5.2.2.1 Positivism

The assumption of this philosophy is that reality is stable, observable and measurable and already exists in the world regardless of whether or not the world knows about it (Merriam, 2009; Rehman & Alharthi, 2016). It assumes the presence of an objective reality that is noticeable, definable and quantifiable (Neuman, 2006; Scotland, 2012). Knowledge gained through this philosophy is called 'scientific' knowledge and often results in the formulation of 'laws'. Experimental research design assumes the positivist philosophy (Merriam, 2009). A unique feature of positivist studies is their endeavour to test theory to increase people's understanding of phenomena (Neuman, 2006). One of its ontological assumptions is that

[5] Merriam, B. S. (2009 p. 11). *Qualitative Research: A Guide to Design and Implementation* (2nd ed.). Jossey-Bass

there is one actual reality (universality), and this reality is external, independent and real (M. Saunders et al., 2019). The typical methods associated with this philosophy are deductive, highly structured, and require large samples and quantitative data analysis methods (M. Saunders et al., 2019).

The shortcomings of this philosophy, including its rigidity, gave way to new philosophies like logical empiricism and postpositivism (Merriam, 2009). Logical empiricism argues that there are no clear-cut methodological differences between natural and social sciences (Merriam, 2009; Patton, 2002, p. 92). On the other hand, according to Patton (2002, p. 93), as cited in Merriam (2009, p. 8), postpositivism argues that reality is not static or absolute but relative, and people can use empirical evidence to “distinguish between more and less plausible claims”.

5.2.2.2 Interpretivism

Interpretivism is a philosophy whose ontological assumptions are that reality is complex, rich, and socially constructed through language and culture, hence, the existence of multiple meanings, interpretations and realities (M. Saunders et al., 2019). It assumes that reality is a social construct; thus, there is no single, absolute, observable reality (Merriam, 2009). Epistemologically, it focuses on descriptions, narratives, stories and interpretations, generating new understandings and worldviews as a contribution (M. Saunders et al., 2019). Unlike positivism, interpretivism assumes that there are many interpretations of one event (Merriam, 2009). The methods used in this philosophy are typically inductive, with small samples, in-depth investigations, and qualitative data analysis methods, but a wide range of data can be interpreted (M. Saunders et al., 2019). The philosophy was developed to critique the positivism philosophy, albeit from a subjectivist standpoint. It argues that people are unlike physical phenomena since they create meanings (M. Saunders et al., 2019).

5.2.2.3 Critical Realism

Critical realists view reality as external, independent and not directly accessible through human observation and knowledge of it (M. Saunders et al., 2019). The philosophy asserts that understanding the world takes two sequential steps: sensations and experience and subsequent mental processing that occurs after the experience (Bhaskar, 2020; M. Saunders et al., 2019). Critical realists refer to this reasoning backwards as ‘retroduction’ (Bhaskar, 2008; Reed, 2005).

5.2.4 Postmodernism

The postmodernism philosophy emerged to address the modernist philosophy's perceived inadequacy in understanding issues, complexities, ambiguities and contradictions of the 20^{th} Century (Mayrhofer et al., 2021). This philosophy assumes that reality is nominal, complex, rich and socially constructed through power relations (Saunders, Lewis and Thornhill, 2019, p. 145). It regards acceptable and adequate knowledge as determined by dominant ideologies and typically uses a range of data types while using qualitative data analysis methods. It is usually deconstructive and mainly applied in comprehensive investigations of anomalies, silences and absences (M. Saunders et al., 2019).

5.2.2.5 Pragmatism

Pragmatism is the research philosophy whose ontological assumptions are that reality is the practical consequences of ideas; that reality is rich, complex and external (Feilzer, 2010; M. Saunders et al., 2019). It argues that any concept is relevant only if it supports action (Kelemen & Rumens, 2008). From a pragmatic viewpoint, truth or reality regarding the questions under study is viewed as what works (Feilzer, 2010; Tashakkori & Teddlie, 2003). Deng Xiaoping best summarised this philosophy when he said: "I don't care if the cat is black or white, so long as it catches mice." It “considers things from a practical point of view” (Cardoso da Silva et al., 2018, p. 1341).

Researchers who adopt pragmatism are not restricted to a single epistemology; instead, multiple views can be chosen to best enable a researcher to answer the research questions (Dudovskiy, 2018). Epistemologically, it assumes that the practical meaning of knowledge is context-specific; theories and knowledge should facilitate successful action and focuses on problems, practices and relevance (Saunders, Lewis and Thornhill, 2019, p. 145). The emphasis is on the action and practical relevance and was advocated for use in information systems research for methodological rigour (Cardoso da Silva et al., 2018). Since the emphasis is on the action and practical relevance, it uses a wide range of methods, including mixed, multiple, qualitative, quantitative and action research, emphasising practical solutions and outcomes (Saunders, Lewis and Thornhill, 2019, p. 145).

This study adopts the pragmatism philosophy to explore the potential role of emerging technologies in reducing under-five mortality in the Makonde District. The main objective of this study is to develop an emerging technologies adoption framework to help reduce under-five mortality in public healthcare facilities in Makonde District; while answering the question: what needs to be done for emerging technologies to be adopted in public healthcare institutions in Makonde District to reduce under-five mortality? Since the study seeks to suggest a practical solution to a problem and has both qualitative and quantitative questions, pragmatism is an appropriate philosophy (Cardoso da Silva et al., 2018; Kelemen & Rumens, 2008; M. Saunders et al., 2019).

5.3 Research Approach

The researcher approached this study from two perspectives: inductive and deductive. The researcher applied the inductive approach to answer questions on factors contributing to high under-five mortality, the most feasible emerging technologies for reducing U5M and how public healthcare institutions can leverage emerging technologies to reduce U5M in Makonde District. Moreover, the study investigated the district's current technologies to reduce under-five mortality. The researcher collected qualitative and quantitative data in two sequential phases. In the first phase, qualitative data were collected from twenty health professionals in the district. This phase comprised of interviews and focus groups. The phase was succeeded by Nvivo-facilitated qualitative data analysis, after which the researcher recalibrated the quantitative data collection instruments to incorporate the findings before the next data collection exercise. Questionnaires were used to collect quantitative data from public healthcare professionals who work with under-fives and the mothers of under-fives.

5.4 Research Strategy

"Research strategy can be referred to as a general way which helps the researcher to choose main data collection methods or sets of methods in order to answer the research question and meet the research objectives" (Melnikovas, 2018, p. 39). It is concerned with how data was collected and analysed, and the strategies include experiments, surveys, case studies, ethnography, grounded theory, action research and narrative inquiry (Cardoso da Silva et al., 2018). This study applied the survey strategy. Surveys involve data collection from people, making the data subjective (Glasow, 2005). Due to the subjectivity of the data collected through surveys, the researcher used triangulation to improve the reliability, dependability or rigour of the research findings (Noble & Heale, 2019; Salkind, 2010).

5.5 Research Choices

The mixed-methods technique, which blends qualitative and quantitative methods (Atlantic Research Centre, 2007), was used in this study. According to Feilzer (2010), the pragmatism philosophy advocates for mixing qualitative and quantitative methods in answering research questions. The ability and inclination of pragmatism towards mixing different methods heavily influenced the researcher's decision to settle for it. The use of mixed methods improves the reliability of findings through method triangulation and helps neutralise the weaknesses of each of the two methods when used independently; hence, the decision to use mixed methods. Qualitative and quantitative techniques were used to collect the data. Moreover, the researcher obtained DHIS-2-generated reports and the Multiple Indicator Cluster Survey (2019) dataset on under-five mortality. These data were used for data triangulation. However, some perceptions could not be validated using these reports. Since the study design was exploratory sequential mixed methods, the qualitative phase findings informed the quantitative research choices.

5.6 Data Collection and Data Analysis

Before starting data collection, the researcher obtained two ethical clearance letters and a gate pass. The Humanities and Social Sciences Research Ethics Committee (HSSREC) of the University of KwaZulu-Natal (UKZN) issued the first clearance letter, while the second came from the Medical Research Council of Zimbabwe (MRCZ). The HSSREC ethical clearance's approval number is HSSREC/00002132/2020**,** while the MRCZ's is MRCZ/A/2782. In between the two ethical clearances, the researcher obtained permission (gate pass) from the Provincial Medical Director (PMD) of the Mashonaland West Province to conduct the study in Makonde District public healthcare institutions. Ordinarily, these three clearance letters would have sufficed for the data collection to commence. However, all clinics in Makonde District are owned by local government authorities. Makonde District has two councils, Chinhoyi Municipality (which owns clinics in the urban areas) and Makonde Rural District Council (which owns public clinics in the rural Makonde). While collecting data, the researcher asked the Social Services Officer of Makonde Rural District Council for the contact numbers of all clinics in Makonde Rural District. The officer advised the researcher to write a formal letter to the Chief Executive Officer (CEO) of the Makonde Rural District Council asking for permission to carry out the study before she could provide the numbers. The CEO granted the permission, resulting in another clearance letter being obtained.

After acquiring all the required clearances and letters, the researcher began recruiting participants by contacting the Chinhoyi Provincial Hospital (CPH) Health Information Officer (HIO) and the District Medical Officer (DMO) of the Makonde District. The DMO is a medical doctor who is responsible for supervising all healthcare institutions in the district. Respondents were recruited through WhatsApp messages, electronic mails (e-mails) and referrals by other healthcare professionals whom the researcher had approached. The CPH is situated in Makonde District and is the main referral hospital in the district. The target population of this study was all the public healthcare professionals in Makonde District who work in the paediatric ward or work with under-fives. Purposive sampling and snowballing were used to recruit focus groups and interview participants.

The qualitative data collection phase involved sixteen interviews and focus group discussion with four healthcare professionals from Chinhoyi Provincial Hospital. The researcher started with a focus group discussion that was conducted through Zoom. All data collection activities were done electronically to adhere to the COVID-19 research guidelines that had been set by the MRCZ. The researcher informed respondents of their rights and the study's rationale and allowed them to go through the informed consent form, clarifying any issues. Consent was sought prior to any interviews and focus group discussions. Participants indicated their willingness to participate by returning the filled-out informed consent forms, after which the researcher bought them data bundles.

The researcher asked the participants for permission to record (video or audio) the discussions before recording the proceedings. The researcher informed the participants that their participation was voluntary and they could withdraw at any stage of the process without any ramifications. Participants who were uncomfortable using their actual names on virtual platforms were asked to use pseudonyms to preserve their identity.

The researcher also obtained reports from the DHIS-2 (District Health Information System-2) on under-five mortality to validate user responses through triangulation. Triangulation helped improve the reliability of the study's findings. All research instruments had an English and Shona version, and the version used depended on the participants' language preferences. The researcher collected quantitative data through online questionnaires designed using Google forms. The researcher designed questionnaires for public healthcare professionals and mothers of under-fives in the Makonde District. Some mothers of under-fives in Makonde do not have internet-enabled devices; hence, online questionnaires would have systematically excluded them. The researcher arranged with at least one nurse from each health facility to provide their phones to mothers without phones, so they could also fill out the questionnaires, minimising the systemic exclusion arising from electronic data collection.

The researcher transcribed all interviews and focus group discussions with the help of Nvivo software's transcription tool. The transcribing exercise was succeeded by a verification exercise to check if the recordings had been correctly transcribed by listening to the audio or watching the videos while reading the transcripts. NVivo 12 and SPSS 27 software tools were used to analyse the collected data. NVivo was used to analyse qualitative data, while the Statistical Package for the Social Sciences (SPSS) was used to analyse the quantitative data. The results of the data analysis are presented in Chapter 6 of this thesis. The researcher coded the respondents' names to preserve their anonymity.

5.7 Data Sources

Data were obtained from more than one source to validate the participants' responses and enrich the findings. A summary of the data sources for different data types is presented in Table 16.

Table 16: Data Availability

Type(s) of Data	Data Source(s)
Readiness to adopt emerging technologies	• Public healthcare professionals in Makonde District • Health Information Officer (Provincial Hospital) • Makonde DMO • Makonde District Health Information Officer • Mashonaland West PMD • Mothers/ guardians of under-5 children in Makonde District • Provincial EPI Officer
Factors are affecting the potential adoption of emerging technologies	• Public healthcare professionals in Makonde District • Mothers/ guardians of under-5 children in Makonde District • DMO • Health Information Officers • Provincial EPI Officer • MICS 2019 Dataset
Perceived potential role of emerging technologies	• Public healthcare professionals in Makonde District • Makonde District's DMO

	• Provincial Specialist Paediatrician • Provincial EPI Officer
Under-five mortality data	• DHIS-2, public healthcare professionals in Makonde

5.8 Research Design

A research design is a complete plan comprised of a set of steps and techniques to carry out a research study (Creswell, 2003); thus, detailing how a researcher answered the research questions (Saunders et al., 2019, p. 173). It is a way of converting research questions into a research project. It specifies data sources, data collection and analysis, and discusses ethical issues and constraints (Saunders et al., 2019). Figure 16 depicts a diagrammatical representation of this study's research design. The initial choice regards whether to pursue a qualitative, quantitative or mixed methods research design (M. Saunders et al., 2019, p. 174). Figure 16 shows the methodological choices one can select from. For each research design, a researcher can either use a single method (mono method study) or multiple methods (multi-method study).

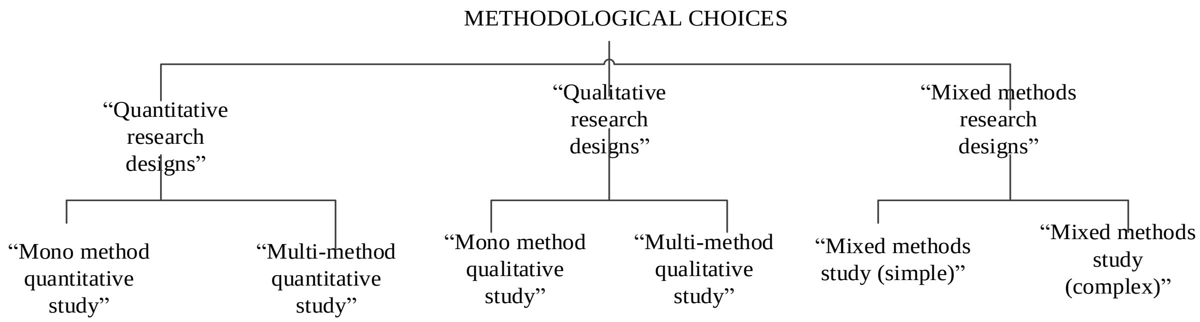

Figure 16: Methodological choices. Source: (Saunders et al., 2019, p. 176)

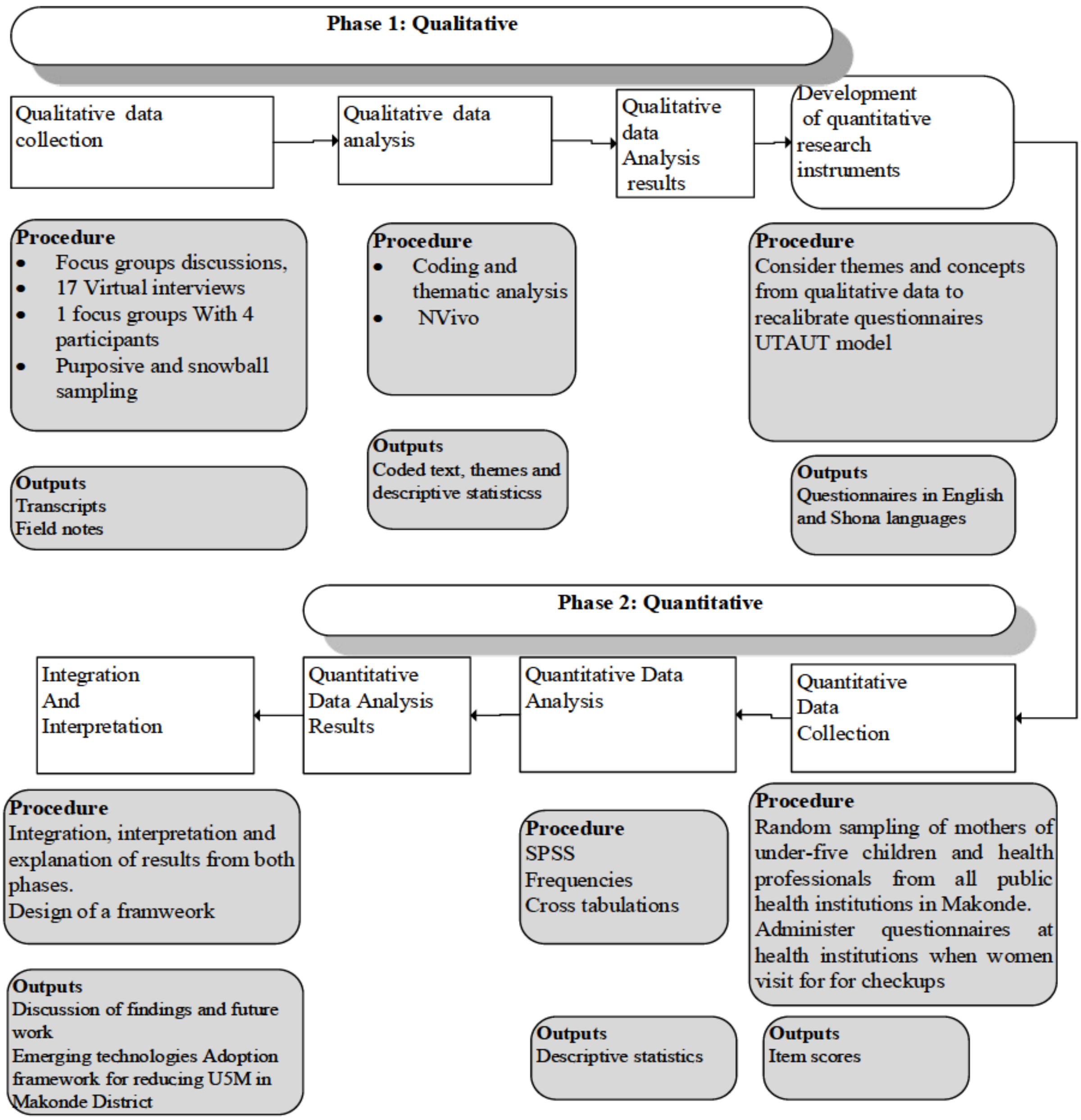

Figure 17: Research Design- Exploratory Sequential Mixed Methods Approach

This research adopted an exploratory sequential mixed methods design, in which two data collection and analysis phases are followed by integration and explanation (Berman, 2017; Mihas, 2019). In the exploratory sequential mixed methods design, the first phase collects qualitative data, which are then analysed before informing the next step of quantitative data collection (Berman, 2017; Mihas, 2019).

In the first phase, the researcher collected qualitative data from health professionals through focus group discussions and virtual interviews through Zoom, Microsoft Teams, and WhatsApp calls, depending on the participants' preferences. The exploratory sequential mixed methods design was appropriate for this study since it has an exploratory phase that should inform the next data collection phase. Qualitative data were collected on all research questions in phase 1.

The purpose of using mixed methods in this research was to improve the validity of the obtained results through triangulation to complement the techniques and use one technique to inform the other. Triangulation facilitates a researcher's ability to look for convergence and substantiate the findings by using diverse methods, look for amplification, enhancement or elucidation of the findings from one technique with the findings of the other use the findings from one method to help improve or enlighten the other technique (Schoonenboom & Johnson, 2017).

There are at least four purposes of mixed methods in research, namely triangulation (looking for convergence, confirmation or correspondence of results from two or more methods), complementarity (pursuing elaboration, enhancement, elucidation of the findings from one technique with another technique's findings), development (using the results from one method to assist in developing or informing the other method) and initiation (discovering paradox and contradictions, new framework perspectives, recasting of questions or findings from one method with those from the other) (Schoonenboom & Johnson, 2017).

The purpose of using mixed methods in this study was to seek convergence or validation of qualitative and quantitative findings, especially on factors affecting the potential adoption of emerging technologies to reduce under-five mortality in Makonde District's public healthcare institutions. Moreover, the researcher selected mixed methods to seek elaboration and clarification of findings from phase I with findings from phase II, with phase I's findings informing phase II. Finally, the researcher sought to discover contradictions and paradoxes in the findings of the two phases. The mixing of methods was more suited to this study as it enables a deeper coverage of issues in exploring the research problem. Moreover, the researcher settled for this research design as it increases the credibility and integrity of findings by validating them through triangulation (Bryman, 2006; Schoonenboom & Johnson, 2017).

5.9 Research Instruments Design

Since the research design for this study was exploratory sequential mixed methods, data were collected in two sequential phases. Qualitative data were collected in the first phase, succeeded by quantitative data elicitation. Consequently, the researcher designed both qualitative and quantitative research instruments. The design of research instruments was sequential, starting with qualitative instruments. The initial instruments design was guided by the theories adopted and findings of literature review which informed the constructs studied. Though the quantitative phase was informed by qualitative findings, the initial instruments were designed based on the study's theoretical lenses as all instruments were required for ethical clearance. However, these were then recalibrated to align with qualitative findings. All instruments were piloted with the then matron of the Concession District Hospital, who played a huge role in aligning the instruments and identifying potential issues to be addressed.

Though the study was at a district level, the researcher collected data from multiple levels to ensure that decision-makers were included in the study, though some of them are at the provincial level. The researcher prepared interview guides for healthcare professionals, the DMO, the PMD, HIOs, DHIO, and the Provincial ICT Officer. A focus group discussion guide was prepared for healthcare professionals only.

Health information officers and the Provincial ICT officer were included in the sample to gain insights into digital healthcare initiatives and impediments to the adoption of emerging digital health technologies in the district. Since the Provincial Medical Director (PMD) is responsible for the oversight and management role throughout the province, an interview schedule was designed for him. In contrast, a different one was intended for the District Medical Officer (DMO). In sections 5.9.1 through 5.9.3, the researcher describes the research instruments used in this study. Questionnaires were also designed for healthcare professionals and mothers of under-fives.

5.9.1 Interviews

Interviews are a way of extracting data from respondents through conversations between the researcher (interviewer) and the participants (interviewees) on questions related to a research study (Merriam, 2009; Y. Zhang & Wildemuth, 2008). The researcher used interviews and focus groups in the first phase of data collection. The emphasis of this phase was on discovery rather than confirmation (Wünderlich, 2009). Interviews allowed the researcher to seek clarification by asking further questions to get a detailed understanding of the phenomenon. The researcher used semi-structured interviews since they are ideal for exploratory studies (Fox, 2006). The researcher created interview guides for the Mashonaland West Provincial ICT Officer, Health Information Officer (HIO), Mashonaland West Provincial Medical

Director, Makonde District Medical Officer and Makonde District Public Healthcare Professionals. Interview guides used are appended hereto in the appendices section. The Provincial Specialist Paediatrician was also interviewed.

5.9.2 Focus Group Discussions

A focus group discussion (FGD) is a detailed group interview (Mishra, 2016) to explore a phenomenon or answer questions in depth. Like with interviews, the researcher conducted a focus group in the first phase of data collection. To understand the problem of U5M, the potential role of emerging technologies in reducing under-5 mortality, the feasible technologies and what needs to be done for the adoption of emerging technologies in Makonde District, the researcher conducted a focus group discussion. In selecting the participants, the researcher preferred paediatricians and had initially planned to conduct two focus group discussions. However, the participants were not always forthcoming with some deployed for the COVID-19 vaccination campaigns and the national census, forcing the researcher to run one session. Some of the participants who had indicated their willingness to participate in the focus group discussion but failed were then interviewed individually on separate occasions. Chinhoyi Provincial Hospital is always open, resulting in some healthcare professionals working at night when others were working day. Synchronising the availability of the potential participants proved hard, making it difficult to schedule focus groups at times convenient to all of them. The focus group discussion guide has been included in the appendices section.

5.9.3 Questionnaires

The second phase of data collection focused on quantitative data to confirm the findings of the first phase, unlike the exploratory phase, which sought information discovery. This was the phase when parents and guardians of under-five children were incorporated into the study. However, healthcare professionals were also included in this phase. Semi-structured questionnaires were used in this phase. Questionnaires used are appended hereto in the appendices section. Some key informants could not show up for interviews and instead opted for qualitative questionnaires, for example, the DMO.

5.9.4 Mapping the Theoretical Framework to Research Objectives, Research Questions, and Research Instruments

The research instruments used in this study were informed by the theoretical framework, the research objectives and questions. Table 17 shows a mapping of the research instruments to the theoretical framework, research questions and research objectives. The specific questions in each research instrument that are mapped to a particular construct of the theoretical framework are shown.

Table 17: Mapping the theoretical framework to research objectives, research questions, and research instruments

Research Objectives	**Research Questions**	**Research Instrument and Question Number**	**Customised Consolidated Capability Approach**
RO1: Investigate the preparedness to adopt emerging technologies in Makonde District to reduce under-five mortality in public healthcare institutions.	**RQ1:** What is the level of readiness to adopt emerging technologies for reducing under-five mortality in Makonde District public healthcare facilities? (a) To what extent do healthcare professionals in Makonde District know about emerging technologies for reducing under-five mortality? (b) To what extent are healthcare professionals in Makonde District willing to adopt emerging technologies to reduce under-five mortality?	Questionnaire to Healthcare Professionals (HCP): • Section B (QN8, QN9, QN10, QN11, QN12)	Personal utilisation function, influences of functionings
RO2: Identify emerging technologies that	**RQ2:** What factors are affecting the potential adoption of emerging	• Questionnaire to Mothers of Under-Five Children: QN9	Influences on functionings

are available in Zimbabwe.	technologies by public healthcare institutions to reduce under-five mortality in Makonde District? (c) Which emerging technologies in healthcare are currently available in Zimbabwe?		
RO3: Identify factors that can affect the potential adoption of emerging technologies to reduce under-five mortality in the Makonde District's public healthcare institutions.	**RQ2:** What factors are affecting the potential adoption of emerging technologies by public healthcare institutions to reduce under-five mortality in Makonde District? (a) What factors affect the potential adoption of emerging technologies for reducing under-five mortality by pregnant women and mothers of under-five children in Makonde District? (b) What factors affect the potential adoption of emerging technologies to reduce under-five mortality	• Questionnaire to Mothers of Under-Five Children: QN3, QN8, QN9, QN10 • Questionnaire to HCP: QN10, QN11, QN12, QN13	Personal utilisation function, influences on functionings, functionings

	by public health professionals in Makonde District?		
RO4: Identify the perceived potential role of emerging technologies in reducing U5M in Makonde District's public healthcare institutions.	**RQ3:** What potential role can emerging technologies play in reducing under-five mortality in Makonde District? (a) What is the perceived contribution of emerging technologies in disease prevention among under-five children in the Makonde District? (b) What is the perceived contribution of emerging technologies in managing diseases among under-five children in the Makonde District? (c) What is the perceived contribution of emerging technologies in improving healthcare quality for under-five children in the Makonde District?		Capabilities and functionings
RO5:	**RQ3:**		Functionings, capabilities,

Develop an emerging technologies framework to help reduce under-five mortality in public healthcare facilities in Makonde District	What potential role can emerging technologies play in reducing under-five mortality in Makonde District? (d) What needs to be done for emerging technologies to be adopted in Makonde District's public health institutions to reduce U5M?		substantive freedoms, DOI and UTAUT factors

5.10 Sampling Strategies

Time and financial constraints did not allow the researcher to survey every eligible person; hence, a representative sample was selected and surveyed. A sample is a subclass of a population or a unit of analysis (Merriam, 2009, p. 76). Since the study collected both qualitative and quantitative data in two stages, the researcher used both nonprobability and probability sampling strategies, with the latter allowing for the generalisation of study findings from the sample to the population it represents (Merriam, 2009; Rwashana & Williams, 2008). Nonprobability sampling allowed the researcher to select the most suitable participants in terms of experience and nature of work, helping to gather rich data from healthcare professionals who work with under-five children.

The researcher used purposive (purposeful) sampling to identify participants in the qualitative phase of data collection. This phase did not seek generalisation, but discovery; hence, purposive (purposeful) sampling was the most suitable since it is more appropriate for qualitative studies (Matakanye et al., 2019; Patton, 2002). Generalisation is a statistical goal (Wünderlich, 2009); hence, unnecessary and unjustifiable in qualitative studies (Merriam, 2009). Moreover, purposive sampling allows the researcher to select respondents based on their characteristics, ensuring that the best respondents are selected based on the research problem (Furusa & Coleman, 2018; Matakanye et al., 2019). Snowball sampling was also used to identify further potential participants. The recruited participants suggested more names of suitable participants based on the study topic and the characteristics of ideal respondents as set out by the researcher.

As an exploratory study, it was important for the researcher to select key informants who could provide rich and detailed data (Vasileiou et al., 2018) instead of random selection. Qualitative studies seek information discovery rather than generalisation. Thus, the sample adequacy for qualitative studies is usually determined by saturation (Vasileiou et al., 2018). The characteristics that qualified public healthcare professionals for the first phase were whether one was: (1) a paediatrician, (2) a nurse or doctor who works in the paediatric ward at Chinhoyi Provincial Hospital, (3) works with under-five children or (4) was a midwife. Criterion number (3) was the one used to identify participants from clinics where there were no paediatricians and very few midwives. However, the insights of the decision-makers were needed; hence, the deliberate inclusion of the DMO, PMD and the Provincial ICT Officer. While the DMO finally participated in the study after several months of trying to schedule a meeting with him without success, the PMD and the Provincial ICT Officer failed to participate despite several attempts to schedule appointments with them. The researcher tried in vain to send qualitative questionnaires to get their responses.

Random sampling, a probabilistic sampling technique in which every member of the study population is equally likely to be selected, was used in the second data collection phase. Links to the online surveys were shared through WhatsApp messages and e-mails, including in the WhatsApp groups of healthcare professionals. The sample size and how it was derived are elucidated in section 5.15 (Sample size).

5.11 Validity and Reliability

The credibility, accuracy and dependability of research findings are hugely affected by the validity and reliability of the study (Schoonenboom & Johnson, 2017; Vasileiou et al., 2018). Sections 5.11.1 and 5.11.2 describe the reliability and validity concepts in detail, including the actions taken by the researcher to ensure that the findings are valid, reliable and accurate. Establishing the validity of a qualitative study can be a daunting task (Creswell & Miller, 2000) due to the various viewpoints on what comprises validity in such studies as well as the multiple terminologies used (Hayashi et al., 2019), such as “trustworthiness, credibility, dependability, confirmability, authenticity, rigour, plausibility, goodness, soundness, transferability, and quality assessment” (FitzPatrick, 2019). Venkatesh et al. (2013) concur with Hayashi et al. (2019) and FitzPatrick (2019) as they claim that qualitative data collection lacks generally accepted standards, guidelines or norms, leaving many information systems (IS) researchers discussing how they ensured data quality in their data gathering endeavours and the extent to which data analyses and reporting were rigorous (Benz et al., 2008; Denzin

& Lincoln, 2005). Nonetheless, the researcher strained every nerve to ensure the reliability and validity of this study's findings. This study involved qualitative and quantitative data collection and analyses; hence, the reliability and validity are discussed from both qualitative and quantitative viewpoints. Section 5.11.3 summarises the approaches used to ensure the validity and reliability of the study's findings.

5.11.1 Reliability

The reliability of a research instrument means the extent of consistency; it looks at whether an instrument can generate consistent results when administered to different groups of people or the same groups but at different times (Price et al., 2015). It refers to whether research instruments and analysis techniques used in research can produce consistent results if the research were to be replicated by a different researcher or repeated on another occasion. A reliable study should produce consistent results if reproduced at a different point in time or by a different researcher. Thus, there are generally three types of reliability – "over time (test-retest reliability), across items (internal consistency), and across different researchers (inter-rater reliability)" (Price et al., 2015, p. 96). Each of these reliability types is described below.

5.11.1.1 Test-Retest Reliability

Test-retest reliability is the extent to which a measured construct that is assumed to be consistent over time really returns constant scores over time (Price et al., 2015).

5.11.1.2 Internal Consistency

Internal consistency is the extent to which different respondents' responses are consistent across items on a multiple-item measure (Price et al., 2015). Participants' scores on the measured constructs should correlate if a research instrument is internally consistent.

5.11.1.3 Interrater Reliability

Interrater reliability is the degree of consistency in different observers' judgements (Price et al., 2015). There are different approaches to measuring interrater reliability to cater for both qualitative and quantitative judgements. Quantitative judgements' interrater reliability is usually measured using Cronbach's α or Cohen's κ for categorical, qualitative observations (Price et al., 2015).

5.11.2 Validity

Discussing validity in qualitative research is a daunting task due to the lack of guidelines and norms guiding validity in such studies and the use of different nomenclatures (Creswell & Miller, 2000; FitzPatrick, 2019; Hayashi et al., 2019). Despite the relative challenges associated with describing validity in qualitative research compared to quantitative, researchers generally have a consensus that one needs to demonstrate the credibility of their findings (Creswell & Miller, 2000). Consequently, the researcher discusses how he ensured that the study's qualitative and quantitative findings were valid.

Validity refers to how accurately an instrument measures what it intends to measure (Price et al., 2015; Vasileiou et al., 2018). A consistent instrument may be unreliable by giving the same results every time, yet the results are incorrect. An instrument, therefore, must be both reliable and consistent. There are various types of validity, such as construct, face, content, criterion and discriminant validity (Price et al., 2015). In measuring validity, reliability is also considered a crucial factor. However, a measure can be exceptionally reliable but have no validity at all (Price et al., 2015). The following sections delve into these types of validity.

5.11.2.1 Construct validity

Construct validity is the capability to generalise a construct of interest because we are accurately measuring it (Price et al., 2015); it can be thought of as how truthful a researcher is labelling their construct.

5.11.2.2 Face Validity

Face validity refers to the extent to which a research instrument appears at face value to measure a construct (Price et al., 2015). A measurement method should be appropriate for measuring a given construct. Thus, face validity is concerned with the degree to which a tool appears to measure what it is intended to. The distinction between construct and face validity is that face validity is the degree to which a tool appears to measure a construct, whereas construct validity is the degree to which an instrument actually measures the construct.

5.11.2.3 Content Validity

This is the degree to which the items on a research instrument span the entire domain of interest (Price et al., 2015; Salkind, 2012); thus, it is concerned with how representative of the domain of interest the items in a research instrument are (Salkind, 2012). Like face validity, content validity is not quantitatively measured but assessed through careful checking of the research instrument against the theoretical definition of the construct of interest (Price et al., 2015).

5.11.2.4 Internal Validity

Internal validity refers to the degree to which the findings reflect the truth within the studied population; thus, it reflects the extent to which the findings are not distorted due to methodological errors (Patino & Ferreira, 2018). Thus, internal validity examines the extent to which bias is eliminated in answering research questions by examining the study design, conduct and analysis methods (Andrade, 2018). Internal validity can be viewed from two perspectives: research instruments and findings (Andrade, 2018). The researcher recorded all interviews and focus group discussions to ensure that he would not miss or misrepresent the data collected from participants. This helped the researcher when transcribing the data for analysis. The researcher also performed internal validity triangulation to check if there were any inconsistencies in the collected data. Moreover, the researcher also assessed the questionnaires for internal consistency, the results of which are presented in the appendices.

5.11.2.5 External Validity

External validity focuses on the generalisability of a study's findings to other contexts (Andrade, 2018; Patino & Ferreira, 2018). The researcher sampled participants from every category possible; that is, medical doctors, midwives, paediatricians, rural and urban dwellers, different age groups and also the decision-makers (DMO and PMD). The randomisation of the sample of mothers of under-five children was also an attempt to ensure fair selection, enhancing the external validity of the findings.

5.11.3 Data Quality Control Approaches

The researcher took deliberate actions to ensure the study's findings were reliable and valid. For reliability, the researcher took steps that minimised the following threats to reliability – participants' error, participants' bias, researcher's error and researcher's bias. To minimise participant error, the researcher scheduled interviews during the times when respondents were free and off-duty, given the fatigue healthcare professionals often experience when on duty because of their tight schedules. Appropriate time was crucial to ensure that the participants were relaxed, with minimal factors negatively influencing their performance in the study.

Moreover, the researcher minimised participants' bias by eliminating factors that could lead to them giving false responses. To reduce participants' bias, the researcher urged respondents not to include personal identification information on the questionnaires and to use pseudonyms for focus group discussions and interviews, which were conducted virtually on Zoom, WhatsApp and Microsoft Teams. In addition, the researcher emphasised to the respondents that their names would not be mentioned in the presentation of the findings, but coded names would be used instead. Additionally, the researcher asked participants to be away from other people for them to give their honest responses.

The researcher spread the interviews and focus group discussions over time instead of having multiple of them in one day to minimise researcher error, especially in interpreting participants' responses. The researcher recorded all the proceedings of the interviews and focused group discussions, eliminating recording errors and omissions that could arise from simultaneously listening and writing.

While the goal of exploration is not generalisation but discovery, the researcher ensured external validity of the findings by handling threats to the generalisability of phase 2 of data collection. This was done by selecting a representative sample that included participants from rural and urban Makonde and different educational and age strata. The researcher acknowledges the risk of systemic exclusion of mothers of under-fives without internet-enabled devices, arising from the use of online questionnaires. However, the researcher arranged with at least one nurse from each health facility to lend their smartphones to mothers of under-five children without internet-enabled devices to fill out the questionnaire.

Moreover, the researcher used multiple instruments to fully measure the meaning of the concepts studied, thus, ensuring content validity. These various instruments included interviews, focus group discussions, questionnaires and reports from the District Health Information System (version 2) tool (DHIS-2 tool). Therefore, the approaches used to ensure data quality are summarised below.

Triangulation: To eliminate individual biases, the researcher used multiple research instruments to collect data, a technique called triangulation (Cohen et al., 2002; Salkind, 2010). It was important for the research to use method triangulation in order to improve the credibility, dependability and validity of the research findings (Noble & Heale, 2019). The multiple instruments used are interviews, questionnaires, focus group discussions, DHIS-2 reports and secondary data from the 2019 Multiple Indicator Cluster Survey (MICS).

Moreover, the researcher also used multiple theoretical perspectives to formulate the theoretical framework used in this study. These perspectives are the Capabilities Approach, Diffusion of Innovation theory and the UTAUT model, whose indicators were fused to create an extended Capabilities Approach framework. Additionally, the researcher selected respondents from different strata and used both qualitative and quantitative methods.

Consensual Instruments Validation: Before using the research instruments for data collection, the researcher sought validation from other experts to measure the validity of the instruments (Vogt, 2005). The instruments were consensually validated by colleagues, supervisors, the HSSREC panel, the MRCZ Research Ethics panel and the then Concession District Hospital Matron. While other experts validated the instruments from their research expertise viewpoints, the former Concession District Hospital Matron, Ms Bongani Mangoye, validated the instruments from the perspective of healthcare professionals. Her comments also helped to recalibrate and fine-tune the instruments.

Representativeness Check: The researcher made deliberate efforts to ensure that the sample provided richer data, at the same time being representative of the entire population. For the qualitative data collection, the emphasis was not on representativeness but on exploration and discovery; hence, the sample was selected purposively and using the snowball approach. However, in the second phase of data collection, the researcher ensured that both rural and urban areas of the Makonde District were represented.

Pilot Testing: The researcher pilot tested the instruments with selected individuals from the target population and other public healthcare professionals from other districts in Zimbabwe, including the then Matron of the Concession District Hospital, Ms Bongani Mangoye. Piloting was useful in identifying issues with the instruments to check if they needed recalibration. The people who participated in the pilot test were excluded from the sample of the study.

To enhance validity, the researcher shared instruments with colleagues and experts (including the HSSREC and MRCZ review boards) to check whether they measured what they intended to measure; and also administered a few instruments as a pilot survey, after which the instruments were recalibrated.

The researcher used data and method triangulation to improve the validity of the data. Method and data triangulation were done by collecting the same data using different methods, checking whether responses to the same questions were similar, and using different data to compare if the findings were consistent. Data on facilitating conditions and determinants of technology adoption, such as mobile phone ownership, were also obtained from a secondary dataset (the 2019 MICS dataset).

Respondents' anonymity was upheld throughout the data collection phases. Moreover, the researcher asked the respondents if they were comfortable doing interviews at their workplaces or elsewhere to ensure that their responses were unbiased because of fear of being overheard by colleagues and superiors. This was important for scheduling the interviews to determine if they should be scheduled during working hours or not. The researcher also asked respondents about the times they were comfortable being interviewed. The researcher performed reliability and validity tests in SPSS for the qualitative data using Cronbach's alpha coefficient (Shmueli et al., 2019), whose validity threshold is 0.7 (Hair et al., 2020).

5.12 Study Area

This study was conducted in Makonde District in Zimbabwe's Mashonaland West Province. Mashonaland West was selected because it is one of the two provinces with the highest under-five mortality in Zimbabwe, together with the Midlands Province (ZIMSTAT, 2019b). One of the districts with the highest U5M rates in Mashonaland West Province is Makonde (Zimbabwe National Statistics Agency, 2013), hence the choice to have it as the study area for this research. Moreover, Makonde District is more accessible and includes the provincial headquarters, where the provincial hospital and medical leadership, including the PMD and DMO, are situated as compared to Sanyati District, which is the district with the highest child mortality rate in Mashonaland West Province. Chapter 2 of this thesis describes the study area in detail.

5.13 Study Context

The context of this study is public health facilities in Makonde District. Public health institutions were chosen as the context because most (approximately 82 per cent) health facilities in Zimbabwe are public institutions (Ministry of Health and Child Care, 2016). A detailed description of the context of this study was presented in Chapter 2 of this thesis.

5.14 Study Population

The population of this study were all public healthcare professionals who work with under-fives and mothers of under-fives in Makonde District. The population also included the District Health Information Officer, Health Information Officers from Chinhoyi Provincial

Hospital, the DMO, PMD, Provincial Paediatric Specialists and the Provincial EPI Officer. Public healthcare professionals who do not work with under-fives were excluded from the study. Health information officers and the Provincial ICT Officer were included to gain insights into the potential technical factors affecting the adoption of emerging technologies in Makonde District and any developments in digital interventions on under-five mortality. The researcher included the management and provincial public health management to get the managerial perspective on the problem. The DMO and PMD were the critical managers included in the study's population on advice from the MRCZ.

5.15 Sample Size

Typically, small samples are used for qualitative studies owing to the in-depth nature of such studies, and if the research is an exploration to understand phenomena, a convenient sample is mainly used (Sekaran, 2003). The sample of this study was obtained using three sampling strategies: purposive, snowball (qualitative phase) and random sampling (quantitative phase). The sample adequacy of qualitative studies is ideally determined by saturation (Vasileiou et al., 2018). The research sample size for the qualitative study was twenty. The researcher realised that no new themes emerged from the interviews after interviewing thirteen participants and having a focus group with four participants but continued until they were twenty without any new emerging themes. The qualitative sample included paediatricians, midwives, primary care nurses, health information officers, the provincial specialist paediatrician, the provincial expanded programme on immunisation officer, the district health information officer and the DMO. The participants were drawn from the following clinics: Doma, Mutala, Umboe, Portlet, Nyamugomba, Godzi, Matoranjera and the Chinhoyi Provincial Hospital.

Determining a sample size entails two stages for a known population: (1) determining sample size for an unknown (infinite) population size and (2) adjusting the sample size to the required population size, using the following formulae (Cochran, 1977):

$$(S) = \frac{Z^2 * p(1-p)}{m^2} \qquad (1)$$

$$S = (S)/(1 + \frac{[(S)-1]}{N}) \qquad (2)$$

Where: $(S) = sample\ size\ for\ an\ infite\ population, Z\ is\ a\ z-score, p = population\ proportion, m\ is\ the\ margin\ of\ error, S = the\ sample\ size\ for\ a\ finite\ population\ and\ N = the\ population\ size.$

Equation (1) is for computing the sample size of an infitie population while Equation (2) is for a finite/known population size. These formulae were used to determine the sample sizes for the quantitative data collection phase. The number of women with children under five years was unknown. However, the number of under-five children registered with public healthcare professionals in the Makonde District was 51 246. While the actual number of mothers could be less than 51 246 due to multiple births like twins and some women giving birth more than once in five years, the researcher assumed that there were as many mothers as the number of children. This assumption did not reduce the sample size and was convenient in determining it.

Using the following values: a fifty per cent population proportion, a five per cent margin of error, a ninety-five (95) per cent confidence interval, and the z score of 1.96, the researcher computed the sample size as follows:

$$(S) = 1.96^2 * \frac{0.5(1-0.5)}{0.05^2}$$

$(S) = 384.16$ (Sample size for infinite population)

$$S = 384.16/(1 + \frac{[384.16-1]}{51\ 146})$$

$$\boldsymbol{S = 381(3\ s.f)}$$

Therefore, the sample size for mothers of under-five children was 381.

The researcher followed the same procedure to calculate the sample size for healthcare professionals. The DHIO’s office indicated that there were approximately 400 public healthcare professionals in the district, of which 120 did not mostly directly work with under-fives as they were deployed in other wards. Of the 280 that remained, 20 had participated in the interviews and thus, were ineligible to participate in the quantitative phase. The population then shrunk to 260, for which sample size was computed as below, making the same assumptions as above:

$$(S) = 1.96^2 * \frac{0.5(1-0.5)}{0.05^2}$$

$(S) = 384.16$ (Sample size for infinite population)

$$S = 384.16/(1 + \frac{[384.16-1]}{260})$$

$$S = 155.3\ (3d.p)$$

$$\boldsymbol{S = 156 (rounded\ up)}$$

Thus, the sample size for the healthcare professionals was 156.

5.16 Ethical Considerations

The researcher adhered to research ethics and abided by all ethical requirements. The following paragraphs expatiate on the steps and actions followed by the researcher to ensure the research was conducted ethically.

Ethical Clearances: Every research conducted at the UKZN must follow ethical procedures. To this end, it is a requirement of the university that all research conducted by its students must be vetted for ethical abidance. Therefore, the researcher obtained ethical clearance from the Humanities and Social Sciences Research Ethics Committee (HSSREC) of the University of KwaZulu-Natal. The protocol number of this ethical clearance is HSSREC/00002132/2020. The ethical clearance (EC) was valid for one year, and when it expired, the researcher applied for renewal, which was granted.

Moreover, all studies conducted in the healthcare domain in Zimbabwe must be ethically cleared by the Medical Research Council of Zimbabwe (MRCZ). Consequently, the researcher obtained ethical clearance from the MRCZ with the protocol number MRCZ/A/2782, which was also valid for one year.

Permission to conduct the research: The researcher obtained permission to conduct the research from the PMD Mashonaland West Province. At the time, the PMD was Dr. Masoja who had just replaced Dr. Nyamayaro. The permission letter, herein referred to as the gatekeeper's pass, is included in appendix III. Both the gatekeeper's pass and ethical clearances were obtained before the data collection began.

Voluntary Participation: The researcher did not coerce any participants to participate in this study. Participation was voluntary and participants were allowed to withdraw at any stage of the process.

Informed Consent: The researcher explained everything about the study to the potential participants, after which the respondents were given an opportunity to either consent or not, to participate in the study. All interview and focus group discussion participants were requested to sign an informed consent form (ICF) if they were willing to participate. However, those responding to questionnaires were not asked to sign an ICF as their filling of the questionnaire was tantamount to consenting. For interviews and focus group discussions, participants were asked for permission to record them, even though they would have initially agreed. Despite consenting to participate, respondents could still withdraw without any consequences to them.

Do no harm: The researcher ensured that no person, animal, living or non-living thing was harmed as a result of this study.

Confidentiality: The researcher did not divulge to anyone the discussions he had with respondents. Thus, the discussions and data remained confidential.

Anonymity: The researcher preserved the anonymity of all participants by asking them not to include any information that might lead to their personal identification on the questionnaires. Moreover, the researcher asked interview and focus group discussion participants to use pseudonyms for the virtual discussions and turn off their cameras if they so wish to. However, even for those who decided to use their actual names and did not turn off their cameras, the researcher used coded names to ensure that they could not be personally identified when the results were presented.

Assessment of relevant components only: The researcher only assessed components that were relevant to the study and were necessary to answer the research questions or meet the research objectives.

Use of the data solely for the research purpose: The researcher did not use the collected data for any other purposes (repurposing) except for which the data were collected.

5.17 Chapter Summary

In this chapter, the researcher described the methodology used in this study to achieve the research objectives and answer the research questions. A detailed description of the ontological and epistemological viewpoints was presented. The research was guided by the pragmatism philosophy, allowing the researcher the flexibility of using multiple and diverse tools for data collection and analysis. This was essential in the exploratory sequential mixed methods research design, upon which this research was based. It allowed the researcher to use both qualitative and quantitative methods in a phased approach, with the former being used in the first phase for exploration (discovery) while the latter were used in the second phase for confirmation.

The research was approached from both the inductive and inductive perspectives. The inductive approach was applied to answer research questions on factors contributing to high U5M in Makonde District's public healthcare institutions, the most feasible emerging technologies for reducing U5M in Makonde District, how emerging technologies can be leveraged to reduce U5M in Makonde District and information technologies currently in use in the district to reduce U5M. On the other hand, deduction was used to investigate the perceived potential role of emerging technologies in managing, controlling and diagnosing diseases among under-five children in Makonde District.

Moreover, the researcher discussed the data collection methods and research instruments. The data were collected in two phases using interviews, questionnaires and focus group discussion. This chapter also presented the validity and reliability issues along with the actions taken by the researcher to ensure the findings are valid and reliable. Additionally, the study area, study context, study population, sample size and ethical considerations are described. The research was conducted in Makonde District, a district in Zimbabwe's Mashonaland West Province. The context was public healthcare institutions in Makonde District. The ethical considerations described in this chapter include obtaining ethical clearances and permission to conduct the research, anonymity of participants, confidentiality of the data obtained from participants, not harming anyone or anything throughout the study, obtaining the informed consent from participants, voluntary participation, allowing participants to withdraw at any stage, assessing only the components relevant to the study and not repurposing the obtained data for any other purposes than for which they were gathered. The following chapter, Chapter 6, presents the findings of this study.

CHAPTER 6: Presentation of Findings

6.1 Introduction

This chapter presents the findings of this study. The study involved collecting qualitative and quantitative data from public healthcare professionals and mothers of under-five children from Makonde District, the Provincial ICT Officer, one Health Information Officer from Chinhoyi Provincial Hospital and the Makonde District Health Information Officer. The District Medical Officer and District Health Information Officer also participated in this research. Through triangulation, additional data were obtained from the DHIS-2 system to improve the findings' richness, accuracy, validity, and reliability. The researcher analysed the qualitative data using NVivo 12, while SPSS v28 was used to analyse quantitative data. The researcher coded themes arising from the responses into Nvivo nodes and sub-nodes. The response rate for healthcare professionals was 57.69 per cent. The response rate was acceptable, as 30 per cent is considered the minimum for surveys (Sekaran, 2003). However, recent literature argues that low response rates do not necessarily translate to low validity (Morton et al., 2012). It took the researcher nearly nine months to collect data since most healthcare professionals were not forthcoming. The researcher began data collection in September 2021 after getting cleared by the MRCZ. Data collection proceeded until June 2022 due to a lack of responses from the healthcare professionals. Some public healthcare professionals had been deployed for the COVID-19 vaccination campaigns while others conducted the Zimbabwe 2022 national census. Others were merely unwilling to participate. Those who participated indicated that some doctors and nurses were disgruntled and frustrated due to poor working conditions and lacked the motivation to participate.

6.2 Demographic Profile of Respondents

6.2.1 Education, Health Facilities and Age of Respondents – Mothers of Under-fives

Table 18: Distribution of Respondents by Age and Highest Education - Mothers of Under-Fives

	Age (Years)					
	Below 18	Between 18 and 25	Between 26 and 35	Between 36 and 45	Above 45	**Total and Percent**
Highest Education	Frequency	Frequency	Frequency	Frequency	Frequency	
Tertiary	1	26	116	36	7	**186 (47.6%)**
Secondary School	12	72	36	26	7	**153(39.1%)**
Primary School	10	14	15	9	0	**48 (12.3%)**

Never been to school	0	0	3	0	1	**4 (1.0%)**

Three hundred and ninety-one (391) mothers of under-fives responded to the questionnaire. The age and educational distribution of these respondents are shown in Table 18. The modal group (47.6 per cent) was that of tertiary education graduates, followed by secondary school graduates (39.1 per cent). The modal age group was the 'between 26 and 35', which accounted for 43.48 per cent.

Table 19: Distribution of Respondents (Mothers of Under-Fives) by Health Facility Attended

Distribution of Respondents by Health Facility				
Health Facility	Frequency	Percent	Valid Percent	Cumulative Percent
Chinhoyi Provincial Hospital	106	27.1	27.1	27.1
Chinhoyi Clinic	41	10.5	10.5	37.6
Chikonohono Clinic	32	8.2	8.2	45.8
Murereka RHC	23	5.9	5.9	51.7
Mzari Polyclinic	22	5.6	5.6	57.3
Alaska Clinic	21	5.4	5.4	62.7
Umboe Clinic	21	5.4	5.4	68.0
Nyamugomba Clinic	20	5.1	5.1	73.1
Shackleton Clinic	16	4.1	4.1	77.2
Matoranjera Clinic	12	3.1	3.1	80.3
Godzi Clinic	11	2.8	2.8	83.1
Portlet Clinic	10	2.6	2.6	85.7
Doma Clinic	9	2.3	2.3	88.0
Mukohwe Clinic	8	2.0	2.0	90.0
ZPS Clinic	7	1.8	1.8	91.8
Green Valley Clinic	7	1.8	1.8	93.6
Mutala Clinic	4	1.0	1.0	94.6
Kenzamba Clinic	4	1.0	1.0	95.7
Kosana Clinic	3	.8	.8	96.4
River Ranch Clinic	2	.5	.5	96.9
Obva Clinic	2	.5	.5	97.4
Zumbara RHC	2	.5	.5	98.0
Chimanimani Clinic	1	.3	.3	98.2
Manyamba RHC	1	.3	.3	98.5
Sadoma Clinic	1	.3	.3	98.7
Chipfuwamiti Clinic	1	.3	.3	99.0
Naison Dip RDC Clinic	1	.3	.3	99.2

Gudubu RHC	1	.3	.3	99.5
Hombwe Clinic	1	.3	.3	99.7
Runene Clinic	1	.3	.3	100.0
Total	**391**	**100.0**	**100.0**	

Table 19 shows the distribution of the participants (mothers of under-fives) by the health facility they typically attend, thus, by the area they are based in. Nearly all of the public health facilities in Makonde District were represented though there were more respondents from Chinhoyi City than any other area.

6.2.2 Distribution of Healthcare Questionnaire Respondents by Health Facility, Gender and Age

Table 20: Distribution of Healthcare Respondents By Health Facility, Age and Gender

		Age (Years)						
		Between 26 and 35		Between 36 and 45		Above 45		Total and (% by Health Facility)
Health Facility	**Gender**	Count	% of Total	Count	% of Total	Count	% of Total	
Chinhoyi Provincial Hospital	Female	21	23.3%	5	5.6%	17	18.9%	63 (70.0%)
	Male	4	4.4%	16	17.8%	0	0.0%	
Chikonohono Clinic	Female	1	1.1%	0	0.0%	2	2.2%	4 (4.44%)
	Male	0	0.0%	1	1.1%	0	0.0%	
SubNation Level	Female	0	0.0%	0	0.0%	1	1.1%	1 (1.11%)
Kenzamba Clinic	Female	1	1.1%	0	0.0%	0	0.0%	1 (1.11%)
Alaska Clinic	Female	0	0.0%	0	0.0%	1	1.1%	1 (1.11%)
Mutala Clinic	Male	1	1.1%	0	0.0%	0	0.0%	1 (1.11%)
Matoranjera Clinic	Female	1	1.1%	1	1.1%	0	0.0%	2 (2.22%)
Portlet Clinic	Female	1	1.1%	0	0.0%	0	0.0%	2 (2.22%)
	Male	0	0.0%	1	1.1%	0	0.0%	
Godzi Clinic	Female	1	1.1%	0	0.0%	0	0.0%	2 (2.22%)
	Male	0	0.0%	1	1.1%	0	0.0%	

Doma Clinic	Male	0	0.0%	0	0.0%	1	1.1%	1 (1.11%)
Alaska Clinic	Male	0	0.0%	1	1.1%	0	0.0%	1 (1.11%)
Shackleton Clinic	Female	1	1.1%	0	0.0%	0	0.0%	1 (1.11%)
Umboe Clinic	Female	0	0.0%	0	0.0%	1	1.1%	1 (1.11%)
Mzari Polyclinic	Male	1	1.1%	1	1.1%	0	0.0%	2 (2.22%)
Murereka RHC	Female	1	1.1%	0	0.0%	0	0.0%	2 (2.22%_
	Male	0	0.0%	1	1.1%	0	0.0%	
ZPS	Female	1	1.1%	0	0.0%	0	0.0%	1 (1.11%)
Runene Clinic	Female	1	1.1%	0	0.0%	1	1.1%	2 (2.22%)
Kosana Clinic	Male	0	0.0%	1	1.1%	0	0.0%	1 (1.11%)
Chinhoyi Clinic	Male	0	0.0%	1	1.1%	0	0.0%	1 (1.11%)
Total	**Female**	**30**	**33.3%**	**6**	**6.7%**	**24**	**26.7%**	**90 (100%)**
	Male	**6**	**6.7%**	**24**	**26.7%**	**0**	**0.0%**	

Table 20 shows the distribution of the healthcare respondents by gender, age and health facility at which they were stationed. Ninety public healthcare professionals responded to the questionnaire. The ratio of women to men respondents was 2:1. Most (70 per cent) of the respondents were from Chinhoyi Provincial Hospital.

6.2.3 Distribution of Healthcare Questionnaire Respondents by Designation

Table 21: Distribution of Healthcare Questionnaire Respondents by Designation

Designation	Frequency	% of N
Nurse	75	83.3%
Doctor	6	6.7%
Primary Care Nurse	4	4.4%
Midwife	3	3.3%
Provincial EPI (Expanded Programme on Immunisation) Officer	1	1.1%
Paediatrician	1	1.1%

Ninety (90) public healthcare professionals responded to the questionnaire. The designations of the respondents were nurses (registered general nurses and primary care nurses), doctors, widwives, the provincial expanded programme on immunization officer and paediatricians. All the respondents directly worked with under-fives either in the paediatric ward at Chinhoyi Provincial Hospital or as nurses at clinics. The majority (83.3 per cent) of the respondents were Registered General Nurses, indicated as Nurses in Table 21. Midwives in this table are Registered General Nurses who are also trained as midwives.

6.2.4 Distribution of Interview and Focus Group Participants by Gender and Designations

Twenty (20) participants were involved in the qualitative data collection phase, with equal distribution between men and women, as shown in Table 22. The participants were drawn from the provincial, district and facility levels. In addition to healthcare professionals, two health information officers also participated in the interviews. All the healthcare professionals who participated in this study worked with under-fives. While the target was to have paediatricians only, it emerged that there are no paediatricians in public clinics in Makonde District, except at the Chinhoyi Provincial Hospital. The researcher then selected nurses who work with under-fives to participate in this study.

Table 22: Distribution of Interview and Focus Group Participants by Gender and Designations

Designation	Gender				Count and % of N
	Male		Female		
	Count	% of N	Count	% of N	
Provincial Specialist Paediatrician	1	5.0%	0	0.0%	1 (5%)
Midwife	3	15.0%	2	10.0%	5 (25%)
Registered General Nurse	1	5.0%	4	20.0%	5 (25%)
Paediatrician	0	0.0%	1	5.0%	1 (5%)
District Medical Officer	1	5.0%	0	0.0%	1 (5%)
Health Information Officer	1	5.0%	0	0.0%	1 (5%)
District Health Information Officer	0	0.0%	1	5.0%	1 (5%)
Primary Care Nurse	1	5.0%	1	5.0%	2 (10%)
Doctor	2	10.0%	1	5.0%	3 (15%)
Total	**10**	**50%**	**10**	**50%**	**100%**

Table 22 shows the demographics of the respondents who participated in the qualitative data collection phase of this study. While the respondents were coded to ensure anonymity during findings reporting, the researcher did not include the respondents' codes in this table since it would lead to the identification of some respondents, especially for such categories as District Medical Officer, where there is only one person occupying that position.

Data were collected at three levels – provincial, district and health facilities/ clinics. While the study area was Makonde District, the executives are not at the health facilities level but district and provincial. Thus, the researcher included the Provincial Specialist Paediatrician, PMD and DMO to get the managerial perspective on processes followed to introduce emerging technologies and the factors affecting the adoption of such technologies. However, the PMD could not participate in this study despite several attempts to try and schedule a meeting with him. Based on the nature of this study, the researcher purposively selected participants in the qualitative data collection phase based on their positions and experience. From CPH, the researcher primarily targeted paediatricians, midwives and general doctors who work with children, as well as nurses working in the paediatrics ward. The researcher also selected healthcare professionals in charge of clinics, who are RGNs. However, two PCNs were also interviewed since the RGNs of their clinics were not forthcoming to participate in this study.

In the first data collection phase, the researcher conducted a focus group discussion and interviews, followed by questionnaires in the second phase. Due to COVID-19 restrictions, all interviews were remotely conducted using Zoom, Microsoft Teams and WhatsApp calls, depending on the respondents' choices. The researcher had planned to conduct two focus group discussions but only managed one as it proved difficult to synchronise free time for participants. The healthcare professionals who had indicated their willingness to participate in the study had different work schedules, with some working at night when others were on day duty. However, the researcher ensured that everyone who expressed their willingness to participate did participate either in the focus group discussion or interviews. Moreover, getting interview time with the healthcare professionals was a challenge since they were having COVID-19 vaccination campaigns. They had been deployed to different areas to vaccinate people, with some of them deployed for the national census exercise just after the vaccination campaigns.

6.3 Research Instruments Reliability and Validity Results

The researcher performed reliability tests using the Statistical Package for Social Scientists (SPSS v28). Cronbach's Alpha was used as the reliability measure. Since the researcher designed questionnaires for healthcare professionals and mothers of under-fives, these were separately checked for reliability and validity.

Table 23: Reliability Statistics - Healthcare Professionals Questionnaire

Reliability Statistics		Comment
Cronbach's Alpha	N of Items	
.867	84	High reliability (coefficient > 0.7)

Table 23 shows the reliability statistics of the healthcare professionals' questionnaire, with Cronbach's Alpha of 0.867. This coefficient is greater than the threshold value of 0.7; thus, the responses are highly reliable.

Table 24: Reliability Statistics - Mothers of Under-Fives Questionnaire

Reliability Statistics			Comment
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items	
.886	.890	20	High reliability (coefficient > 0.7)

The questionnaire for mothers of under-fives was separately assessed for reliability, with the results shown in Table 24. The Cronbach's Alpha coefficient is 0.886, which is higher than the one for healthcare professionals. Similarly, the dataset is highly reliable since the coefficient is greater than the threshold.

Table 25: Measure of Item Consistency

Item	Cronbach's Alpha	Comment
Knowledge of Artificial Intelligence	.866	High consistency (Coefficient >0.7)
Knowledge of Cloud Computing	.867	High consistency (Coefficient >0.7)
Knowledge of Social Media	.865	High consistency (Coefficient >0.7)
Knowledge of Telemedicine	.865	High consistency (Coefficient >0.7)
Knowledge of the Internet of Things	.865	High consistency (Coefficient >0.7)
Knowledge of Telehealth	.864	High consistency (Coefficient >0.7)
Knowledge of 3D Printing	.864	High consistency (Coefficient >0.7)
Knowledge of Mass Media	.865	High consistency (Coefficient >0.7)
Knowledge of 5G Technology	.865	High consistency (Coefficient >0.7)

Knowledge of Blockchain	.864	High consistency (Coefficient >0.7)
Knowledge of Robotics	.864	High consistency (Coefficient >0.7)
Knowledge of Virtual Reality	.864	High consistency (Coefficient >0.7)
Willingness to adopt Artificial Intelligence	.866	High consistency (Coefficient >0.7)
Willingness to adopt Cloud Computing	.865	High consistency (Coefficient >0.7)
Willingness to adopt Social Media	.864	High consistency (Coefficient >0.7)
Willingness to adopt Telemedicine	.864	High consistency (Coefficient >0.7)
Willingness to adopt Internet of Things	.865	High consistency (Coefficient >0.7)
Willingness to adopt Telehealth	.865	High consistency (Coefficient >0.7)
Willingness to adopt 3D Printing	.868	High consistency (Coefficient >0.7)
Willingness to adopt Mass Media	.864	High consistency (Coefficient >0.7)
Willingness to adopt 5G Technology	.862	High consistency (Coefficient >0.7)
Willingness to adopt Blockchain	.865	High consistency (Coefficient >0.7)
Willingness to adopt robotics	.864	High consistency (Coefficient >0.7)
Likeliness To Use ETs	.864	High consistency (Coefficient >0.7)
Capability - Remote Monitoring	.864	High consistency (Coefficient >0.7)
Capability - Diagnosis Support	.864	High consistency (Coefficient >0.7)
Capability -Disease Tracking	.862	High consistency (Coefficient >0.7)
Capability - Personalisation of Care	.864	High consistency (Coefficient >0.7)
Capability -Remote Data Collection	.864	High consistency (Coefficient >0.7)
Capability - Education and Awareness	.864	High consistency (Coefficient >0.7)
Capability - Remote Treatment	.864	High consistency (Coefficient >0.7)

Capability – Training	.864	High consistency (Coefficient >0.7)
Capability – Communication	.864	High consistency (Coefficient >0.7)
FC Confidentiality	.864	High consistency (Coefficient >0.7)
FC Government Policies	.864	High consistency (Coefficient >0.7)
FC Legislation	.864	High consistency (Coefficient >0.7)
FC Affordability	.864	High consistency (Coefficient >0.7)
FC Infrastructure	.866	High consistency (Coefficient >0.7)
FC Infrastructure Reliability	.861	High consistency (Coefficient >0.7)
FC Phone Ownership	.867	High consistency (Coefficient >0.7)
PE Efficiency	.861	High consistency (Coefficient >0.7)
PE Audience Expansion	.858	High consistency (Coefficient >0.7)
PE Improved Service Quality	.869	High consistency (Coefficient >0.7)
PE Automated Diagnosis/ Diagnostic Support	.862	High consistency (Coefficient >0.7)
PE Accuracy	.858	High consistency (Coefficient >0.7)
EE Ease of Use	.859	High consistency (Coefficient >0.7)
Medico-legal hazards	.865	High consistency (Coefficient >0.7)
Perceived Role - Diagnosis Service Quality	.859	High consistency (Coefficient >0.7)
Perceived Role - Remote Disease Monitoring	.857	High consistency (Coefficient >0.7)
Perceived Role - Disease Tracking	.852	High consistency (Coefficient >0.7)
Perceived Role - Education and Awareness	.851	High consistency (Coefficient >0.7)
Perceived Role - Improved Diagnosis in the Absence of Doctors	.852	High consistency (Coefficient >0.7)
Perceived Role - Reminders to Patients	.851	High consistency (Coefficient >0.7)
Perceived Role - Remote Data Collection	.854	High consistency (Coefficient >0.7)

Perceived Role - Patient Data Sharing	.864	High consistency (Coefficient >0.7)
Perceived Role - Information Sharing Among Healthcare Professionals	.859	High consistency (Coefficient >0.7)
Perceived Role - Communication Between Patients and Healthcare Professionals	.857	High consistency (Coefficient >0.7)
Perceived Role - Training Improves Quality of Service	.860	High consistency (Coefficient >0.7)
Determinant – Confidentiality	.854	High consistency (Coefficient >0.7)
Determinant - Ease of Use	.856	High consistency (Coefficient >0.7)
Determinant – Compatibility	.856	High consistency (Coefficient >0.7)
Determinant – Convenience	.850	High consistency (Coefficient >0.7)
Determinant – Reliability	.855	High consistency (Coefficient >0.7)
Determinant - Government Support	.856	High consistency (Coefficient >0.7)
Determinant - Standardisation of Technology	.865	High consistency (Coefficient >0.7)
Determinant - Integration to Existing Systems	.866	High consistency (Coefficient >0.7)
Determinant – Demotivation	.867	High consistency (Coefficient >0.7)
Impediment – Infrastructure	.865	High consistency (Coefficient >0.7)
Impediment - Security, Privacy and Confidentiality	.862	High consistency (Coefficient >0.7)
Impediment - ICT Skills	.859	High consistency (Coefficient >0.7)
Impediment - MoHCC Policies	.870	High consistency (Coefficient >0.7)

Impediment - Network Issues	.868	High consistency (Coefficient >0.7)
Impediment -Low Phone Ownership	.866	High consistency (Coefficient >0.7)
Impediment - Lack of Incentives	.864	High consistency (Coefficient >0.7)
Impediment - Confident Computer Use	.865	High consistency (Coefficient >0.7)
Viable Technology - Telemedicine and Telehealth	.864	High consistency (Coefficient >0.7)
Viable Technology - Internet of Things	.866	High consistency (Coefficient >0.7)
Viable Technology - Mobile Applications	.864	High consistency (Coefficient >0.7)
Viable Technology - Social Media	.862	High consistency (Coefficient >0.7)
Viable Technology - SMS-Based Solutions	.861	High consistency (Coefficient >0.7)
Viable Technology - Electronic Billboards	.863	High consistency (Coefficient >0.7)
Viable Technology - Cloud Computing	.866	High consistency (Coefficient >0.7)
Viable Technology - Medical Chatbots/Virtual Assistants	.858	High consistency (Coefficient >0.7)
Viable Technology - Social Media	.860	High consistency (Coefficient >0.7)
Overall	**0.867**	**High consistency (Coefficient >0.7)**

The item consistencies of the questionnaire items are presented in Table 25. All the items had a consistency coefficient of above 0.8, indicating that they are all highly consistent.

Table 26: Composite (Construct) Reliability

Construct	Cronbach's Alpha	Comment
Knowledge	.740	Adequate reliability (>=0.7)
Willingness	.733	Adequate reliability
Capabilities	.725	Adequate reliability
UTAUT	.709	Adequate reliability
Perceived Role	.762	Adequate reliability

Determinants	.732	Adequate reliability
Impediments	.708	Adequate reliability
Viable Technologies	.707	Adequate reliability

Table 26 shows the construct validity results. All the constructs had a coefficient of greater than 0.7, a Cronbach Alpha value greater than the threshold.

6.4 Findings Based on Research Questions

The findings of this study are presented from two perspectives, qualitative and quantitative since the study design was exploratory sequential mixed-methods. Interviews and a focus group discussion were conducted during the qualitative data collection phase. The participants included public healthcare professionals who work with under-fives and health information officers. The researcher also selected the District Medical Officer and Provincial Medical Director to participate in this study to get management's perspectives. However, the PMD could not participate in the study despite several attempts to book him for an interview for a period of almost six months. The Provincial Paediatric Specialist was also purposively selected to participate in the study. Thus, the respondents were selected from three levels – provincial, district and health facility. All interviews were conducted virtually due to the COVID-19-induced restrictions. Respondents were selected from ten public health facilities in Makonde District.

In the second phase of data collection, the researcher used questionnaires to primarily collect data from mothers of under-five children and healthcare professionals who did not participate in the first phase. The data were collected using online questionnaires. The findings of this study are presented in this section based on research questions.

6.4.1 Research Question 1: What is the level of readiness to adopt emerging technologies for reducing under-five mortality in Makonde District public healthcare facilities?

a. To what extent do healthcare professionals in Makonde District know about emerging technologies for reducing under-five mortality?

6.4.1.1 Qualitative Findings on Knowledge of Emerging Technologies by Healthcare Professionals

Table 27: Mapping Themes To Research Question 1(a)

Respondents	**Theme**	**Sub-themes that emerged from respondents**	**Interview question(s)**
Nurses, DHO, paediatricians	Emerging technologies knowledge	Neotree	State any emerging information technologies in healthcare that you know
		electronic health records	
		Telemedicine	
		Electronic mails	
		Short Messaging Service	
		Mass media (TV, radio, electronic billboards)	
		3D Printing	
		Social media	
		Robots	
		Virtual reality	
		Drones	

Knowledge of emerging technologies by public healthcare workers in Makonde

This section presents the extent to which public healthcare professionals in Makonde District know about emerging technologies that could be used to reduce under-five mortality.

Neotree

All the respondents from Chinhoyi Provincial Hospital professed knowledge of Neotree, whose positive contribution to their care and treatment of neonates they attested. One nurse who works in the paediatric ward applauded the use of Neotree at Chinhoyi Provincial Hospital, which she said helped them diagnose and manage diseases in children using artificial intelligence (AI)-powered technology accessible to them through tablets. An experienced midwife (Respondent 10) stated that:

"We are having what is called Neotree research where we are using tablets to diagnose children. It's helping us with statistics and the management of certain diseases. The system automatically tells you that these symptoms are for this disease. It has already programmed management for each disease, so nurses do not have to go through many pages searching how to manage the disease."

However, it is worth noting that this technology is only available at the provincial hospital in the whole district and that it is donor-funded. One of the health information officers stated that they did not deploy this technology at clinics because they do not admit neonates. All the healthcare professionals who have used this technology indicated that it is helpful in managing and treating neonates.

Electronic Patient Management System (ePMS)

The UNDP funded a digital system called the electronic patient management system (ePMS). This system is currently used in public healthcare institutions, making it one of the digital technologies that the public healthcare professionals in Makonde District know. The system has helped improve patient data access and management since its deployment.

Electronic Health Record (EHR)

Makonde District rolled out the electronic health record in late 2021; hence, it was a popular emerging technology amongst the respondents. However, at the time of data collection, some clinics had not started using this technology despite the nurses having been trained in it. The technology has been deployed even at rural clinics. It comes with tablets, mobile WiFi (MiFi) and a monthly allocation of 50 Gigabytes data bundles. They use this technology to capture patients' data. However, this technology is not specifically for child patients.

Telemedicine

The respondents also mentioned that they know telemedicine as an emerging technology in healthcare. A specialist paediatrician (Respondent 1) claimed that the major mobile phone service providers in Zimbabwe had already introduced telemedicine, while an experienced midwife (respondent 10) equated telemedicine to data sharing. While the healthcare professionals indicated telemedicine as one of the technologies they knew, the word seems to have been loosely used and appeared to mean different things to different people.

Data Analytics

While data analytics was less popular among the respondents, it was mentioned by one specialist doctor who emphasised the importance of data in paediatrics. They stated that data analytics would help analyse data and inform childcare through analysing datasets on conditions like congenital malformations and congenital heart diseases, among others.

Short Messaging Service and Electronic mail

Public healthcare professionals in Makonde District indicated that they knew of SMSs and electronic mail. These are useful for sending health information and reminders to patients, such as when they are due for the next review.

Mass media (TV, radio, electronic billboards, social media)

Mass media was popular among healthcare professionals for its use in providing health education. The mentioned examples were radio, television, social media and electronic billboards. However, public healthcare facilities in Makonde District are not using these mass media to interact with or educate patients. Communication is often among healthcare workers themselves.

3D Printing

3D printing helps reduce the duration of surgical operations, improve precision and personalise medicine by choosing the right therapies suitable for different genetic makeups of patients. However, this technology is not popularly known among public healthcare professionals in Makonde District. A senior midwife who mentioned this technology indicated that she had researched it before the interview, before which she was not aware of this technology. An experienced midwife (Respondent 10) stated:

> *"I have read about what they call **3D printing**. I haven't actually used any of these technologies, but I have read about the 3D printing that can be used in dental care, like for customizing a hearing aid and printing the epileptic medication."*

Robots

Respondent 10, a senior midwife, is the only one who claimed knowledge of robots as an emerging technology in healthcare. However, she indicated that she only knew of this technology while preparing for the interview. She stated that:

"I have also read about robots. They can also assist in monitoring patients in the absence of nurses and doctors. Patients with heart conditions can be monitored using the robots."

Drones

Drones are known for their usefulness in delivering medication and other essential supplies to hard-to-reach areas, such as disaster-stricken ones. However, Zimbabwe's public healthcare is not currently using them. The knowledge of this technology was through preparation for the interview. An experienced midwife (Respondent 10) said:

"Also, I have read about ***drones*** *that can be used to deliver medications in, for example, disaster-stricken areas, like what we had in Chimanimani with Cyclone Idai. If we had drones, we could bring medications and food items to those in need.*"

Virtual reality

Virtual reality helps manage post-traumatic disorders, as mentioned by one midwife. The midwife said:

"Yeah, I think we would use them because some of them are really important. For example, like I was saying, the ***virtual reality****, because children are really difficult to work with, especially like when they have experienced something traumatic. It keeps coming to their mind and they keep screaming even in their sleep. So If we had virtual reality, we could use it. And also, I have read about the virtual reality, which can also help manage patients who have experienced trauma, like post-traumatic disorders can be treated with this* ***virtual reality****. It is said to immerse patients in relaxing environments, such that all the anxiety, maybe about surgery, pre-surgery or post-surgery can be allayed*."

Integrated Management of Neonatal and Children Illnesses (IMNCI)

Public health institutions in Makonde District are using the integrated management of neonatal and childhood illnesses (IMNCI); hence, public healthcare professionals are aware of this system. However, the system does not provide information on how to manage neonates' health, unlike the Neotree. It uses the data captured by healthcare professionals.

6.4.1.2 Quantitative Findings on Knowledge of Emerging Technologies by Healthcare Professionals

A middle-aged, experienced midwife stated that there was generally poor knowledge of emerging technologies by public healthcare professionals in Makonde District, stating that she only knew about them while preparing for the interview. Findings from the quantitative phase appear to concur with the midwife as most of the respondents indicated that they did not know anything about artificial intelligence, the Internet of Things, telehealth, 3D printing, 5G technology, robotics and virtual reality, as depicted in Table 28. While the average values show that nearly 3 in every 4 healthcare professionals knew nothing about the emerging technologies considered and their application in paediatrics, this value was heavily diluted by the knowledge of social media, which had extremely favourable knowledge outcomes.

Table 28: Knowledge of Emerging Technology by Healthcare Professionals

Emerging Technology	Statement on knowledge	Count	% of Respondents
Artificial Intelligence	I do not know anything about it	68	75.6%
	I know about it but have never used it before	20	22.2%
	I have used it before	2	2.2%
Social Media	I do not know anything about it	1	1.1%
	I have used it before	89	98.9%
Telemedicine	I do not know anything about it	29	32.2%
	I know about it but have never used it before	44	48.9%
	I have used it before	17	18.9%
Internet of Things	I do not know anything about it	86	95.6%
	I know about it but have never used it before	3	3.3%
	I have used it before	1	1.1%
Knowledge of Telehealth	I do not know anything about it	86	95.6%
	I know about it but have never used it before	1	1.1%
	I have used it before	3	3.3%
3D Printing	I do not know anything about it	88	97.8%
	I know about it but have never used it before	2	2.2%
5G Technology	I do not know anything about it	86	95.6%
	I know about it but have never used it before	3	3.3%
	I have used it before	1	1.1%
Robotics	I do not know anything about it	88	97.8%
	I know about it but have never used it before	1	1.1%
	I have used it before	1	1.1%
Virtual Reality	I do not know anything about it	89	98.9%
	I know about it but have never used it before	1	1.1%
Average Values	**I do not know anything about it**		**76.69%**
	I know about it but have never used it before		**9.24%**
	I have used it before		**14.07%**

b. To what extent are healthcare professionals in Makonde District willing to adopt emerging technologies to reduce under-five mortality?

6.4.1.3 Qualitative Findings on Willingness of Healthcare Professionals to Adopt Emerging Technologies to Reduce Under-Five Mortality in Makonde

Table 29: Mapping Themes to Research Question 1 (b)

Respondent	**Theme**	**Sub-themes that emerged from respondents**	**Interview question(s)**
Public healthcare workers in Makonde District	Reasons for willingness to adopt emerging technologies	Diagnosis of complex cases	If emerging information technologies were to be introduced at your workplace to promote under-five children's health, would you use them? Why?
		remote monitoring	
		user-friendly	
		globalisation of technologies	

The willingness of public healthcare professionals in Makonde District to adopt emerging technologies

Public healthcare professionals in Makonde District are willing to adopt emerging technologies, provided they are user-friendly. This willingness emanates from their perceived usefulness of emerging technologies in helping diagnose complex cases and remotely monitor patients, and they would want to keep up with the world in digitising paediatrics.

Diagnosis of complex cases

It was revealed that diagnosing diseases in under-fives can sometimes be difficult, especially when the children cannot talk and there is inadequate equipment. There is only one public hospital in Makonde District, and it is the provincial hospital. The rest are clinics without doctors, meaning the diagnosis of diseases is made by nurses. Healthcare professionals are willing to adopt emerging technologies that can help them make correct diagnoses of diseases among under-fives. One doctor claimed that some deaths of under-fives in Makonde District are a result of lack of or incorrect diagnosis, and technology could address that. The respondent stated:

"They can also help us with diagnosis. Some of these under-fives die due to wrong or lack of diagnosis, something which can be minimised by using technology. Using technology would make our work easier"

The technology-assisted diagnosis was said to boost the confidence of nurses, knowing that they would have made the correct diagnosis. Moreover, with technology, nurses do not have to rely merely on asking patients to diagnose diseases.

Data Sharing

The ability to share patient data among healthcare professionals makes patient data readily available for diagnosis and prescriptions, as stated by a paediatrician from Chinhoyi Provincial Hospital. Moreover, they would want to use emerging technologies for record-keeping as using digital technologies was said to facilitate persistent storage of patient data unlike using papers that can easily get scattered or lost. Moreover, paper-based records make data sharing difficult as they require one to be physically present at the site of storage. With emerging technologies, healthcare professionals can access test results conducted on a child at different health facilities, helping them make informed diagnoses and prescriptions. Thus, the public healthcare professionals are willing to adopt emerging technologies to help them quickly access and share patient data among themselves to improve the treatment and care of under-fives.

Remote monitoring

Nurses in rural clinics expressed their willingness to adopt emerging technologies that can help them monitor the health status of under-fives remotely. There are under-fives with special conditions that require constant monitoring. Using technology like wristbands that can monitor their physiological parameters and notifying the nurses when any of them shows critical readings is one reason healthcare professionals are willing to adopt emerging technologies. Two nurses based at different rural clinics not far from Chinhoyi City stated that:

"It's very acceptable this side because we have other patients and caregivers who have under-fives with special conditions that require special attention, but they don't have access to facilities."

"We have experienced cases of parents who sometimes bring their babies thinking they have high body temperature when it's just the external temperature as a result of the

babies playing in the sun, and then we send them back home. Sometimes, the baby's temperature will be high and the parents might think it's just because of the sun, and they won't come and end up losing lives. So we would gladly accept that technology."

User-friendliness

Public healthcare professionals desire to adopt emerging technologies in paediatrics, provided such technologies are easy to use. Several nurses pointed out that they would need digital systems that are more user-friendly, unlike the recently deployed electronic health record that they deem unfriendly. They stated that the design of the current electronic health record lacks evidence of the involvement of healthcare professionals due to its unfriendliness. They also require thorough training on digital technology systems as some nurses stated they were not computer proficient.

Globalisation of technologies

The healthcare professionals who participated in this study are willing to move with the times and use technologies that are used in developed countries and elsewhere. While some public healthcare professionals did not know some of the emerging technologies in healthcare, they were willing to adopt any technologies that could help them improve their execution of duties. They would want access to the same technologies in developed countries to make technology use universal. One old nurse indicated that she was not computer proficient but would want to use any technologies that are used in developed countries. She said:

"We would like them because like now we are in the 21st Century, we should move with technology, whatever technologies are used in the developed countries should also be available locally. The management of illnesses should be universal, it must not be different from one region to another so using technology would achieve that. Technology will lessen this manual job of ours like using pens and books, so many books."

6.4.1.4 Quantitative Findings on Willingness of Healthcare Professionals to Adopt Emerging Technologies to Reduce Under-Five Mortality in Makonde

On a scale of 1 to 5, all the healthcare professionals who participated in this study picked 5 as their score for willingness to adopt emerging digital technologies if they are introduced to reduce under-five mortality, as shown in Table 30.

Table 30 :Willingness to Adopt Emerging Technologies to Reduce Under-Five Mortality in Makonde District

If emerging technologies were to be introduced in Makonde District to reduce under-5 mortality in public healthcare institutions, how likely are you to use them?				
	Frequency	Percent	Valid Percent	Cumulative Percent
Very Likely	90	100.0	100.0	100.0

The reasons given for the willingness to adopt emerging technologies were varied. Some respondents from the Chinhoyi Provincial Hospital indicated that they foresaw emerging technologies succeeding because of the facilitating conditions like ease access to networks, stable mobile phone network and availability of backup solar energy. While some would want to embrace technology for the sake of moving with the times, others are driven by the need to improve under-five health outcomes as they perceive emerging technologies as helpful in preventing omissions in patient care, providing accurate diagnosis and helping to easily collate patient data for analysis. Some of the healthcare professionals arguably value their patients the most judging by one of the nurses' response to a qualitative question on the questionnaire and stated that *"I am a nurse called to serve, so I'd accept anything that helps me save lives"*. However, some of the reasons to want to use emerging technologies arguably focus on the healthcare professionals than the patients. For example, some want to adopt emerging technologies because 'they reduce the workload and make work easier', reasons that appear not patient-centric.

Regardless of the expressed high willingness to adopt emerging technologies to reduce under-five mortality in Makonde District by public healthcare professionals, there are impediments that could potentially hinder the adoption of these technologies. Section 6.4.2 presents the facilitating conditions and factors that could affect the adoption of emerging technologies in the Makonde District.

6.4.2 Research Question 2: What factors are affecting the potential adoption of emerging technologies by public healthcare institutions to reduce under-five mortality in Makonde District?

a. What factors affect the potential adoption of emerging technologies for reducing under-five mortality by pregnant women and mothers of under-five children in Makonde District?

6.4.2.1 Qualitative Findings on Potential Factors Affecting the Adoption of Emerging Technologies by Mothers of Under-Fives in Makonde District

Table 31: Mapping Themes To Research Question 2(a)

Respondent	Theme	Sub-themes that emerged from respondents	Interview question(s)
Mothers of under-fives, Healthcare professionals, health information officers	Determinants of emerging technologies adoption by mothers of under-fives	Lack of incentives	What factors (both negative and positive) could potentially affect the adoption of emerging technologies for reducing U5M in Makonde District by pregnant women and mothers of under-five children?
		Unstable network	
		Lack of knowledge and computer literacy	
		Misinformation and misinterpretation	
		Lack of trust	
		Mobile phone ownership	
		Resistance to change	
		Religion and tradition-	

Factors affecting the potential adoption of emerging technologies by mothers of under-fives and pregnant women

Misinformation and misinterpretation

Oftentimes, there are individuals in communities who pretend to be enlightened and tend to mislead others. Examples of misinformation about COVID-19 vaccines were cited, and some healthcare professionals believe that misinformation could hinder the adoption of some emerging technologies by mothers of under-fives and pregnant women. Moreover, some women may prefer physical contact with healthcare professionals. It was noted that health education provided through social media might be misinterpreted.

Mobile phone ownership

Mobile phone ownership among mothers of under-fives is estimated to be as high as 90 per cent in some areas like Matoranjera, 85 per cent in Mutala, 70-80 per cent in Portlet, 70 per cent in Umboe, 50 per cent in Nyamugomba and 30 per cent in Doma. These figures were reported by the healthcare professionals working in those areas and also indicative of the stability of network connections in the areas. Areas like Matoranjera, Mutala and Portlet are close to Chinhoyi City; hence, they have relatively stable network connections. The high mobile phone ownership in some of these areas presents opportunities to introduce digital technologies like SMS-based applications.

Resistance to change

A shift to emerging technologies might face resistance from mothers of under-fives. During the introduction of the electronic health record in public healthcare institutions in Makonde District, some patients resisted the technology as they considered the technology slow and delaying them. This led to complaints against nurses to their superiors, asking them to abolish the technology. However, a specialist paediatrician argued that resistance is always expected, but education can minimise the resistance through behaviour change.

Religion and tradition

Religious leaders like prophets and church leaders are often blindly followed by their devout followers. If these church leaders utter negative sentiments towards the technologies, their followers will likely reject them, like what happened during the COVID-19 vaccinations where they claimed the spirit had said the vaccines were bad for them. Moreover, some areas in Makonde District like Matoranjera, have high populations of the Johanne Marange apostolic sect. These people completely reject medical assistance regardless of their babies' conditions as they solely believe in the healing by the 'spirit'. Such people are highly likely to reject emerging technologies. Moreover, traditional leaders like village heads might also utter negative sentiments that could negatively influence their followers to reject emerging technologies.

Lack of trust

Some people prefer physical interaction with healthcare professionals than using technology. Again, some of them do not trust the technologies and might think their information is being used for other purposes. Moreover, others might be less confident in the technologies' ability to deliver quality healthcare, making them reject the emerging technologies.

6.4.2.2 Quantitative Findings on Potential Factors Affecting the Adoption of Emerging Technologies by Mothers of Under-Fives in Makonde District

Ownership of Devices

Table 32: Devices Ownership Among Mothers of Under-Fives

Which of the following devices do you own?	Frequency	Percent
Smartphone	317	81.1%
Feature Phone	88	22.5%
Desktop	25	6.4%
Laptop	119	30.4%
Radio	107	27.4%
Television	213	54.5%
Tablet	39	10.0%
None	19	4.9%
Total	**391**	**100%**

Table 32 depicts that there is high smartphone ownership among the mothers of under-fives who participated in this study. Over half of the participants also indicated that they owned a functional television set, with a few owning tablets and desktop computers. 4.9 per cent of the respondents did not own any functional device at the time of data collection. The high ownership of these devices could present opportunities for technology adoption, such as conducting health education.

Willingness to Adopt Emerging Technologies

Table 33: Willingness by mothers of under-fives to adopt emerging technologies

Willingness of Mothers to Adopt Emerging Technologies			
If your clinic or hospital was to introduce emerging technologies to monitor and manage your under-five child/children's health, would you agree to use them?	Frequency	Percent	Cumulative Percent
No	21	5.4	5.4
Maybe	66	16.9	22.3
Yes	304	77.7	100.0
Total	**391**	**100.0**	

Almost 78 per cent of the respondents indicated that they would accept emerging technologies if their health facilities were to introduce them to monitor and manage their under-fives' health. It is noteworthy that almost 17 per cent were undecided, while 5.4 per cent indicated that they would certainly not adopt the technologies.

Network Stability

Table 34: Perceptions of Mothers of Under-Fives on Network Stability

Network Stability			
There is a stable phone network in my area	Frequency	Percent	Valid Percent
Strongly Disagree	9	2.3	2.3
Disagree	48	12.3	12.3
Neutral	62	15.9	15.9
Agree	183	46.8	46.8
Strongly Agree	89	22.8	22.8
Total	391	100.0	100.0

The deployment of emerging technology requires a stable network. 69.6 per cent of the mothers who participated in this study perceive the mobile phone network in Makonde District as stable, as shown in Table 34.

Observability and Trialability

Table 35: DOI Factors: Observability and Trialability

DOI Factors	Frequencies					
Observability	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	Agree+ Strongly Agree
I would use emerging technologies to monitor my child's health if I am shown the positive results such technologies have produced elsewhere	13	8	48	160	162	**322 (82.35%)**
Trialability						
I would adopt emerging technologies for under-five children's healthcare if I can be allowed to experiment with such technologies first	11	22	67	166	125	**291 (74.42%)**

Observability and triability are factors considered by mothers of under-fives in Makonde District, with 82.35 per cent and 74.42, respectively. Table 35 shows the findings related to observability and triability.

Affordability

Table 36: Affordability of Emerging Technologies

UTAUT Factors: Facilitating Conditions	Frequency					
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	**Agree + Strongly Agree**
I would adopt emerging technologies for under-five children's health if the technologies are cheaper or for free	16	17	32	97	229	**326 (83.38%)**

The mothers of under-fives would consider the cost of emerging technologies to them before considering adoption. Over 83 per cent of the respondents would consider if the technologies are free or cheaper.

Incentives

Table 37: Perceptions on Incentives for Emerging Technologies Adoption

Incentives for Technology Adoption	Frequencies					
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	**Strongly Agree+ Agree**
I would need an incentive (e.g. money, cooking oil, bar of soap, etc) for me to accept emerging technologies to be used by health workers on my under-5 child	129	144	44	34	40	**74 (18.93%)**

It emerged during interviews that parents would need to be incentivised to accept the use of emerging technologies on their under-fives. However, the findings in Table 37 reveal that most of the respondents would not need incentives to adopt technology that improves their under-fives' health and wellbeing.

Trust

Table 38: Trust in Technology Use to Monitor People's Health

Incentives for Technology Adoption	Frequencies					
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	**Strongly Agree+ Agree**
I trust the use of technology in monitoring people's health	13	50	118	153	57	**210 (53.71%)**

One of the factors that affect technology adoption in healthcare is lack of trust in it. Barely over 50 per cent of the respondents indicated that they trust the use of technology in monitoring people's health.

Willingness to Use Emerging Technologies for Doctors' Appointments

Table 39: Willingness to Use Emerging Technologies for Doctors' Appointments

	Frequencies					
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	**Strongly Agree + Agree**
I would use technology to book appointments with doctors if such technology is introduced	10	9	17	118	237	**355 (90.79%)**

There was a high willingness by respondents to adopt emerging technologies for making doctors' appointments for their under-fives, as shown in Table 39. This high willingness could positively affect the likelihood and success of the adoption of emerging technologies to promote the health and wellbeing of under-fives.

Influence of Friends and Relatives

The influence of friends and relatives on the intention to use emerging technologies among mothers of under-fives in Makonde District to promote the health and wellbeing of under-fives is notable, with nearly two in every three respondents agreeing and strongly agreeing, as shown in Table 40.

Table 40: Influence of friends and relatives on intention to use emerging technologies

	Frequencies					
	Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree	**Strongly Agree + Agree**
I would use emerging technologies to monitor my under-five child's health if my close friends and relatives are using them	22	20	91	205	53	**258 (65.98%)**

b. What factors affect the potential adoption of emerging technologies to reduce under-five mortality by public health professionals in Makonde District?

6.4.2.3 Qualitative Findings on Potential Factors Affecting the Adoption of Emerging Technologies by Public Healthcare Professionals in Makonde District

Table 41: Mapping Themes To Research Question 2(b)

Respondent	Theme	Sub-themes that emerged from respondents	Interview question(s)
Healthcare professionals, health information officers, DMO	Factors affecting emerging technologies adoption by healthcare professionals	Fear of medico-legal hazards	What factors (both negative and positive) could potentially affect the adoption of emerging technologies for reducing U5M in Makonde District by healthcare professionals? (Interview Guide Question)
		Policies	
		Resistance to change/ apathy	
		Patients' complaints	
		Computer literacy	
		Resource shortages (e.g. gadgets)	
		Lack of involvement	
		Lack of training	What do you consider the hindrances to the successful adoption of emerging information technologies to reduce U5M in Makonde District's public healthcare institutions? (Focus Group Discussion)
		Lack of knowledge	
		Demotivation	
		Network challenges	
		Lack of skilled manpower and understaffing	
		User-friendliness	
		Power supply	
		Cost of acquisition	
		National ICT Policy: has a positive impact as it emphasises bridging the digital divide and focuses on connecting rural areas. It supports digital healthcare innovations	How does the current national ICT policy impact on the potential introduction of emerging technologies in public healthcare institutions to enhance disease management, prevention and control among under-

			five children in Makonde District?
		MoHCC Policies: allow digital health research and digital health interventions. However, decision-making is centralised	What policies are in place to promote the use of emerging information technologies for promoting child health and well-being?

Factors affecting the potential adoption of emerging technologies by public healthcare professionals in the Makonde District

Fear of medico-legal hazards

Medico-legal hazards include giving the wrong dosage, the use of inappropriate medication, the failure to monitor treatment for side effects and toxicity, and the failure to provide the patient with important information. There is fear among some healthcare professionals that using emerging technologies could lead to medico-legal hazards being quickly identified by management, resulting in them being dismissed or sued. With papers, it was said that one could easily destroy the evidence of any unintentional malpractice, omission or errors, unlike with computers, where they would not know where the data got stored. One registered general nurse, Respondent 16, from Chinhoyi Provincial Hospital, had this to say:

> *"I think the other factor is, with health professionals, there is this fear of medico-legal hazards. The use of tablets, once recorded, the data is recorded forever, and you may be sued or barred from practice if you are found to be negligent by the Ministry because you did not observe the dos and don'ts. With papers, we can easily destroy the evidence, unlike with ICT. Because of that fear, the healthcare professionals might not want to use it because people might think they are being trapped. E.g. a pregnant mother might come in early in the morning, but due to understaffing, we might not be able to attend to them on time, but once you capture the data in the tablet, any of the management can access it, and it can then be used against us. In my opinion, I think it's wise to use emerging technologies, but maybe there must be dedicated people who capture patients' data in the tablet, especially in emergency wards, to allow those attending to emergencies not to waste time with documentation."*

However, healthcare professionals at clinics did not see eye to eye with this view. They argued that nurses at hospitals are not allowed to diagnose patients or prescribe medication as those are done by doctors only. Nonetheless, there are no doctors at clinics, meaning the nurses do everything, making them unafraid of the medico-legal hazards, lest they do not work at all. A nurse-in-charge at one of the clinics, Respondent 13, said that these are just excuses to justify resistance to change. She said:

> *"Yes, there is a certain percentage that has a resistance to change the mentality, but I think if one is fully and properly trained, there is no need to be afraid. If one is not sure about the treatment, one should just avoid making guesswork. There is no need to be afraid when one is trained. If you are someone who is afraid of medico-legal hazards, then you are not a nurse. As a real nurse, you will be proud of using this technology; it will help you."*

In a separate interview, Respondent 9, who is a nurse at another clinic, concurred with Respondent 13. She argued that destroying paper-based evidence might not save anyone since patients might take images of the prescription and share them with friends or relatives to help them buy the medication, in which case it will be enough evidence. She had this to say pertaining to the fear of medico-legal hazards as a deterrent to emerging technologies adoption by healthcare workers:

> *"I think it's 50:50 the chances because, at the end of the day, people are now educated, and there is technology. As much as one can destroy the record, what if someone had sent a picture to their relative or friend to buy the medication for them? That evidence will still remain, and no nurse will be able to go and delete it. So what I think is that if the technology is properly designed, the software should also help nurses by guiding them that the medication you have given a patient is not the right one for the given symptoms. But in any case, medico-legal hazards are part of our work; those are the ones we call errors of omission and commission. They would have happened but never was it our intention. Such things always happen. Sometimes I can treat a patient, and they die because of other underlying conditions. Tearing a book is not the solution because with phones these days, people can keep records. Moreover, nowadays, people are learned and can google the uses of the prescribed medication. It's better for us to help each other to minimise such wrong medications.*

As long as one was not negligent, I don't see anything wrong with using technology – there is no need to fear medico-legal hazards."

Resistance to change

Like any change, a shift to emerging technologies to reduce under-five mortality could face resistance from public healthcare professionals. "It might take time for some people to get on board. To some, using technology might seem like something out of their job description", according to one of the nurses (Respondent 15). Moreover, the resistance could emanate from fear of the unknown and ignorance. Resistance was encountered during the introduction of other digital technologies before and was perceived as a potential impediment if emerging technologies to improve the care, management and diagnosis of diseases among under-fives were to be introduced in Makonde District. The resistance is also fuelled by disgruntlement among public health professionals who are more inclined to reject anything since they are overwhelmed and frustrated.

Policies and Centralisation of decision-making

Public healthcare professionals in Makonde District are not aware of the specific Ministry of Health and Child Care policies regarding digital health. They could not really tell how the policies affected the introduction of emerging technologies. However, they pointed out that there are digital health systems in use in the district, including the DHIS-2, Neotree and the recently introduced electronic health record, suggesting that the policies do promote the use of digital technologies in healthcare.

However, digital technology policies are not made at a district or provincial level but at the national level. The central government makes the decisions and gives the green light regarding the introduction of digital technologies in public health institutions. Before any digital health technology is deployed, it is first introduced to the Secretary of Health and the Director of Information. These form technical working groups responsible for analysing the technology and whether it is ideal for the local environment. The recommendations of the technical working groups are presented to the Minister of Health and Child Care, followed by the signing of memoranda of understanding (MOUs) with the Minister of Health and Child Care and the Secretary of Health. Post the signing of MOUs, training of the head office staff begins and cascades down to the province and, finally, the district. The districts remain governed by the provincial and national levels. The centralisation of digital health decision-making makes it hard for districts to introduce digital technology interventions without the intervention of the central government.

Resource shortages (e.g. gadgets)

The under-resourcing of public healthcare institutions in the Makonde District was perceived as a potential impediment to the adoption of emerging technologies. The healthcare institutions are understaffed as some healthcare professionals are leaving the country for greener pastures. There is a shortage of ICT equipment; for instance, it was reported that departments share tablets to use for electronic health records. The sharing of gadgets means patient data cannot always be captured at the time of collection. As a result, nurses need to record the data on paper and then transfer them to the electronic health record system. This was viewed as a double entry and as making the already demotivated healthcare professionals shun the electronic health record as extra work. Thus, the adoption of emerging technologies was viewed as requiring sufficient funding to provide enough resources.

Lack of involvement

Public healthcare professionals in Makonde District decried their lack of involvement in digital technologies design and throughout the process. Their lack of involvement was perceived as contributing to the design of systems that are not friendly. They want to be involved from design throughout the entire process, not just to be trained on the use of the technologies. One nurse asked if the people who designed the electronic health record were healthcare professionals at all due to the way it is designed.

Lack of training

Several public healthcare professionals in Makonde District are computer illiterate. When digital technologies are introduced, they need to be trained over a period of at least two weeks. They indicated that they are not trained in using digital technologies at the nursing colleges; thus, they are not techno-savvy. They would want more time to understand these technologies. For instance, nurses were trained on the electronic health record for one week, and some considered it too short to grasp everything.

Lack of knowledge

Some healthcare professionals in Makonde District lack knowledge of the potential benefits of emerging technologies. The lack of knowledge is a source of resistance to change as such people will resist the emerging technologies. This was the case when Neotree was introduced at Chinhoyi Provincial Hospital. People rejected it due to a lack of knowledge, but after seeing others using it and its benefits, they later accepted the technology. Thus, knowledge inadequacy is a potential impediment to emerging technologies adoption to reduce the under-five mortality rate in Makonde District.

Demotivation

Public healthcare professionals in Makonde District are demoralised due to poor working conditions and inadequate remuneration. This is evidenced by many healthcare professionals leaving for other countries, and the few that are left are overwhelmed. They would resist using technology as they consider it an extra workload. One midwife said:

> *"Many healthcare professionals have left Makonde District for greener pastures, so a few that are left are overwhelmed, and I had said I don't want to say that they are frustrated, but they are just tired. Many public healthcare professionals in Makonde are tired, such that when you try to introduce new things, it's like you are further frustrating, boring and tiring them. They are no longer enthusiastic about anything, so that can be a hindrance. Also, some people are afraid of using these technologies."*

Network challenges

There are some areas in Makonde District that are so remote that the network is a problem. This would affect the adoption of emerging technologies in such areas. However, reports from the district indicated that about 70 per cent of the public healthcare institutions in Makonde District have internet access. Moreover, the government is working on ensuring that public healthcare institutions are connected. At Chinhoyi Provincial Hospital, for instance, they were working towards ensuring that the whole place had Wi-Fi coverage, and some offices had already been connected by the time of data collection. However, cases of network abuse were reported. Some of the employees were using the Wi-Fi for personal use, such as downloading and watching videos on YouTube, resulting in the network slowing down for legitimate uses. In clinics, the government is providing MiFi gadgets together with a monthly data allocation of 50GB. Nonetheless, this allocation is insufficient, as reported by some clinics.

Lack of skilled manpower and understaffing

Healthcare professionals complained about understaffing as a potential impediment, especially if the emerging technology requires data capturing. They cited the electronic health records system as an example and said they could not have time to capture patient data on a tablet in critical situations. Respondent 17, who works in a casualty department, had this to say:

> *"It may be a challenge due to different reasons. For example, in a labour ward or casualty department, you cannot enter patient data on a tablet because we would be having lots of pressure due to understaffing. You can't use a mobile device like a tablet when you want to monitor critical physiological parameters like foetal heart rate and the mother at the same time. You can't do it properly going back and forth using a tablet when the situation is critical".*

User-friendliness

User-friendliness is a potential factor that could negatively affect the adoption of emerging technologies to reduce under-five mortality rates in Makonde District's public healthcare institutions. There were several complaints about the electronic health record system. They complained that it was not user-friendly, frustrating them and the patients. They prefer user-friendly systems that process instructions quickly. Two registered general nurses from different clinics gave reference to the EHR system and said:

> *"We have had many complaints from patients because the system is not user-friendly. It asks too many questions; it locks and freezes, so you will take about 45 minutes with one patient. So it's important to explain to the patients that you are using the tablet because it's a requirement, but it should be improved to take minimal time. We are understaffed, so it should not take too long".*

Another nurse-in-charge also expressed their frustration with the unfriendliness of the EHR as he emphasised the need to have friendly digital systems. He said:

> *"At the same time, our experience with the EHR is bad, it's not user-friendly, and it's also slow. For example, suppose an under-five child has come to the clinic; the EHR can start showing me information about the mother and her history of pregnancies and other children before it shows the information about the current baby that we are focusing on, so it's not user friendly. We need systems that are user-friendly. We need a way of directly searching for records of the current under-five. It takes us long, and clients will be angry; they might even beat us because of the long time it takes. We haven't faced problems of patients thinking that we are on WhatsApp when using the tablets because we sensitised them before. For instance, on average, I serve about 80 patients per day, and it takes about 30 minutes to deal with only one patient because*

of the slow speed of the tablet. Patients start complaining that this technology delays them, and considering the long distances they walk, they will be upset."

Power supply

Some clinics in Makonde District do not have electricity, for instance, Nyamugomba clinic. The clinic was using solar energy, but it developed a fault in 2021 and had not been fixed. It destroyed the batteries, inverter and charging control. They only had two working solar panels that they bought using the clinic's results-based financing (RBF) funds. Though they were working with the Zimbabwe Electricity Supply Authority (ZESA) to electrify the clinic, they still needed solar panels as backup power. Even at those clinics with electricity supply, it is unreliable due to load shedding. However, some sites, like Chinhoyi Provincial Hospital, have solar panels for backup. The problem was when these solar systems malfunctioned, it took too long to fix them.

Cost of acquisition, resource shortages and lack of funding

The cost of acquiring, maintaining and sustaining emerging technologies at every public healthcare institution in Makonde District was perceived to be higher than what the government could afford. Moreover, the training costs were also viewed as a potential impediment due to the underfunding of healthcare institutions by the government. Due to underfunding, public healthcare institutions are under-resourced. However, as mentioned by the participants, Zimbabwe's healthcare is usually funded by donors.

National ICT Policy

The national ICT policy is regarded as having a positive impact on the potential adoption of emerging technologies to promote under-five healthcare. It emphasises bridging the digital divide and focuses on connecting rural areas as well as supporting digital health innovations.

Unreliable network

There are some areas where the network is a challenge. However, 70 per cent of the public clinics in Makonde District have a fairly stable mobile network. In addition, the healthcare institutions received MiFi gadgets for internet access. The government is working to improve connectivity in public healthcare institutions to ensure that the recently-launched electronic health record succeeds. Other emerging technologies can ride on that success as connectivity improves.

6.4.2.4 Quantitative Findings on Potential Factors Affecting the Adoption of Emerging Technologies by Public Healthcare Professionals in Makonde District

Devices Provided at Work

The healthcare professionals in Makonde District's public health institutions have high access to tablets, with the results showing that about nine in every ten healthcare professionals have access to a tablet at work. The high access to tablets could be attributed to the district's rolling out of the electronic health record in late 2021, for which tablets were provided to facilitate the capturing of patients' data. However, the rolling out of the electronic health record was in a phased manner as some health facilities did not have the required conditions, such as electricity supply, for the successful deployment of the technology. Figure 18 shows the distribution of access to desktop computers and tablets by public healthcare professionals at work. Reports from the District Medical Officer's office indicated that about 70 per cent of the public healthcare facilities in Makonde district have access to a stable mobile phone network and internet. The introduction of the electronic health record system has seen health facilities provided with tablets and monthly data bundles. These could be enabling conditions for the deployment of emerging technologies to reduce under-five mortality and improve under-five health outcomes.

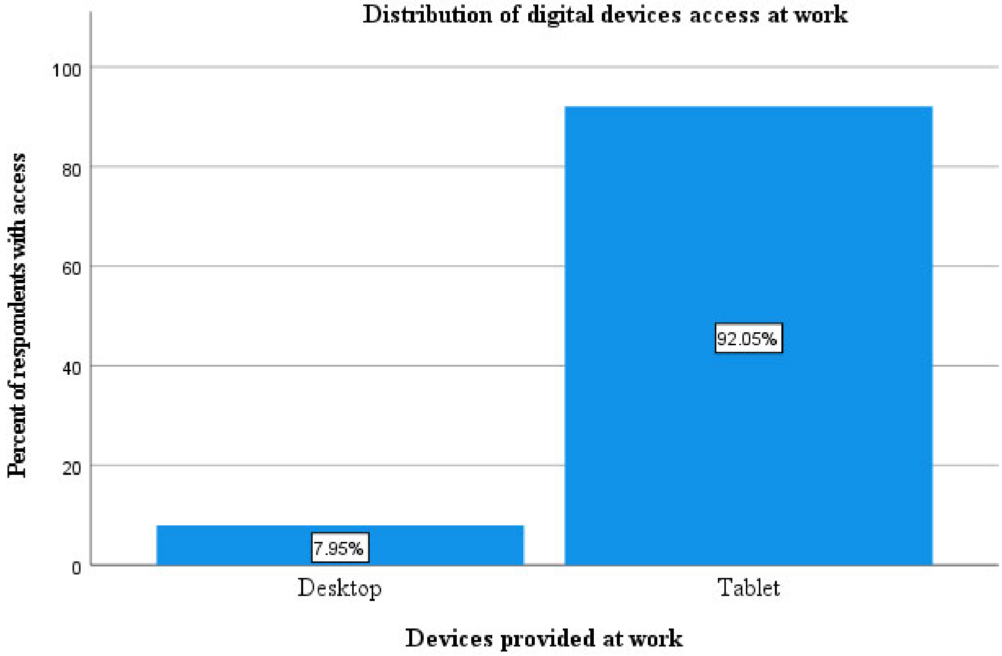

Figure 18: Access to digital devices at work by healthcare professional

Personal Devices Ownership

The devices owned by healthcare professionals who participated in this study include feature phones, smartphones, laptops and desktop computers, as depicted in Figure 19. Smartphones were the commonest owned gadget. The high mobile phone ownership could provide a fertile ground for ubiquitous access to healthcare information systems by healthcare professionals.

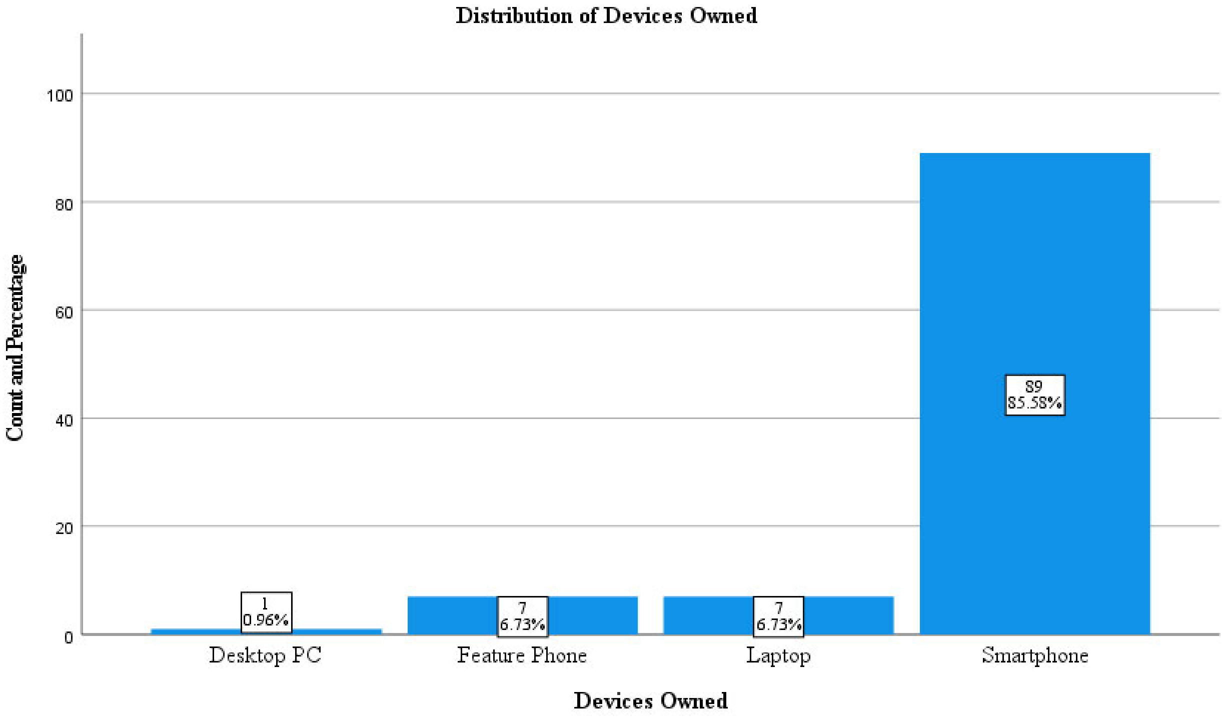

Figure 19: Distribution of Device Ownership Among Respondents - Healthcare Professionals

The UTAUT model, being one of the constituent theories of this study's theoretical framework, was used to explore potential factors that affect the adoption of emerging technologies to reduce under-five mortality in Makonde District's public healthcare institutions. These factors are grouped into facilitating conditions, effort expectancy and performance expectancy. Table 42 summarises the findings relating to facilitating conditions.

Table 42: UTAUT Factors : Facilitating Conditions

UTAUT Factors: Facilitating Conditions	Frequencies						
	Strongly Disagree	Disagree	I am not sure	Agree	Strongly Agree	Agree+Strongly Agree	Rank

I would use emerging technologies to deliver healthcare to under-fives in Makonde if the technologies ensure confidentiality and privacy of patient data	0	0	1	11	78	**98.89%**	**2**
The policies of my organisation support the use of emerging technologies to deliver healthcare to under-fives	0	0	0	90	0	**100.00%**	**1**
The national legislation supports the use of emerging technologies to deliver healthcare to under-fives	0	0	78	12	0	**13.33%**	**7**
Affordability plays an important role in the potential adoption of emerging technologies to reduce under-five mortality (U5M) in Makonde District	0	0	3	1	86	**96.67%**	**3**
The required infrastructure (e.g. computers, networks, mobile phones) to support the deployment of emerging technologies is available in Makonde District's public healthcare institutions	0	9	0	50	31	**90.00%**	**4**
The ICT infrastructure available in Makonde District's public healthcare institutions is reliable	0	6	60	24	0	**26.67%**	**6**
There are enough mobile phones in Makonde District to support the deployment of emerging technologies to support healthcare delivery to under-fives	0	11	18	61	0	**67.78%**	**5**

Confidentiality

Whether digital technologies ensure the confidentiality of patients' data was one of the highly regarded factors in determining the intention to use emerging technologies to reduce under-five mortality in Makonde District's public healthcare institutions. 98.89 per cent of the respondents indicated that they would consider confidentiality as a factor.

Organisational Policies

All the respondents indicated that the policies of the Ministry of Health and Child Care promote the use of emerging technologies to reduce under-five mortality. However, there appeared to be some doubt as none of the respondents strongly agreed.

National Legislation

Legislative frameworks are important in guiding digital innovations. The majority of the respondents were unsure how the national legislation affects the potential introduction of emerging technologies to improve under-five health outcomes. Only 13.33 per cent of the respondents viewed the national legislation as promoting the use of emerging technologies to reduce under-five mortality in Zimbabwe.

Affordability

Affordability of emerging technologies was highly ranked amongst the respondents as a determinant of the intention to use technology to reduce under-five mortality in the Makonde District. Nearly 97 per cent of the respondents considered affordability as a factor.

ICT infrastructure Availability and Reliability

While 90 per cent of the healthcare professionals thought that the ICT infrastructure to support emerging technologies deployment was there, only 26.67 per cent considered such infrastructure reliable. At the time of data collection, Makonde District was introducing the electronic health record and providing tablets and the necessary infrastructure for the success of the technology. The provision of these tablets might arguably have influenced the respondents' views on infrastructure availability.

Table 43: UTAUT Factors: Performance Expectancy

UTAUT Factors: Performance Expectancy	Frequencies						**Rank**
	Strongly Disagree	Disagree	I am not sure	Agree	Strongly Agree	Agree + Strongly Agree	
I would use emerging technologies if they improve my efficiency in doing my work	0	0	12	11	67	**78 (86.67%)**	**4**

I would use emerging technologies if they enable me to reach a wider audience	0	0	6	36	48	**84 (93.33%)**	**2**
I would use emerging technologies if they improve my service's quality	5	0	5	25	55	**80 (88.89%)**	**3**
I would use emerging technologies if they automate the diagnosis of diseases in patients	0	6	11	37	36	**73 (81.11%)**	**5**
I would use emerging technologies if they diagnose diseases accurately	0	0	5	19	66	**85 (94.44%)**	**1**

To improve the study's validity, the researcher also used data from the Zimbabwe Multiple Indicator Cluster Survey (MICS) report of 2019. **Table 44** shows the results of electronic gadgets ownership among Mashonaland West residents, as obtained from the MICS 2019 dataset. These gadgets fall under facilitating conditions of the UTAUT model, which is one of the constituent theories in this study's theoretical framework.

Table 44: Findings from the 2019 MICS report on ownership of radios, TVs and mobile phones and religious affiliations of mothers of under-fives in Mashonaland West Province

Variable		Region: Mashonaland West Province Frequencies (N=2 437) Count	Per cent (%)
household has: radio	No	1224	50.23
	Yes	1122	**46.04**
	not a dejure resident	91	3.73
household has: television	No	1291	52.97
	yes	1055	**43.29**
	not a dejure resident	91	3.73
owns a mobile telephone	no	817	33.52
	yes	1620	**66.48**
Religion	traditional	0	0.00
	roman catholic	115	4.72
	protestant	372	15.26
	Pentecostal	573	23.51
	apostolic sect	1102	**45.22**
	other Christian	79	3.24
	Muslim	16	0.66
	None	180	7.39

	Other	0	0.00

c. Which emerging technologies in healthcare are currently available in Zimbabwe?

Table 45: Mapping Themes To Research Question 2(c)

Respondent	**Theme**	**Sub-themes that emerged from respondents**	**Interview question(s)**
DMO, Health Information Officer, Healthcare professionals	Emerging healthcare technologies in Zimbabwe	DHIS-2	Please state any emerging digital technologies that are being used in public healthcare in Zimbabwe.
		EHR	
		Neotree	
		Integrated Management of Neonatal and Child Illnesses	
		ePMS	
		eLMIS	
		CCTVs	
	Emerging technologies for under-fives in Makonde District	Mhuri/imuli	State any digital technologies that are used in Makonde District"s public health institutions to promote the health of, manage and diagnose diseases in, under-five children?
		weekly disease surveillance (WDS) using SMS	
		ePMS	
		Neotree	

Current emerging technologies in Zimbabwe's public healthcare institutions

Several digital technologies exist in Zimbabwe's public healthcare institutions. These include the district health information system 2 (DHIS-2), electronic health record (EHR), Neotree, integrated management of neonatal and childhood illnesses (IMNCI), electronic patient management system (ePMS), electronic logistics management information system (eLMIS), closed-circuit televisions (CCTVs), mhuri/imuli and weekly disease surveillance (WDS) using SMS. Some of these systems are not solely meant for paediatric use but across the spectrum, such as the DHIS-2, EHR, ePMS and CCTVs. Some hospitals are using CCTVs to monitor patients in the isolation ward. Patients can communicate with visitors via video intercom.

6.4.3 Research Question 3: What potential role can emerging technologies play in reducing under-five mortality in Makonde District?

a. What is the perceived contribution of emerging technologies in disease prevention among under-five children in the Makonde District?

Table 46: Mapping Themes To Research Question 3 (a)

Respondent(s)	Theme	Sub-themes that emerged from respondents	Interview question(s)
Public healthcare professionals, DMO	Perceived contribution of emerging technologies in disease prevention	Tracking unimmunised children	What role do you think emerging information technologies can play in disease prevention among under-five children in Makonde District? (interview question) What contribution could emerging technologies make towards disease prevention among under-fives in Makonde District? (focus group question)
		Early disease trends detection	
		Easy communication	
		Health education	
		Behaviour change	
		Surveillance and real-time reporting	

Table 46 maps the themes to research question 39(a), indicating the alignment between the two. It shows the respondents, theme, subthemes, and the interview questions asked.

6.4.3.1 Perceived contribution of emerging technologies in disease prevention among under-fives in Makonde

Health education

Emerging technologies could be used to provide health education to mothers and guardians of under-fives. Educational information on how to prevent diseases among under-fives, the importance and duration of exclusive breastfeeding, immunisation and early treatment seeking could be easily spread from genuine and trustworthy sources through emerging technologies. Mass media like electronic billboards, social media, television and radios can help educate people on disease prevention, hygiene, the importance of seeking early treatment and ensuring their babies get immunised. A registered general nurse at a satellite clinic (Respondent 11) argued that health education could help reduce under-five mortality in Makonde District:

> *"If the mother is knowledgeable of the diseases that their under-fives are susceptible to, and the effects of not getting early treatment for their under-fives, like delayed treatment of measles can lead to blindness. If mothers are educated and adhere to health advice and expectations, it can reduce the under-five mortality in Makonde as a parent would seek early treatment of their children's diseases."*

With these technologies, healthcare professionals can stress the importance of boiling drinking water before giving it to babies, cooking food thoroughly and serving it while it is still hot to prevent diarrhoea among under-fives. Some parents use unscientific home remedies, which may worsen the babies' conditions. One paediatrician (Respondent 10) had this to say:

> *"We can also use mass media to give health education to people who are in remote areas, using, for example, the radio. Some may not have access to TV, but the radio at least it's the easiest anyone can get. So we can give health education on these mass media or social media to teach mothers about the prevention of diseases, such that their children, for example, we can teach them about hygiene – to boil water before giving it to their babies, to cook their food thoroughly, and to serve the food while still hot so that they prevent diarrhoeal diseases in their children. This can help save the lives of under-fives. We can also give information, for example, to vaccinate children against diseases. This will help us in disease prevention in the under-five because once they get vaccinated against such diseases, they won't suffer from them. Even if they would suffer from them, it won't be as bad as if they were not vaccinated. We can even give health information about what to do against certain conditions. For example, we have cases of burns. Children can be burnt, and when they are burnt, people start applying anything, like cow dung, on these wounds and by the time the children come for medical help, they will be already infected. So we can give information on basic red cross knowledge on how to handle such conditions so that when the children finally visit the hospital, they will be manageable. I think that will help save children's lives."*

Electronic billboards could provide visual health education, like how to manage certain minor conditions, how to make homes and the environment clean, how to stop mosquito breeding sites and the benefits of family planning. However, these electronic billboards should be strategically positioned. "They need to be placed in places where people queue up for some services because you found out that when people are queuing, they end up not having anything to do and will be checking around whatever is around them", suggested an experienced midwife (Respondent 10).

Behaviour change

Emerging technologies could help change the minds of those mothers and/or guardians of under-fives with poor health-seeking behaviours. They could help people appreciate the importance of seeking medical help early. For instance, watching television advertisements and educational videos on disease outbreaks, negative impact, prevention and control of diseased under-fives could change peoples' behaviours for the better, leading to reduced diseases among under-fives.

Tracking unimmunised children

Tracking the immunisation statuses of under-fives is a challenge faced by public healthcare institutions in Makonde District. Using hard copy records makes it difficult to quickly generate reports of who is due for what immunisation at any specific time. Moreover, it is difficult for them to identify defaulters quickly. The respondents stated that immunisation is crucial in preventing diseases among children, and those who miss it will be susceptible to diseases and infections. Emerging technologies were viewed as helpful in keeping track of who is yet to receive what immunisation, making it easier for them to ensure every eligible child gets the necessary vaccines.

Early disease trends detection

Detecting disease trends and identifying outbreaks would help take preventive and precautionary measures. Healthcare professionals viewed emerging technologies as useful in detecting disease trends on time.

Surveillance and real-time reporting

Surveillance and real-time reporting of disease outbreaks were said to be critical components of disease prevention. At the time of data collection, public healthcare institutions were using SMSs to report on diseases weekly (Weekly Disease Surveillance System). However, the respondents argued that real-time surveillance and reporting would be more effective than weekly reporting. A doctor from Chinhoyi Provincial who is interested in big data analytics mentioned that real-time surveillance and reporting would quickly show the distribution and concentration of disease outbreaks, making it easier to prioritise and make timely interventions.

b. What is the perceived contribution of emerging technologies in managing diseases among under-five children in the Makonde District?

6.4.3.2 Perceived contribution of emerging technologies in managing diseases among under-fives in Makonde District

Table 47: Mapping Themes To Research Question 3 (b)

Respondent	**Theme**	**Sub-themes that emerged from respondents**	**Interview/focus group question(s)**
Healthcare professionals, DMO	Perceived contribution of emerging technologies in managing diseases among under-five children	Managing complicated conditions	What is your perceived contribution of emerging technologies in managing diseases among under-five children in the Makonde District?
		Early disease diagnosis	
		Growth and health status monitoring	
		Information provision	
		Data availability	
		Health education	
		Continuity of care	
		Reminders and patient tracking	
		Skills development	
		Treatment and surveillance	

Managing complicated conditions

It was noted that some of the under-fives cannot talk to tell their symptoms, which could help determine the appropriate methods to deal with the ailments. Moreover, all the clinics in Makonde District do not have resident doctors as all the doctors are stationed at the provincial hospital. The unavailability of doctors at clinics means if the nurses fail to manage and treat a condition, they refer the patients to the provincial hospital. However, the time it takes to get to the nearest referral hospital is usually long due to bad roads and transport problems. As a result, some under-fives die due to delayed access to medical services. With emerging technologies, the respondents believed nurses could quickly and remotely get assistance from specialists stationed not only at the provincial hospital but even beyond. This would reduce the number of referrals to the provincial hospital, help nurses manage complicated conditions and save lives.

Early disease diagnosis

An experienced paediatrician indicated that the basic management of under-fives requires timely interventions whenever they are sick. "*They need to be attended to early because the moment there is a delay, then we are likely to lose the babies*", said the paediatrician. Consequently, early diagnosis of diseases among under-fives is key in ensuring timely medical interventions. The paediatrician stated that technology could help parents get medical advice remotely from physicians without having to walk long distances to the nearest health facility, especially for minor problems. Moreover, Makonde District clinics were said to be understaffed with a lack of access to doctors and specialists except at the provincial hospital. With technology, the respondents indicated that nurses could get remote assistance from specialists on what the problem could be, thus helping diagnose diseases early.

Growth and health status monitoring

Emerging technologies could help monitor the growth and health status of under-fives, helping to identify challenges and anomalies early enough to improve the management of such children. Generating growth reports is relatively easier using technologies.

Information provision

Emerging technologies were perceived as being useful in providing information upon which healthcare institutions could base their decisions and inform their disease management strategies. Moreover, the technologies could help provide current information to healthcare professionals, such as new behaviour of certain pathogens and diseases and how to manage them.

Health education and Skills development

Managing diseases among under-fives happens in and out of healthcare facilities. For under-fives with special conditions, their parents and guardians would need to be educated on how to manage the conditions at home. One paediatrician (Respondent 10) stated that a lack of knowledge on how to manage certain conditions could worsen the babies before they get medical help. A senior and experienced midwife concisely explained a typical potential role of emerging technologies in Makonde District by saying:

> *"As I said, some women bring babies with collapsed veins such that you cannot put intravenous (IV) lines to the babies, and we will end up losing the babies. So with technology, they can bring the baby to a better state, and we can save lives. They can be taught how to manage certain conditions, or maybe there can be an app that they can refer to".*

Moreover, participants from rural healthcare facilities expatiated on the possibilities of healthcare professionals virtually attending training on how to manage new conditions for under-fives without having to leave their workstations. They claimed that some of the clinics are in remote areas, making them understaffed as professionals shun them. Allowing nurses to travel for training would worsen the staff shortages since even if the training would be for an hour or so, travelling from the clinics to Chinhoyi would take longer due to bad roads and terrains. Remote training sessions would allow nurses to be immediately available to their patients soon after the training.

Data availability

Availability of, and ease of access to, patients' data was viewed as potentially helping with providing appropriate and personalised care to under-fives in Makonde District. Moreover, a paediatric cardiologist from Chinhoyi Provincial Hospital stated that with more patient data available, big data analytics could be performed to learn new trends and inform disease management methods.

Continuity of care

Emerging technologies were perceived to promote continuity of care for under-fives, facilitated by the availability of patient data. Once captured, the data would be easier to share and access among healthcare professionals. Easy access to a patient's treatment history would enable continuity of care, rather than when using paper-based records that can easily be torn or lost.

Reminders and patient tracking

Some respondents stated that emerging technologies would help manage diseases among under-fives in Makonde District by sending reminders and tracking patients. If an under-five patient is due for review, emerging technologies could identify them and alert the mothers and healthcare professionals, helping reduce loss-to-follow-ups. Patients could also be tracked, and their health statuses continuously monitored using emerging technologies.

Treatment and surveillance

Technology-assisted treatment and surveillance were also perceived as useful in improving disease management among under-fives. Surveillance would help remotely and continuously monitor under-fives with special conditions.

c. What is the perceived contribution of emerging technologies in improving healthcare quality for under-five children in the Makonde District?

6.4.3.3 Perceived contribution of emerging technologies in improving the quality of care for under-fives in Makonde District

Table 48: Mapping Themes To Research Question 3(c)

Respondent(s)	Theme	Sub-themes that emerged from respondents	Interview question(s)
Healthcare professionals, DMO	Perceived contribution of emerging technologies in improving healthcare quality for under-five children	Technology-assisted treatment	What is your perceived contribution of emerging technologies in improving the quality of healthcare for under-five children in the Makonde District?
		Quick delivery of critical supplies (Drones)	
		Data availability (easy access to patient data)	
		Disease diagnosis	
		Drug supply management (e.g. real-time monitoring of drug stock levels)	
		Increased efficiency	
		Information dissemination	
		Minimal loss to follow-up	
		Minimise the effect of staff shortages	
		Promote continuity of care	
		Remote specialists consultation	
		Skills development	
		Appointments	
		Resource management	

Table 48 maps the emerged subthemes to the research question, respondents, theme and interview questions, while each of the themes is explained below.

Technology-assisted treatment

One nurse indicated that technology-assisted treatment could improve the quality of care for under-fives in the Makonde District. They perceived emerging technology to reduce the chances of wrong treatment.

Quick delivery of critical medical supplies

While some of the clinics are not very far from town, the roads are bad. A nurse stationed at Nyamugomba clinic, 38 kilometres from Chinhoyi, said that the road network is dilapidated, with two bridges near collapse, making it hard for them to get critical medication frequently. Another nurse at a clinic 48 kilometres from Chinhoyi said that because of the poor state of the roads, it would take them close to 3 hours from Umboe clinic to Chinhoyi Provincial Hospital. These challenges were associated with some under-fives dying due to delayed access to medication because even if they referred them to the nearest referral hospital, it would take a long time before getting there. Resultantly, the healthcare professionals believed that using drone technology to deliver medication could help save lives and improve the quality of services offered at clinics. Some nurses argued that if drones were used to provide essentials and rescue efforts in the Manicaland Province after the cyclone Idai disaster, they could also be used to deliver essential medical supplies to hard-to-reach clinics in Makonde District.

Disease diagnosis

Artificial intelligence (AI) was perceived to reduce misdiagnoses by both nurses and doctors, helping them make good judgements and manage patients. Improving diagnosis would reduce human errors. One midwife stated that some surgeries done on patients are preventable. She had this to say:

> *"Also, quality of care, for example, artificial intelligence helps healthcare professionals, including doctors, to make good judgments and manage patients without risking them. That improves the quality of care. We won't have problems of misdiagnosis and mismanagement of patients because the doctors will be consulting this artificial intelligence for better judgment, and it reduces human error and the risk of preventable surgeries. Sometimes surgeries are done on patients on whom they*

were not supposed to be done, so using artificial intelligence assists in the quality of care that a patient can get".

The same midwife also stated that emerging technologies like 3D printing could help provide personalised paediatrics. She said: *"The quality of care, like I was talking about the 3D printing, like I was saying it helps in the prosthetics and transplant, customizing hearing aids – that can be beneficial."*

Resource management

Managing resources required to reduce under-five mortality was indicated as critical. For instance, there are drugs that would be needed by healthcare institutions to manage certain conditions to reduce under-five mortality, but they are not always available. A primary care nurse from one clinic stressed the need to have emerging technologies that can check for drug stock levels every time they dispense medication and inform the relevant authorities about the re-stocking status. Nurses at clinics mentioned that they receive drug consignments quarterly. Even if some essential medicines run out of stock, they will have to wait for the next consignment and meanwhile, they will be asking parents to go buy medicines from the pharmacies in Chinhoyi. Because most of the parents will not have the money, they will not go buy the medicines, leading to the babies' conditions worsening.

Moreover, the distribution of drugs to the clinics is not based on data and demand, resulting in some clinics getting drugs that they already have and insufficient quantities for the drugs they need more. Emerging technologies could help provide insights on drug demands, provide real-time monitoring of stock levels and inform the district, provincial and national pharmacies on which drugs are used more at different sites. The data-driven pharmacy management would help respond to demands when distributing medical essentials.

Increased efficiency

The participants stated that using emerging technologies would reduce the queuing times of under-five patients at healthcare institutions. They said the technology would improve their efficiency and cut costs. Moreover, they said that if telemedicine could be introduced to connect clinics to the provincial hospital, it would help reduce the number of referrals since specialists could remotely diagnose under-fives and prescribe medication which the nurses could then dispense for free, as is the government's policy to offer free health services to under-fives.

Data availability (easy access to patient data)

Public healthcare institutions in Makonde District were introducing the electronic health record system at the time of data collection for this study. The system's deployment started around November 2021 and was still ongoing, with some clinics yet to have it. The respondents expected this technology to improve data availability, helping in providing effective care to under-five patients.

Information dissemination

Emerging technologies were perceived as helping to easily disseminate information among healthcare institutions, healthcare professionals and patients. The respondents said ease of information access among healthcare professionals could improve service quality. One midwife said using emerging technology could help share notes among healthcare professionals, resulting in improved diagnosis and quality of care.

Minimal loss to follow-up (Quick identification of defaulters)

Nurses indicated that some women in rural areas are illiterate and not able to read dates written on their babies' health cards. Some are literate but forget important dates that they should visit health facilities, resulting in some under-fives missing important vaccinations. The nurses said that emerging technologies would help remind them of babies who would have defaulted on immunisations to help them make a follow-up. A paediatric specialist from Chinhoyi Provincial Hospital had this to say:

> *"Okay, so in terms of emerging technologies, of course, they have a great and immense contribution in terms of improving the quality of care for under-fives in Makonde District. What I mean by this is that there is what we call "loss to follow-up", but with databases and emerging technologies, there will not be any loss to follow-up. I think it would be easier for us to pick defaulters; for example, I told you of the osteogenesis imperfecta (OI) clinic. So everything is input into the database; there is no loss to follow-up, really, because it will be easy to pick defaulters, you know, just like a phone call away. So I think it's got an immense contribution. The main reason is that there is no loss to follow-up. So I think that's one thing that I really like about emerging information technology in terms of managing and improving the quality of care. Yeah, loss to follow-up is minimum."*

Similar sentiments were echoed by a nurse at one of the satellite clinics, who said:

"Suppose we have a system that reminds us of when a baby was born and when they are due for critical vaccinations, we can easily follow up on the under-fives because some mothers forget these important dates, while others are unable to read. So if we can have a system that reminds us, it will be easier for us to make follow-ups on defaulters, but as nurses, we have lots of work and can't keep track of these children manually. Such a system will be helpful."

Minimise the effect of staff shortages

They could minimise the effect of specialist staff shortages by providing systems that can advise nurses on how to handle certain cases. For instance, at Chinhoyi Provincial Hospital, there is a system called Neotree that is used to manage neonates. All healthcare professionals do is enter patient data like weight, temperature and symptoms, and the system tells the nurses how to manage the condition and treat the neonates. Such technologies could reduce the impact of specialists' shortages.

Remote specialists' consultation

With no doctors at clinics, nurses often refer patients to the nearest referral hospital for cases they find difficult to handle. However, bad roads and parents' failure to afford to go to Chinhoyi result in them just staying at home even after the referral. With remote consultations using teleconsultation, the nurses believed that it would help improve the quality of care without patients having to travel.

Skills development

Remote training of healthcare professionals would improve their skills and improve the quality of care. They can learn how to handle certain conditions that could be newer, improving their skills. Community (village) health workers could also benefit from the training.

6.4.3.4 Findings on What needs to be done for emerging technologies to be adopted in Makonde District's public health institutions to reduce U5M

d. What needs to be done for emerging technologies to be adopted in Makonde District's public health institutions to reduce U5M?

Table 49: Mapping Themes To Research Question 3(d)

Respondent	**Theme**	**Sub-themes that emerged from respondents**	**Interview question(s)**
Health Information Officers, Healthcare Professionals, DHO	Strategies to promote the adoption of emerging technologies to promote the health and well-being of under-fives in Makonde District	Community and health workers' involvement (get community buy-in, involve health workers in design)	What do you think needs to be done for emerging technologies to be adopted in Makonde District's public health institutions to reduce U5M?
		Demystify audits	
		Show positive cases from places where technology yielded good results	
		Provide backup power (solar energy)	
		Automation of drug supply management	
		Change of mindset	
		Communication	
		Computer literacy policy	
		Continued use of technology	
		Design user-friendly systems	
		Educate policy-makers	
		Education	
		Effective funding	
		Erecting more base stations and use of satellite	
		Incentives (incentivise patients)	
		Post-installation support (maintenance and troubleshooting)	
		Rope in influencers	
		Provision of resources	
		Spearheaders	
		Staff motivation	
		Training	
		Incentivise parents	

Regardless of the findings showing that most of the respondents were willing to adopt emerging technologies to reduce under-five mortality, it was revealed that there are also impediments to the adoption. Moreover, emerging technologies that seek to reduce under-five mortality are yet to be introduced in public healthcare institutions in Makonde District; hence, the question of what needs to be done for them to be introduced should be answered. Table 49 shows the subthemes to answer that question.

Inform policy-makers

Some participants argued that the policy-makers need to be pro-technology for some of these emerging technologies to be introduced. They said most of the policy-makers are old people with little knowledge about technology, nor are they aware of the potential role emerging technologies could play in improving the health, care and well-being of under-fives. A health information officer (Respondent 4) made an interesting comment about informing policy-makers:

> *"In my own view, giving someone information will help. So, first of all, it's the top-down approach. When the top understands the need for technology in this global age, they will cascade it down. The policy-makers have to have knowledge about these technologies. Most of them were born before computers. So they need to understand that computers are here to stay. I have heard some people saying that nothing will ever replace paper, yet they are using emails in place of letters. So we need education and to have young blood among policymakers, those who know about these technologies. Especially in the medical field, they need specialists in information technology who know about technologies. One of the major things is to educate the policymakers. When they get educated, they will cascade down the education, and you will see everyone adopting technology."*

Demystify the purpose of audits

Some healthcare professionals said they could not accept the technologies for fear of medico-legal hazards. A senior registered general nurse from Chinhoyi Provincial Hospital stated that healthcare professionals could resist emerging technologies because it would be impossible for them to destroy the evidence should they make a wrong diagnosis or give a patient the wrong medication that would worsen their condition or even die. If the records were on papers, they said they could simply go to the health facility and destroy the evidence, evading the medico-legal hazards. However, some argued that medico-legal hazards are part and parcel of their job and that destroying the evidence would not serve any good. A senior specialist paediatrician contended that the reason some of those people resist technology, fearing medico-legal hazards, is that they do not appreciate the purpose of audits. He suggested that there is a need to demystify what audits are for, saying they are meant to improve systems, not to find faults and penalise people. Therefore, it is important to explain to healthcare professionals the purpose of technology and audits, which are meant to improve systems. There is also a need to provide cases of healthcare professionals who were protected because they had recorded their prescriptions and diagnoses in the provided systems. A specialist paediatrician supported this view by saying:

> "*So sometimes it takes us, trainers, to get the positives out of those cases that you can actually teach others to say, you see, just because one, two and three were entered in the system, this is the reason why this case was dealt with in a nice manner rather than just looking at the negatives*."

Incentives

Whether or not people should be incentivised to adopt emerging technologies to reduce under-five mortality in Makonde District was a bone of contention, creating two camps among the respondents. Some nurses said that public healthcare professionals in Zimbabwe are demotivated because of poor working conditions and meagre salaries. As a result, they are demotivated to work, and some would reject emerging technologies if introduced. It was also mentioned that even the mothers of under-fives could reject the technologies if they are not incentivised, as they have a tendency to ask what is in it for them. However, there are other healthcare professionals who said they did not want any incentives to adopt technologies that help reduce under-five mortality and would do anything that helps save the lives of innocent babies. Responding to whether parents should be incentivised to adopt emerging technologies for their under-fives, an experienced midwife (Respondent 10) had this to say:

> *"Yeah, I actually experienced it because with the Neotree project, we often had interviews with these mothers, and sometimes they would ask, "what's in it for me?" I don't know how our people have been. It can help, but I believe in giving information. Yes, rewards and incentives, but where will they be coming from? Because we are saying, this is a public health institution, so who will actually be buying those sugars and cooking oil? I just believe in giving people information. An*

informed person is an empowered person. They can make informed decisions. I think people should be given information and be assured that this is important and beneficial to their children. I am sure people love their children and would do anything for their children. So if we just give them information, I am sure they will be forthcoming".

On the other hand, a sister-in-charge (RGN) stationed at one of the rural clinics argued that incentivising people could lead to stigmatisation if some of the technologies are known to be associated with certain conditions like HIV. She (Respondent 13) said:

"I don't agree with that statement because it will increase stigmatisation, which we are running away from. Because we are not looking at just one disease, there might come technologies meant for managing HIV, for instance, and that would lead to stigmatisation. What I know is every mother loves their child, so if we tell them the importance of the technologies, they will willingly accept the technology. What if the incentives get finished? They will stop using the technologies. So what's important is to give people information and they will accept it willingly. You don't need to incentivize someone but just to give health education and the importance of the technologies."

Others argued that while some people might need incentives, sensitisation was a more feasible method since parents ideally love their children and would do anything that benefits them.

Community and health workers' involvement (get community buy-in, involve health workers in design)

Participants said that the success and failure of digital health arguably depend on community and healthcare professionals' buy-in. Nurses based in rural areas claimed that there is disinformation and misinformation that happens in rural areas, most influenced by influential community members like pastors, politicians, traditional leaders and headmasters. The influential leaders' views are highly regarded by communities; hence, getting their buy-in would mean they can extend their influence positively towards acceptance of the technologies. Community-based organisations could also play a role in positively influencing people to accept the technologies.

Healthcare professionals have been complaining about unfriendly digital health systems. A senior nurse questioned whether the people who design the technologies know anything about nursing because they design systems that are user-unfriendly. Involving healthcare professionals would not only make the designs suit their requirements but also brings a sense of involvement and ownership, which would minimise the chances of resistance once the technologies are deployed. There is also a need to sensitise communities whenever a new technology is introduced.

Show positive cases from places where technology yielded good results

Showing the positive cases where emerging technologies helped reduce under-five mortality could help reduce resistance, thus, promoting acceptance of the technologies. Some people resist technology out of ignorance. A typical example was given of the Neotree technology at Chinhoyi Provincial Hospital, which some healthcare professionals rejected at the beginning but accepted later after realising its benefits from the ones who had accepted it.

Provide backup power (solar energy)

While about 70 per cent of the public healthcare institutions in Makonde District are electrified, the electricity supply is unreliable with long hours of load shedding. If the public healthcare system is heavily reliant on emerging technologies, an unreliable power supply could hamper the success of the technologies. Thus, there is a need to provide backup power in the form of solar energy. Even in areas where there is no electricity, solar panels could be used to provide power. A typical example is the Nyamugomba clinic, where they installed solar panels using results-based financing (RBF) funds while awaiting the national electricity company to electrify the area.

Automation of drug supply management

Nurses at satellite clinics are asking for emerging technologies that incorporate automated drug supply management. Providing emerging technologies that incorporate automated drug supply management for reducing under-five mortality would give such people an incentive to want to adopt the technologies, hence, increasing the chances of a successful adoption.

Change of mindset

There is a need to change the mindset of healthcare professionals who resist change. This could be done through training, seminars and education.

Sensitisation

Healthcare professionals and communities should be sensitised to understand the technologies to be introduced and the benefits they bring to them. Sensitisation would improve the acceptance and adoption of the technologies.

Computer literacy policy

Participants said there are several public professionals in Makonde District without computer skills. It was revealed that the nurse training colleges in Zimbabwe are not offering computer skills training, resulting in some of their graduates lacking computer literacy skills. Introducing emerging technologies without training those public healthcare professionals to acquire computer skills could lead to the nonuse of the technologies. Therefore, there is a need to have a computer literacy policy that ensures that all public healthcare professionals who are not computer proficient are trained to gain the skills.

Continued use of technology

Some healthcare professionals believe that there is a need for continuous use of technology until resistance is minimised. They argued that using technology should become a culture of the organisation until everyone realises digitisation is there to stay. With that culture inculcated, the chances are high that when emerging technologies to reduce under-five mortality are introduced, they will highly be adopted.

Design user-friendly systems

Any digital health system designed to reduce under-five mortality in Makonde District must be user-friendly, taking cognisance that there are many computer illiterate public healthcare professionals in the district.

Education

In addition to educating policy-makers on emerging technologies and their potential impact, patients and healthcare professionals need to be sensitised as well. Knowledge inadequacy among both patients and healthcare professionals was cited as one of the sources of resistance to digital health adoption.

Effective funding

Technological interventions come at a cost, such as training and installation expenses. Sustainable technology use would require effective funding for the projects. Thus, participants indicated that there is a need for effective funding for emerging technologies to be introduced and sustained.

Erecting more base stations and use of satellite

Reports from the DMO's office indicated that about 30 per cent of the public healthcare institutions in Makonde District lack internet connectivity. The respondents unanimously concurred that there is poor or no network at all at some of the rural clinics in the district. To bridge that divide and have all healthcare institutions shifting to emerging technologies to reduce under-five mortality, there is a need to ensure that there is phone network and internet access everywhere. The nurses advocated for the erection of additional cellular base stations or the use of satellite technology to provide network access to all healthcare institutions in the district.

Post-installation support

There is a need to provide post-installation support, such as maintenance and troubleshooting. Nurses in remote areas complained that there was a neglect of technologies after installation, and it took too long for the technical team to address any challenges faced.

Rope in influencers

Influences can influence people to adopt or reject technologies. It was suggested that for emerging technologies to be successfully adopted, it is critical to involve influencers like business people, religious, traditional and political leaders who can positively influence others to adopt the technologies.

Provision of resources

The necessary resources for the successful deployment of the emerging technologies must be available. Without resources, the chances of success of the technologies are slim.

Spearheaders

In addition to influencers, there is a need to have people spearheading the introduction of technologies. These people will be trained, and they can then train their colleagues. They can be the go-to people when their colleagues face challenges or need assistance. They will be more like ambassadors for the technologies.

Staff motivation

The issue of staff motivation was topical in the focus group discussion and some interviews. Public healthcare professionals were said to be highly demotivated due to poor remuneration and working conditions. The demoralisation was said to make them frustrated and could be a cause for them to reject anything new, including technology. Therefore, the issue of staff motivation needs to be addressed, according to several participants. A senior midwife commented on the need for staff motivation:

> *"It's difficult, John, but something has to be done, and that should start by making the health practitioner happy. Nurses are not happy. The salaries that we are getting are too low, making us angry and unwilling to do anything. So the government should first address the issues of healthcare professionals' welfare so that the healthcare professionals are at least willing to adopt something. The government should pay health workers well, give them money that means something.*"

Training

Several respondents believed that healthcare professionals should be trained on new technologies before they are deployed, holding seminars that show the benefits of using such types of technologies. However, there was disgruntlement over how workshops are currently done, where managers attend workshops on issues that involve daily clinical work, yet they do not do the job but are attending to get allowances. One of the midwives commented on this matter and said:

> *"Then they should be trained on whatever will be coming. There is a tendency to train bosses who will not be using these technologies because there are incentives and money for transport and subsistence when people go for training. Then the bosses come back and tell us to come for a feedback meeting. In that meeting, no nurse will be listening; they will be thinking about the problems they left at home. Now when they are given tablets, they won't use them because they won't even know how to use them because they were not listening during the meetings."*

6.5 Results Merging

Since the study collected qualitative and quantitative data, some findings were common from the two phases. The common findings were merged and are presented in this phase. These were mainly factors affecting the potential adoption of emerging technologies in Makonde District's public healthcare institutions.

Fear of medico-legal hazards

Though the qualitative findings revealed fear of medico-legal hazards as an impediment to emerging technologies adoption, the confirmatory phase revealed that the majority of nurses at satellite clinics did not consider it as a factor. They argued that the factor could apply to those nurses at hospitals since they are not allowed to diagnose patients, which is preserved for doctors. However, at clinics, nurses are expected to diagnose and treat patients, and they would welcome any technology that helps them execute these duties efficiently and effectively.

Incentivising technology use

Another diverging finding between qualitative and quantitative results was that only 18 per cent of the healthcare professionals that participated in the confirmatory phase indicated they would want incentives to use emerging technologies to reduce under-five mortality. This divergence was also noted during the qualitative phase as some indicated they wanted incentives, while others stated that incentives were unnecessary since technology would make their work easier.

Mobile phone ownership

Qualitative findings had revealed divergent views on mobile phone ownership by mothers of under-fives, with healthcare professionals at the provincial hospital suggesting that there was a low mobile phone ownership among mothers of under-fives in rural areas. However, some nurses in rural areas indicated that mobile phone ownership among mothers of under-fives in their catchment areas was as high as 90 per cent in some areas. However, quantitative findings revealed that 81.1 per cent of mothers of under-fives who participated in this study had smartphone. These findings were triangulated with findings from the MICS dataset that indicated a 66.48 per cent mobile phone ownership among mothers of under-fives in the province. Therefore, it can be concluded that generally, there is high mobile phone ownership among mothers of under-fives in Makonde District.

Unstable network

Makonde District has urban, semi-urban and rural areas. While some areas have a relatively stable mobile network and internet connectivity, other areas have poor network connectivity where people have to walk to specific spots to access network. It was noted that in Kazangarare, there is completely no network, as stated by one of the respondents stationed at Chinhoyi Provincial Hospital. However, 70 per cent of the clinics in Makonde has a fairly stable mobile network connectivity, according to the DMO's office. An unstable network was perceived as a potential impediment to the adoption of emerging technologies by mothers of under-fives and pregnant women in the Makonde District. However, 69.6 per cent of mothers of under-fives who participated in this study's quantitative data collection phase stated that there was a relatively stable network connection in their areas.

Computer literacy

Some mothers of under-fives and public healthcare professionals lack the know-how on computer use. A nurse based at a rural clinic mentioned that some of the nurses are not computer literate and it is even worse among some mothers of under-fives who do not have tertiary education, especially those in rural areas. She emphasised the need for training on computer usage before the deployment of emerging technologies that might require using computers. Some registered general nurses at rural clinics emphasised the need for training sessions to be done for long periods since some of them have never used computers before. They cited the training they did for Neotree, which they claimed was done in haste and they missed many concepts since they lack proficiency with computers.

6.6 The Most Feasible Technologies to Reduce Under-Five Mortality in Makonde District's Public Healthcare Institutions

Table 50 shows the findings on the perceptions of healthcare professionals on the most feasible technologies in Makonde District's public healthcare institutions.

Table 50: Perceived Feasible Technologies in Makonde District's Public Healthcare Institutions

Which of the following technologies do you consider feasible in Makonde District's public healthcare facilities		Count	Percentage
Telemedicine and Telehealth	No	60	**67**
	Yes	30	**33**
Internet of Things	No	73	**81**
	Yes	17	**19**
Mobile Applications	No	18	**20**
	Yes	72	**80**
Social Media	No	12	**13**
	Yes	78	**87**
SMS-Based Solutions	No	23	**26**
	Yes	67	**74**

Electronic Billboards	No	30	**33**
	Yes	60	**67**
Cloud Computing	No	78	**87**
	Yes	12	**13**
Medical Chatbots/Virtual Assistants	No	42	**47**
	Yes	48	**53**
Social Media	No	30	**33**
	Yes	60	**67**

6.6.1 Mass Media

The study revealed that mass media could help provide health education on preventing and managing diseases among under-fives in Makonde District. However, these technologies mainly help with disease prevention and home-based management of conditions and diseases with little contribution to the quality of care.

6.6.1.1 Radio

Though only 27.4 per cent (Table 32) of mothers of under-fives who participated in this study had radios at home, the participants viewed radio as a feasible knowledge dissemination tool. One nurse argued that though some do not own radios, they can access radio on their phones; thus, many people can access radio.

6.6.1.2 Television

Television technology could also be used to provide health education to mothers and guardians of under-fives in the Makonde District. However, slightly over half of the mothers of under-fives who participated in this study had TV sets at home, suggesting that TV only could not reach everyone. More so, TV ownership in rural areas of Makonde District is not as high as in towns. While 54.5 per cent (Table 32) of the mothers of under-fives who participated in this study had TVs, most were from urban areas.

6.6.1.3 Electronic Billboards

The participants viewed electronic billboards as useful in providing visual health education on how to care for and prevent diseases in under-fives. However, they emphasised the need to use the main local languages and strategically position the electronic billboards. An experienced midwife had this to say:

> *"I also think that electronic billboards can help if they are strategically positioned. They need to be placed in places where people queue up for some services because you find out that when people are queuing, they end up not having anything to do and*

*will be checking around whatever is around them. I think they can really be valuable in saving children's lives. We can put in information that shows the management of certain minor conditions, how to make our homes clean, the benefits of family planning, putting images of a well-planned family who have everything they need, can afford school fees and many more things. This will be helpful for people to know how to keep their environments clean, how to stop mosquito breeding sites to deal with malaria, and many more. All that can be put on electronic billboards. Using images and videos can attract people's attention, and they can try to prevent diseases, injuries and all that in under-fives because parents will implement that in their homes" (*Respondent 10).

6.6.2 Social Media

Most participants had social media accounts. The most popular ones were WhatsApp and Facebook, with a few having Instagram and Twitter accounts. These could be used for health education. However, it is crucial to ensure that the information is in a visual format and the presenters (educators) are known healthcare professionals from within the area to help reduce misinformation. The official pages must also be verified to help users quickly identify fake accounts.

6.6.3 Mobile Technologies

Zimbabwe has a high mobile phone penetration rate (POTRAZ, 2021a), and the findings of this study confirmed that. Mobile apps, USSD apps and SMSs are feasible technologies in Makonde District. However, the adoption of these applications could be hampered by financial challenges if they require users to pay for access. It could help to use USSD apps that can be accessed free of charge and to zero-rate the mobile applications and websites that provide health education about taking care of children.

6.6.4 Medical chatbots/ virtual assistants

Over half of the healthcare professionals believed that medical chatbots were feasible. However, most of the respondents lacked a clear idea of what medical chatbots were. Medical chatbots are interactive and could be used to provide information and health education to parents and guardians on how to take care of their under-five children. However, the medical chatbots could need to be hosted on the cloud.

6.6.5 Cloud Computing and Artificial Intelligence

Most healthcare professionals believed that cloud computing was not feasible in Makonde District. However, they also did not clearly understand what cloud computing is and how it works. Conversely, the health information officer, who understood cloud computing, mentioned that it was a feasible technology, and there were talks of public healthcare institutions having to use the cloud. Cloud computing would pave the way for adopting resource-intensive technologies like artificial intelligence as the models would run on the cloud and be accessed through less powerful gadgets like mobile phones ad tablets.

6.7 Chapter Summary

This chapter presented the findings of the study from qualitative and quantitative perspectives since the study design was an exploratory sequential mixed-methods. The researcher organised the findings by research questions. A total of 501 respondents participated in this study. These were distributed to 110 public healthcare professionals and 391 mothers of under-fives. The findings revealed that there was a high willingness among the participants to adopt emerging technologies to reduce under-five mortality in public healthcare institutions in Makonde District. The reasons given for wanting to adopt emerging technologies included the desire to improve under-five health outcomes; they perceived the technologies as lessening their work, while others would like to adopt emerging technologies for the sake of moving with the times. However, there was generally poor knowledge of emerging healthcare technologies among the respondents, with two participants having researched in preparation for the interviews. Moreover, emerging technologies were perceived as useful in improving disease prevention, management and quality of care through technology-assisted diagnosis and treatment, health education, keeping track of under-fives immunisation statuses and many others. Nonetheless, the potential adoption of the emerging technologies does not come with expected obstacles. The perceived impediments to adoption include communication network problems, fear of medico-legal hazards, resistance to change, centralisation of digital health decision-making, demotivated workforce, lack of funding, inadequate and unreliable ICT infrastructure, a negative mindset as well as the UTAUT of DOI factors like facilitating conditions and knowledge variables. As the findings were organised by the research questions, the discussion of the findings will be presented by research objectives. The next chapter discusses the findings of this study.

CHAPTER 7: Discussion of Findings

7.1 Introduction

This chapter discusses the findings of this study, as presented in Chapter 6. The discussion is sequentially organised based on the research objectives. Prior to discussing the findings, the chapter recaps the research questions and the extended capabilities approach theory.

7.2 Recap of the Research Questions and the Extended Capabilities Approach

Despite emerging technologies having positively contributed to reducing under-five mortality in some countries like the United Kingdom and Zanzibar, the potential role of such technologies in reducing under-five mortality in Zimbabwe had not been explored prior to this study. Though digital interventions in public healthcare continue to penetrate resource-constrained settings, there is a dearth of studies on the role of emerging technologies in such contexts. This study used an exploratory sequential mixed-methods study design to explore the perceived potential role of emerging technologies in reducing under-five mortality in public healthcare institutions in the Makonde District. The study further explored the potential impediments and enablers of the successful deployment and adoption of emerging technologies to reduce under-five mortality in Makonde District's public healthcare institutions. Moreover, what needs to be done for emerging technologies to be successfully adopted in Makonde District's public healthcare institutions was also explored.

Three theories underpinned this study, upon which the custom theoretical framework that guided this study was based. Mainly, the research questions and objectives focused on the perceived capabilities of emerging technologies and the determinants of adoption. The Capabilities Approach informed the study in relation to the perceived potential role, while the Unified Theory of Acceptance and Use of Technology (UTAUT) model and the Diffusion of Innovation (DOI) theory informed the study regarding the readiness to adopt, potential determinants and enablers of emerging technologies adoption.

The main research question of this study was "What is the perceived role of emerging technologies towards reducing under-five mortality in Makonde District's public healthcare institutions?" This main research question led to the following sub-questions:

Research question 1: What is the level of readiness to adopt emerging technologies for reducing under-five mortality in Makonde District public healthcare facilities?

Research question 1(a): To what extent do healthcare professionals in Makonde District know about emerging technologies for reducing under-five mortality?

Research question 1(b): To what extent are healthcare professionals in Makonde District willing to adopt emerging technologies to reduce under-five mortality?

Research question 2: What factors are affecting the potential adoption of emerging technologies by public healthcare institutions to reduce under-five mortality in Makonde District?

Research question 2(b): What factors affect the potential adoption of emerging technologies to reduce under-five mortality by public health professionals in the Makonde District?

Research question 2(c): Which emerging technologies in healthcare are currently available in Zimbabwe?

Research question 3: What potential role can emerging technologies play in reducing under-five mortality in Makonde District?

Research question 3(a): What is the perceived contribution of emerging technologies in disease prevention among under-five children in Makonde District?

Research question 3(b): What is the perceived contribution of emerging technologies in managing diseases among under-five children in the Makonde District?

Research question 3(c): What is the perceived contribution of emerging technologies in improving healthcare quality for under-five children in Makonde District?

Research question 3(d): What needs to be done for emerging technologies to be adopted in Makonde District's public health institutions to reduce U5M?

These research questions led to the following research objectives:

Research objective 1: To investigate the preparedness to adopt emerging technologies in Makonde District to reduce under-five mortality in public healthcare institutions.

Research objective 2: To identify emerging technologies that are available in Zimbabwe.

Research objective 3: To identify factors that can affect the potential adoption of emerging technologies to reduce under-five mortality in the Makonde District's public healthcare institutions.

Research objective 4: Identify the perceived potential role of emerging technologies in reducing U5M in Makonde District's public healthcare institutions.

Research objective 5: To develop an emerging technologies framework to help reduce under-five mortality in public healthcare facilities in Makonde District.

The main objective was to develop an emerging technologies adoption framework to help reduce under-five mortality in public healthcare facilities in Makonde District.

7.3 Discussion By Objective

7.3.1 Research Objective 1: To investigate the preparedness to adopt emerging technologies in Makonde District to reduce under-five mortality in public healthcare institutions

The willingness of healthcare professionals and mothers of under-fives in Makonde District to adopt emerging technologies to reduce under-five mortality

All the healthcare professionals who participated in this study indicated that they were very likely to adopt emerging technologies if introduced to reduce under-five mortality in Makonde District's public healthcare institutions. On the other hand, 77.7 per cent of the mothers of under-fives indicated that they would definitely adopt emerging technologies to be used on their under-fives to reduce under-five mortality, while 16.9 per cent were undecided. The results indicate that there is generally a high willingness among both healthcare professionals and mothers of under-fives in Makonde District to adopt emerging technologies for the sake of the under-fives in the district. However, the high willingness might not translate into actual adoption by all those who indicated the willingness to adopt. The reasons for that include the concerns raised by the respondents, as discussed under research objective 3. The reasons given for the high willingness included that they perceived emerging technologies as improving efficiency, diagnosis, quality of care, data sharing and record-keeping, as shown in Figure 20.

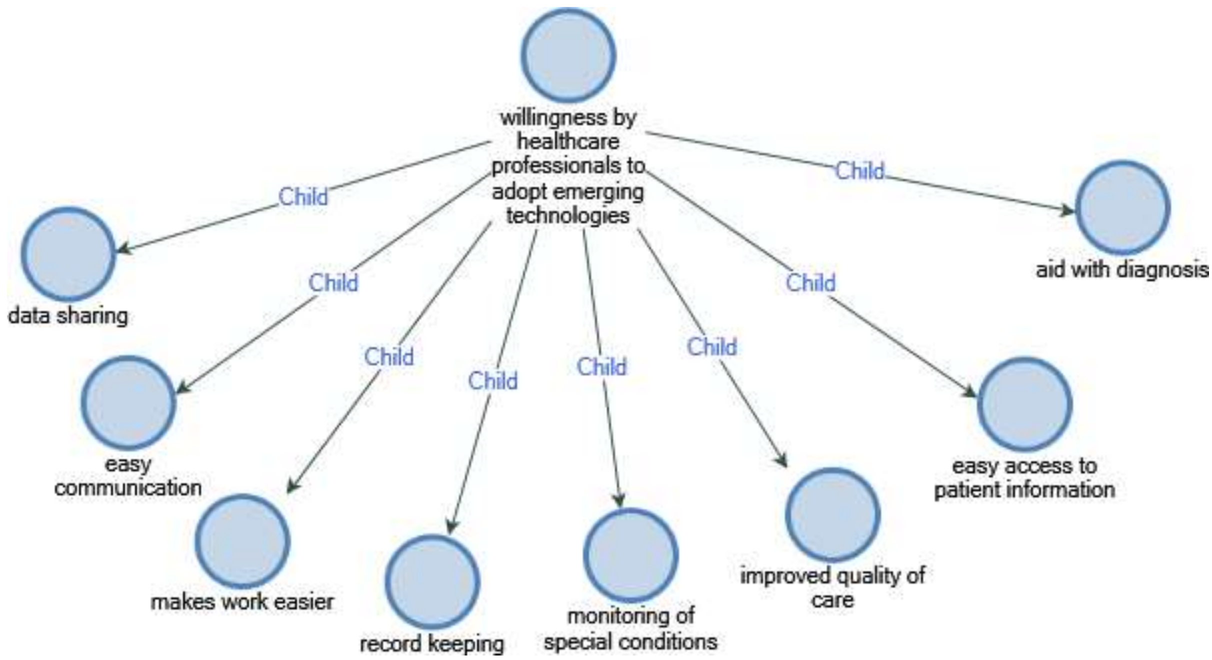

Figure 20: Reasons for willingness to adopt emerging technologies by healthcare professionals

Nurses, especially those stationed at clinics, are ready to adopt emerging technologies as they can help diagnose diseases in the absence of doctors. A nurse-in-charge at one rural clinic stated that using technology for diagnosis support would boost their confidence, knowing that they would have a correct diagnosis. Another nurse stated that using technology would help them make informed decisions and diagnoses based on physiological measurements obtained rather than entirely relying on asking patients for the symptoms. Artificial intelligence is gaining popularity in diagnosing diseases (Macaulay et al., 2021) and, in some cases outperforming human experts, such as in cancer diagnosis (Davenport & Kalakota, 2019). Deep learning, which is a subfield of artificial intelligence, can detect clinically relevant features in imaging data beyond the capability of a human eye (Vial et al., 2018), making it improve disease diagnosis.

Moreover, ease of communication among healthcare professionals and mothers of under-fives was given as another reason for willingness to adopt emerging technologies. A midwife from Chinhoyi Provincial Hospital stated that there are no technologies in use in public healthcare institutions to communicate with patients. She said that the healthcare professionals have WhatsApp groups in which they can share information, but not with patients. As a referral hospital, Chinhoyi Provincial Hospital services people from all over the province, including those from remote areas. Some of those patients could go for tests and be asked to come back for the results after a certain period, and it could be costly for them to come back. The midwife argued that not all the time would the results be positive, and sometimes there will not be a need for further tests, but parents would be expected to travel only to get the results which could be communicated through emerging technologies.

This finding resonates with literature that emerging technologies can improve communication between healthcare institutions and patients, such as sending reminders (Bervell & Al-samarraie, 2019; Blaya et al., 2010) and disseminating important health information, including to underserved rural areas (Naveena, 2015). The ability to communicate between the public and healthcare institutions and professionals is crucial in enhancing the health and wellbeing of the public through public health education (Alshammari et al., 2017). Mass media is commonly used for this public health education (Alshammari et al., 2017) and communicating public health information (Naveena, 2015). The role of mass media in enhancing public health education has been studied for over three decades (Saunders & Goddard, 2002). Health education is an important aspect of public health that helps influence patients' behaviour and attitude change, helping promote healthy behaviours (Sharma & Gupta, 2017). Governments and health authorities used mass media to debunk myths about COVID-19 and influence behavioural change (Mbunge, Akinnuwesi, Fashoto, Metfula, et al., 2021c).

Moreover, the willingness to adopt the emerging technologies was influenced by their capability to easily keep patients' records in a format that is easier to search, organise and retrieve. Some nurses said they would embrace emerging technologies because they help with record keeping. The electronic health record (Marcus et al., 2019) could help with keeping records of patients and sharing the data across healthcare professionals to enhance patient care. The collected data could be analysed to discover new disease trends through big data analytics (Ali et al., 2021; Ristevski & Chen, 2018) and artificial intelligence (Agbehadji et al., 2020), facilitating data-driven paediatrics (Batani & Maharaj, 2022a).

The findings revealed that there are under-fives with special conditions that require constant monitoring, yet they may not be close to health facilities. A primary care nurse said that parents, some of whom are also healthcare professionals, would accept technologies like the internet of things to help them continuously monitor their under-fives with special conditions. Indeed, healthcare innovations around the medical internet of things are increasingly emerging, helping with collecting patient data remotely and monitoring adherence to medication and treatment (Islam et al., 2015). IoT-based innovations have been deployed in other countries to remotely monitor the physiological parameters of pregnant women and foetuses, contributing to the reduction of maternal, prenatal and under-five mortality (Amala

& Mythili, 2017). Besides monitoring the health status of patients remotely, IoT is also used to collect big datasets that are analysed using technologies like deep learning and machine learning to help discover new disease information and trends, contributing to early disease detection (Jagadeeswari et al., 2018) and data-driven paediatrics (Bourgeois, 2022; Gout et al., 2021). Parents and guardians often find it hard to identify if babies are not feeling well, especially if they cannot talk. In such cases, monitoring babies' physiological parametres could be helpful. However, the concept of IoT is not well-known among the public healthcare professionals in Makonde District. Only a few respondents appreciated what IoT is after researching in preparation for the interviews.

The healthcare professionals said they were ready to adopt emerging technologies because they make their work easier. Reference was made to the Neotree system used for neonates' care at Chinhoyi Provincial Hospital. The Neotree system, a digital system used to manage neonates' health by guiding healthcare professionals on the appropriate care and treatment plan for neonates based on symptoms and other parameters like height, age and weight, was touted as having significantly reduced healthcare professionals' workload. This finding concurs with that of Gannon et al. (2021) that revealed that Neotree is improving disease management among neonates in developing countries. The use of such a system helps save lives that could be lost because of misdiagnosis or failure by healthcare professionals to follow standard procedures for dealing with neonatal illnesses, thus reducing preventable deaths of children (The UK Government, 2021a).

Knowledge about emerging technologies for reducing under-five mortality by healthcare professionals in Makonde District

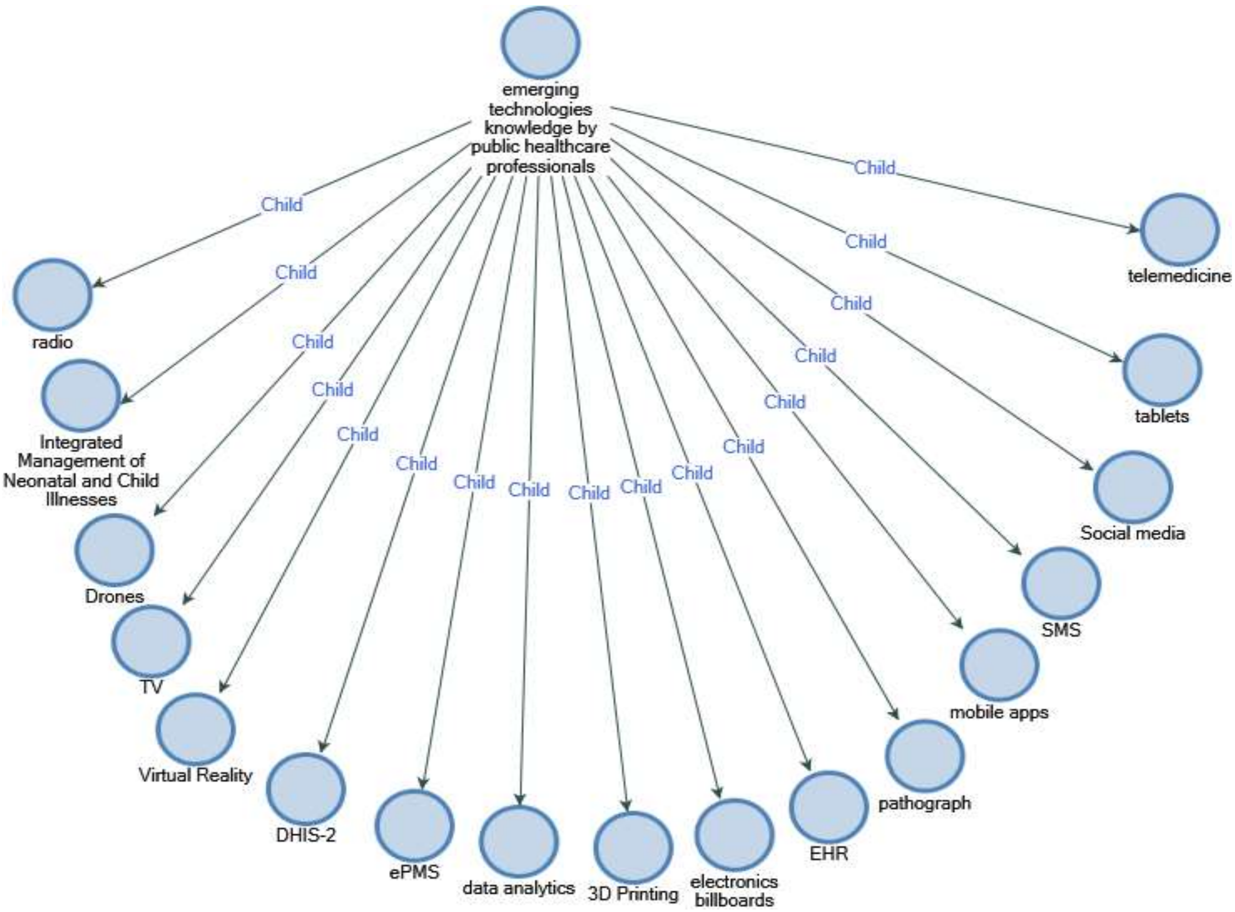

Figure 21: Emerging technologies mentioned by healthcare professionals during qualitative data collection

Figure 21 shows the emerging technologies and systems mentioned by participants during the qualitative data collection phase. The electronic health record system, television, radio, SMS and social media were popular among the participants. The electronic health record had just been introduced in some healthcare institutions while training had been done for all healthcare professionals, including those at facilities where the technology had not yet been introduced. The benefits of electronic health record systems include the ability to access patient data online and share patient medical data among healthcare professionals and institutions (Shi et al., 2020). The electronic health record system could help collect data that could be used for data-driven paediatrics (Bourgeois, 2022), helping healthcare institutions to transition to evidence-based paediatrics informed by machine learning, deep learning and big data analytics (Gout et al., 2021; Zamora et al., 2016; Y. Zhang et al., 2012). Since electronic tablets have been issued to healthcare institutions in Makonde District's public healthcare institutions to be used for the electronic health record, some nurses mentioned tablets as an emerging healthcare technology.

Moreover, mass media technologies were also mentioned. Electronic billboards, radios, televisions, and social media were mentioned among the emerging technologies that could help improve under-five health outcomes through health education. Nurses based at rural clinics claimed that there was high ownership of mobile phones among mothers of under-fives within their catchment areas. The estimated mobile phone ownership percentage ranged between 70 and 90 per cent. The survey of mothers of under-fives revealed that over 85 per cent owned smartphones, a finding that concurs with the national ICT quarterly reports that Zimbabwe has a high mobile phone penetration rate (POTRAZ, 2019, 2020, 2021b). A primary care nurse from one clinic argued that the high mobile phone ownership also translates to high radio access since almost all the phones owned in those areas have access to FM (Frequency Modulation) radio. Radios can help promote health by improving people's behaviour, perceptions and attitudes towards health issues (Saunders & Goddard, 2002). Mass media plays an important role in disease prevention by educating the public on health matters and disease prevention methods as well as reminding patients of critical information like vaccination dates for children and updating people on new diseases and disease outbreaks, disease prevention, and whom to seek medical help from (Balamurugan, 2018; Naveena, 2015; Sharma & Gupta, 2017). However, one nurse argued that social media needs to be treated with caution, ensuring that patients can differentiate genuine user accounts of healthcare institutions from those imitating them and misinforming the public. Social media, though it has brought people together regardless of their geographical locations, has been accused of spreading fake news, misinformation and disinformation (Panchal et al., 2021). Nonetheless, social media is crucial tool that can be used to advance public health through health education and information sharing (Emilio et al., 2021; Fagherazzi et al., 2020). More so, some nurses advised that electronic billboards need to be strategically placed in areas where people queue for services, and they should display content in local languages.

Drones, data analytics, virtual reality and 3D printing were less popular among the participants. Drones were mentioned by a midwife and a primary care nurse, while data analytics was mentioned by a paediatric specialist. Those who mentioned these technologies indicated that they did not know about them until they researched in preparation for the interviews after receiving an invitation. A midwife from Chinhoyi Provincial Hospital and a primary care nurse from one of the rural clinics mentioned that drones could be used to deliver medicines and other essential supplies. Their perception could have been influenced by a rise in the use of drones in healthcare during the COVID-19 pandemic (Musanabaganwa et al., 2020; Restás et al., 2021). They mentioned that nurses lack knowledge of emerging technologies in healthcare as these are not taught at nurse training colleges. Drones were used to deliver essential medical supplies and transport test samples in disaster-stricken and hard-to-reach places like in Haiti after the deadly earthquake (Medicins Sans Frontiers Inc., 2015), in Zimbabwe after Cyclone Idai (Mudzingwa, 2019) and in Guinea's impassable areas (Medicins Sans Frontiers Inc., 2015). Since some areas in Makonde District are hard-to-reach, drones could be used to deliver essential medical supplies to save under-fives' lives.

Electronic Patient Management System (ePMS), was also mentioned by the participants. The ePMS was funded by UNDP Zimbabwe (UNDP Zimbabwe, 2015a). This system is currently used in public healthcare institutions, making it one of the digital technologies that the public healthcare professionals in Makonde District know. The system has helped improve patient data access and management since its deployment (UNDP Zimbabwe, 2015a). Public health institutions in Makonde District are using the integrated management of neonatal and children's illnesses (IMNCI); hence, public healthcare professionals are aware of this system. The IMNCI seeks to improve child health outcomes through training healthcare professionals, strengthening healthcare systems, and community and household interventions (James & Acharya, 2021). Moreover, the DHIS-2 is also known among some healthcare professionals. However, there are some nurses who do not know about the DHIS-2 system, although it is used in Makonde District. This finding reveals that digital health interventions are there in Zimbabwe, as shown by Bishi et al.,(2017), Chawurura et al. (2019a), Gannon et al. (2021), Marongwe et al. (2022) and Batani and Maharaj (2022).

7.3.2 Research Objective 2: To identify the emerging technologies available in Zimbabwe.

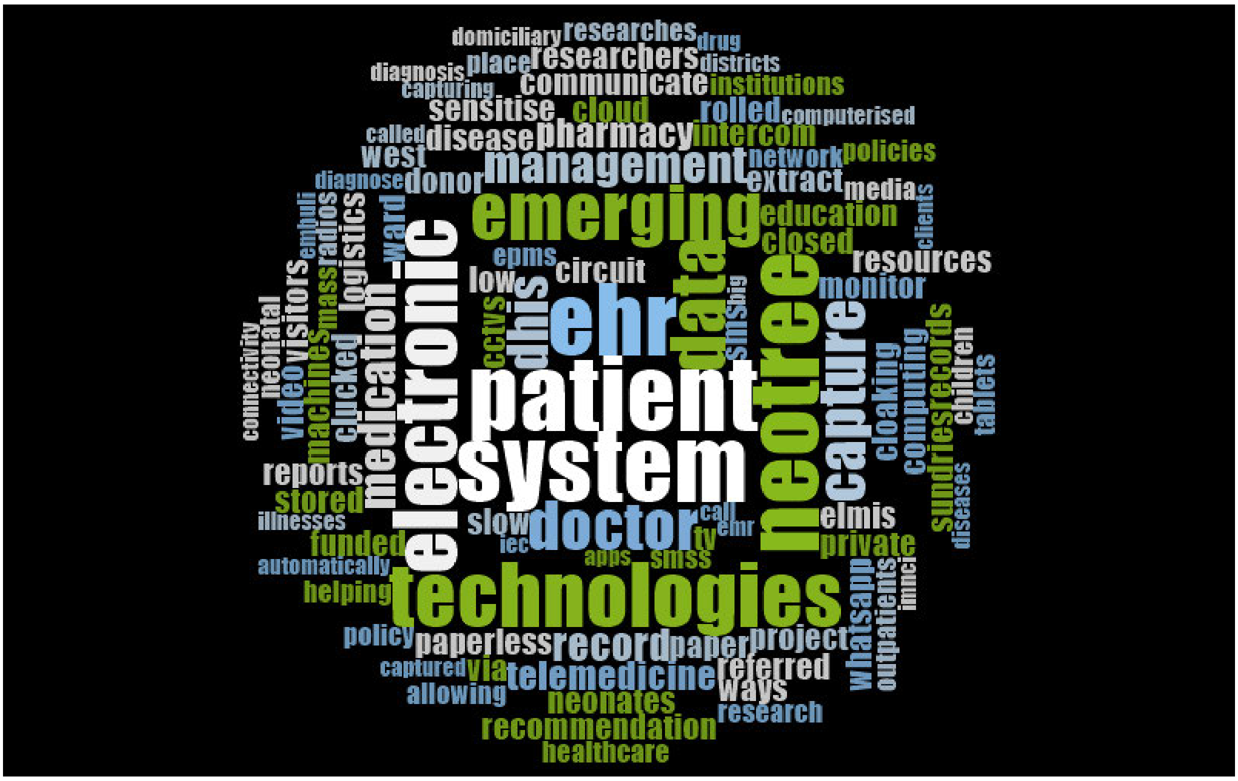

Figure 22: Word cloud for identified technologies in Zimbabwe

Figure 22 is a word cloud for the technologies mentioned by respondents as available in Zimbabwe's public healthcare institutions. The technologies identified from interviews and questionnaires include the electronic health record, electronic patient management system (ePMS), DHIS-2, intercom, closed-circuit television (CCTV), telemedicine, electronic logistics management information system (eLMIS), Neotree and mhuri/imuli. One respondent said that some hospitals were using CCTV to monitor patients in isolation, with visitors communicating with them using the intercom However, telemedicine in Zimbabwe's public healthcare is still at its infancy and is not widely deployed (Ndhlovu, 2021). It is being used for teaching and learning purposes in the University of Zimbabwe's School of Medicine (Moyo & Madziyire, 2020) and trialled in some rural areas as Nyanga (Maruta, 2018).Though there was a rise in telemedicine usage during COVID-19, particularly by the private health sector, regulatory requirements are stifling widespread adoption as they lag behind technological advances (Ndhlovu, 2021).

The electronic Logistics Management Information System (eLMIS) was said to be at an early implementation phase at Chinhoyi Provincial Hospital, aimed to improve pharmacy management. Telemedicine was a popular technology mentioned by the participants. Telemedicine is defined as the provision of healthcare services remotely using information and communication technologies (Moyo & Madziyire, 2020). This technology gained significant popularity globally due to the lockdowns and social distancing restrictions induced by COVID-19 (Mbunge, Akinnuwesi, Fashoto, Metfula, et al., 2021a). Countries like Israel quickly transitioned to telemedicine, with healthcare professionals who used to reject the technology accepting it during the COVID-19 pandemic (Grossman et al., 2020; Taha et al., 2021). Telemedicine interactions between patients and physicians could be synchronous or asynchronous, using such means as video and voice calls, video conferencing, text messages electronic mails (Ohannessian, 2015). The benefits of telemedicine include reducing the effects of understaffing in healthcare institutions as patients can access services from specialists located far away from them (Mbunge, Muchemwa, et al., 2022). This technology can be useful in remote areas like Makonde District since professionals shun working in remote areas, resulting in understaffing (Nyandoro et al., 2016). Moreover, it could present unprecedented opportunities for under-fives in remote areas to easily, timeously and cheaply access paediatric specialists who are stationed at the provincial hospital and beyond. In the Manicaland Province of Zimbabwe, telemedicine was trialled successfully in Nyanga (Maruta, 2018) and proved feasible and beneficial in interfacing rural communities with healthcare specialists (Ndhlovu, 2021).

If telemedicine trials succeeded in rural Nyanga and Chimanimani, the technology could arguably succeed in Makonde District too, which has urban and rural parts. It could immensely benefit the under-fives in the district since the health facilities are understaffed with a lack of access to specialist physicians (Nyandoro et al., 2016). However, public healthcare institutions in Makonde District are not using telemedicine. In fact, telemedicine in Zimbabwe's public healthcare has mainly been for educational and piloting purposes, with telemedicine equipment and applications installed at the University of Zimbabwe School of Medicine for purposes of training students (Ministry of Health and Child Welfare, 2012) and another telemedicine application deployed in two Manicaland districts, Nyanga and Chimanimani, as pilot studies to facilitate remote consultation by nurses at remote clinics enabling them to consult doctors at district hospitals without the need for patients to travel to district hospitals (Maruta, 2018).

Mhuri/imuli was also mentioned. However, the mhuri/imuli is almost coming to an end as it is a five-year project funded by the USAID, the life of which ends in 2023 (FHI 360, 2020).

From the FHI 360's website, it is clear that the mhuri/imuli is a USAID-funded project in Manicaland targeting to improve maternal, newborn and child health as well as family planning. However, it is not clear what digital innovations that project is implementing.

Emerging technologies like the internet of things are already in use in Zimbabwe, though not in public health. Econet Wireless, a mobile phone operator in Zimbabwe, is offering IoT-based solutions for home and car security, called the Econet ConnectedHome and ConnectedCar (Econet Wireless Zimbabwe, 2014). Nonetheless, researchers have shown interest in the possibility of integrating the internet of things in Zimbabwe's public health (Chipambwa & Terera, 2016).

Save the Children Zimbabwe and Econet Wireless Zimbabwe are examples of organisations using drone technology for disaster recovery and preparedness (Save the Children Zimbabwe, 2021). Econet Wireless used drones to help in the search efforts in Manicaland after the devastating Cyclone Idai (Mudzingwa, 2019). However, drones and IoT are not in use in public healthcare institutions in Zimbabwe.

While Zimbabwe's public healthcare is slowly embracing digitisation, as evidenced by the digital health systems deployed, there is arguably little drive to have emerging technologies that are specifically meant to improve the health and wellbeing of under-fives. This does not, however, suggest that the Government of Zimbabwe is not concerned about reducing under-five mortality, but their emphasis is more on non-technological interventions, such as free access to healthcare and prevention of mother-to-child transmission. Commendably, the Chinhoyi Provincial Hospital has a dedicated digital paediatrics system called Neotree, though it is donor-funded. Healthcare professionals who used the Neotree system expressed satisfaction with the role it plays in making correct diagnoses and treatment plan suggestions, a finding that agrees with that of the study by Gannon et al. (2021). However, this system is only available at the provincial hospital and not clinics, yet clinics arguably need diagnosis support more than the hospital as clinics have no doctors and specialist paediatricians.

Digital health interventions are already there in Zimbabwe's public healthcare, though most of them are funded by organisations like the UNDP, USAID and Neotree, for instance, the ePMS (UNDP Zimbabwe, 2015a), mhuri/imuli (FHI 360, 2020) and Neotree (Neotree, 2021). Of late, electronic health record has been introduced in public healthcare institutions (Batani & Maharaj, 2022a). However, most of these digital systems are not specific to paediatric care, yet children have peculiar healthcare needs, including growth monitoring (Shiffman et al., 2001). Zimbabwe's overreliance on donors to deploy digital health interventions leads to nonuniformity in the distribution of these systems as donors deploy them in the areas they are registered to operate, not necessarily countrywide.

7.3.3 Research Objective 3: To identify factors that can affect the potential adoption of emerging technologies to reduce under-five mortality in the Makonde District's public healthcare institutions.

This section discusses the findings relating to factors that could affect the adoption of emerging technologies to reduce under-five mortality in Makonde District's public healthcare institutions. In doing so, the researcher does not only focus on the primary data of this study but triangulates with secondary data findings from the Multiple Index Cluster Survey (MICS) dataset obtained from the Zimbabwe Demographic Health Survey of 2019 conducted by ZIMSTAT. Table 44 shows the findings relating to radio, television and mobile phone ownership, as well as religious affiliations of 2 437 mothers of under-fives from the Mashonaland West Province, to which Makonde District belongs.

Figure 23 and Figure 24 depict the identified factors potentially affecting the adoption of emerging technologies to reduce under-five mortality in Zimbabwe.

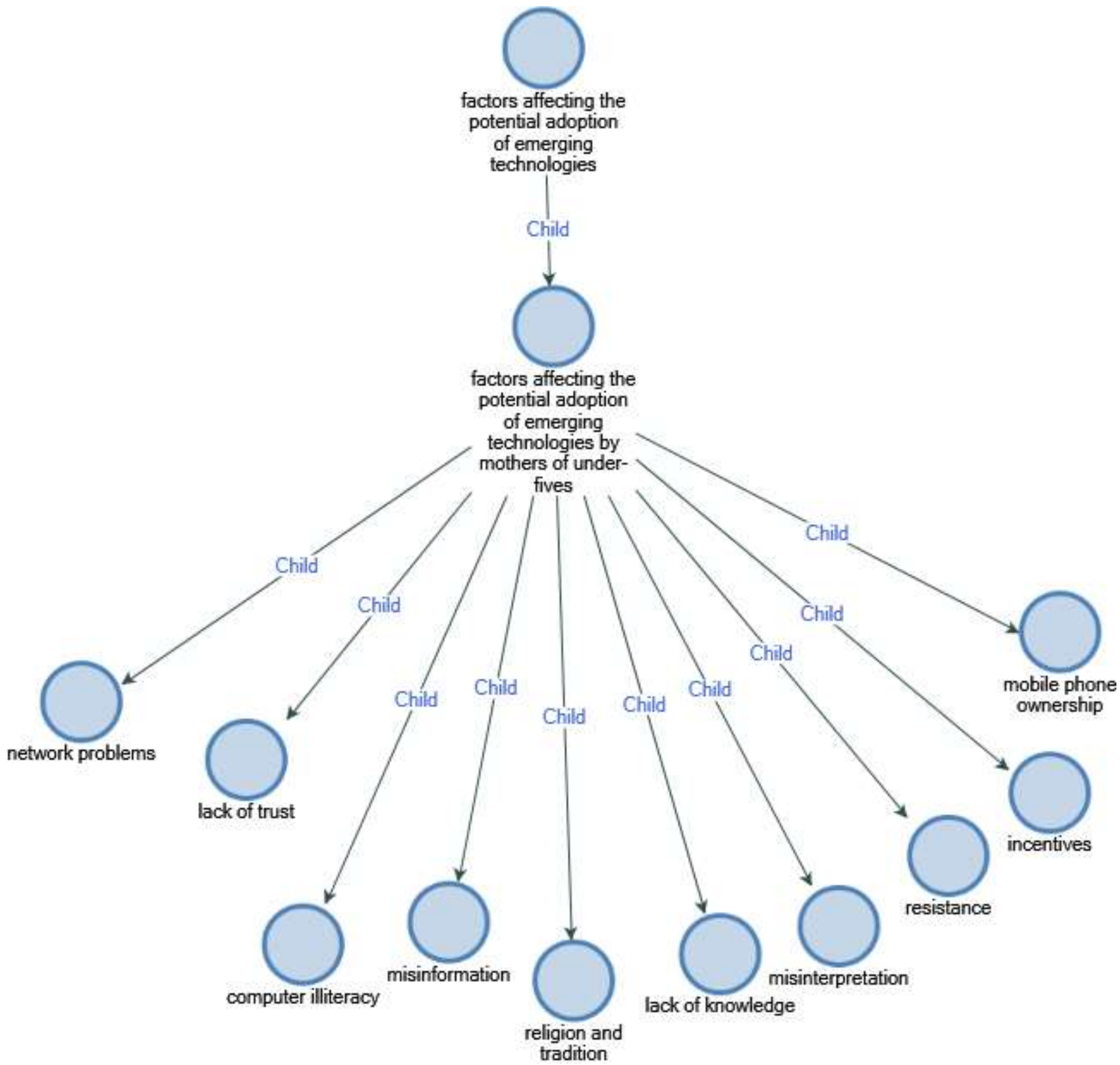

Figure 23: Factors affecting emerging technologies adoption by mothers of under-fives in Makonde District

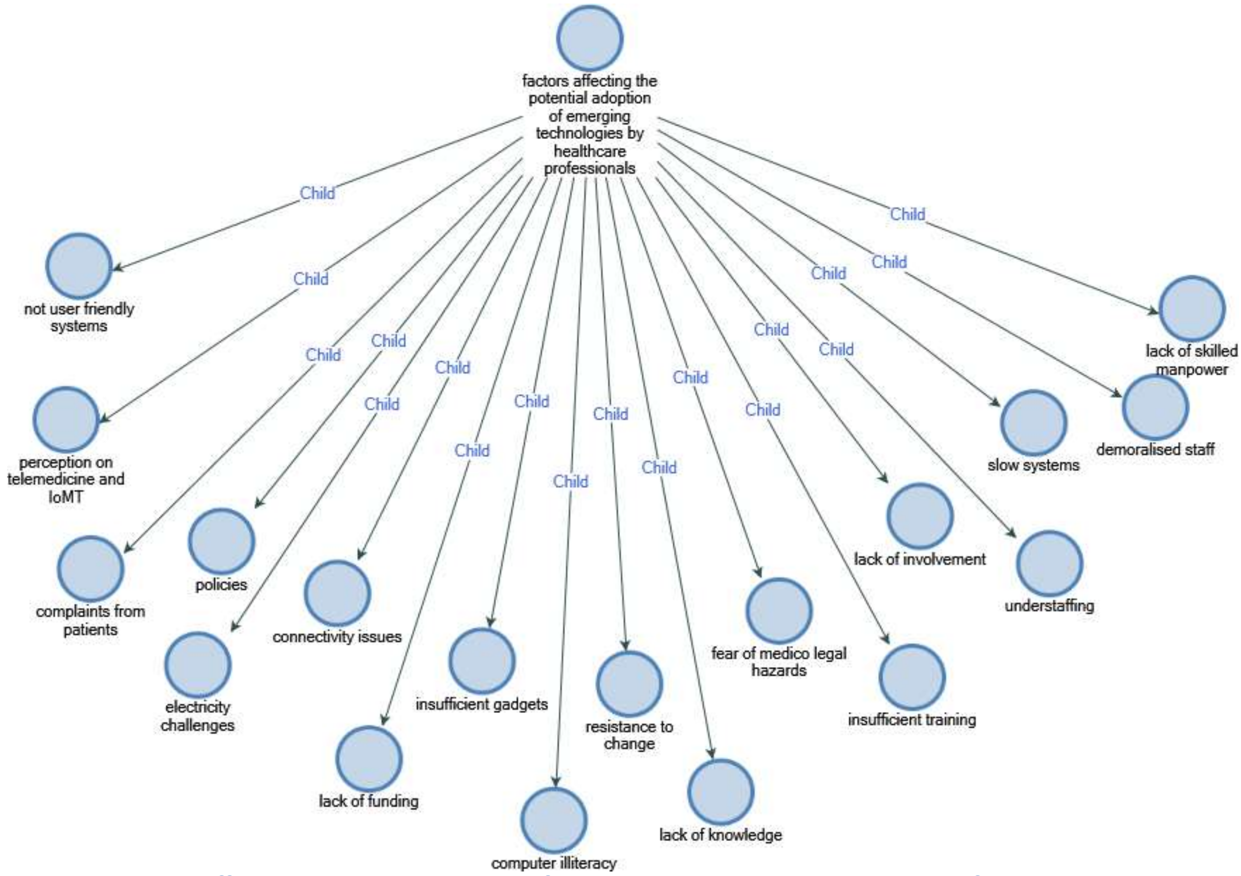

Figure 24: Factors affecting the potential adoption of emerging technologies by healthcare professionals in Makonde

Religion and tradition

Some nurses indicated that they face challenges convincing the apostolic sect members to ensure their under-fives get all the required immunisations. Some areas are highly populated by members of the apostolic sect, like in Matoranjera, where about ninety (90) per cent of the population was said to be members of the Johane Masowe apostolic sect. The Johane Masowe church members do not believe in going to a health facility, and doing so is considered a sin and a lack of faith in the 'spirit'. Findings from the 2019 MICS report, as shown in Table 44, support the claims that the apostolic sect is famous in Mashonaland West. Religiosity, religion and religious backgrounds are potential deterrents to the adoption of digital health (Alanezi, 2021; Fagherazzi et al., 2020). Besides, religious leaders are influential, and their followers' decisions tend to be influenced by the leaders' views, like what happened with the COVID-19 vaccines (Chu et al., 2021). Conversely, if religious leaders speak well of emerging technologies, they could help reduce the hesitancy around technology adoption to reduce under-five mortality in Makonde District. The messenger matters when it comes to influencing religious people's decisions on matters of health, such as vaccine acceptance (Viskupič & Wiltse, 2022) and technology adoption (Fagherazzi et al., 2020). Therefore, getting the buy-in of religious leaders could improve the chances of emerging technologies adoption in the Makonde District. After registering preventable child mortalities due to preventable measles, the Government of Zimbabwe introduced a law that criminalised denying babies access to immunisation, and any parents or guardians found wanting would be charged with a criminal offense (ZLHR Legal Monitor, 2010). With the criminalisation of denying children access to healthcare by parents and guardians, emerging technologies could be used to anonymously report cases to the police (Batani & Maharaj, 2022a).

Fear of medico-legal hazards

Medico-legal hazards include giving the wrong dosage, use of inappropriate medication, failure to monitor treatment for side effects and toxicity, and failing to provide the patient with important information. There is fear among some healthcare professionals that using emerging technologies could lead to medico-legal hazards being quickly identified by management, resulting in them being dismissed or sued. With papers, it was said that one could easily destroy the evidence of any unintentional malpractice, omission, or errors, unlike with computers where they would not know where the data got stored. Whether fear of medico-legal hazards could deter healthcare professionals from using emerging technologies to reduce under-five mortality in Makonde District was a bone of contention among the respondents, with nurses stationed at satellite clinics arguing that they do not have doctors to consult and must do everything, unlike nurses at hospitals who are not allowed to diagnose patients or prescribe medication. This was arguably the most contentious deterrent debated by healthcare professionals in interviews and focus group discussions. One participant argued that with technologies like WhatsApp, a patient could take an image of a prescription and send their friends or relatives to buy the medication for them, and those images would be enough evidence even if a healthcare professional destroys the evidence in the event of a mishap. The researcher could not find literature from studies on Zimbabwe to support or dispel this finding, suggesting that it could be a new finding related to digital health adoption impediments in Zimbabwe. A different version of medico-legal hazards combined with ethics related to digital health has been discussed in other papers. These include patients not knowing where their data are stored (data invisibility), incorrectness of the gathered patient data, a lack of time-bound patient data storage (immortality), marketability and possible identifiability of patient data even if anonymised (Oliva et al., 2022). Moreover, the repurposing of patient data is often a concern in digital health (Gaobotse et al., 2022b; Sipior, 2020).

Policies and Centralisation of decision-making

Public healthcare professionals in Makonde District are not aware of the specific Ministry of Health and Child Care policies regarding digital health. They could not tell how the policies affected the introduction of emerging technologies. However, they pointed out that there are digital health systems in use in the district, including the DHIS-2, Neotree and the recently introduced electronic health record, suggesting that the policies do promote the use of digital technologies in healthcare. Although the digitisation of public health in Zimbabwe is still nascent, the country's health strategy emphasises the need for digital innovations in healthcare (Ministry of Health and Child Care, 2016), and has even developed a national e-health strategy (Ministry of Health and Child Welfare, 2012). However, the legislative framework lags behind technological developments, bottlenecking the adoption of some latest technologies (Ndhlovu, 2021).

Digital technology policies are not made at a district or provincial level but at the national level. The central government makes the decisions and gives the green light regarding the introduction of digital technologies in public health institutions. Before any digital health technology is deployed, it is first introduced to the Secretary of Health and Director of Information. These form technical working groups responsible for analysing the technology and whether or not it is ideal for the local environment. The recommendations of the technical working groups are presented to the Minister of Health and Child Care, followed by the signing of MOUs with the Minister of Health and Child Care and the Secretary of Health. Post the signing of MOUs, training of the head office staff begins and cascades down to the province and districts. The districts remain governed by the provincial and national levels. The centralisation of digital health decision-making makes it hard for districts to introduce digital technology interventions without the intervention of the central government. The involvement of the central government leads to red tape, affecting the pace at which technology adoption occurs in public healthcare institutions. Moreover, the task teams might not have adequate environmental knowledge of the areas in which the technologies are intended to be deployed. Instead, the Government of Zimbabwe should decentralise decision-making to local levels, instituting boards responsible for digital health interventions. The decentralisation of digital health decision-making would resonate with the national drive on devolution of power (Constitution of Zimbabwe, 2013). The national ICT policy was regarded by some respondents as having a positive impact on the potential adoption of emerging technologies to promote under-five healthcare. It emphasises bridging the digital divide and focuses on connecting rural areas as well as supporting digital health innovations.

Computer literacy

Some public healthcare professionals and mothers of under-fives in Makonde District lack computer skills. One nurse argued that some of the mothers are primary school graduates or have never been to school at all. If nurses lack computer skills, she reasoned, those mothers would obviously lack them too. Lack of computer skills was also identified as a challenge among some healthcare professionals in Zimbabwe (Bishi et al., 2017; Furusa & Coleman, 2018). A senior paediatrician from Chinhoyi Provincial Hospital encouraged the Ministry of Health and Child Care to have a computer literacy policy aimed at ensuring that all public healthcare professionals get basic computer skills to empower them for the digital health revolution. Zimbabwe has established Community Information Centres (CICs) with the aim of bridging the digital divide in rural areas by providing access to ICT services like internet and printing, as well as providing training in basic ICT skills. POTRAZ collaborated with the Ministry of Information, Postal and Courier Services and Zimpost to establish at least 210 CICs in the country (Pikirayi, 2018). These CICs could be used to train and empower public healthcare professionals in Makonde District to acquire basic ICT skills, which are critical in facilitating digital paediatrics adoption.

Misinformation and misinterpretation

Oftentimes, there are individuals in communities who pretend to be enlightened and tend to mislead others. Examples of misinformation about COVID-19 vaccines were cited as examples, and some healthcare professionals believe that misinformation could hinder the adoption of some emerging technologies by mothers of under-fives and pregnant women. Moreover, some women may prefer physical contact with healthcare professionals. It was noted that health education provided through social media might be misinterpreted. However, social media has been successfully used to provide genuine health education and information about COVID-19 and vaccines by several health bodies and governments globally, debunking some misinformation that is rampant on social media (Mbunge, Batani, et al., 2022). With the rise in social media popularity, using it to provide health education could widen the audience reached (West, 2015). However, the social media accounts of health institutions should be verified by social media companies to differentiate them from the fake accounts imitating them. Doing so would help patients quickly identify fake information. The content shared on social media should include visual content in the main local languages, customised from region to region. Using videos to provide health education on social media, where patients can see, relate and identify the person sharing the information, could increase their trust, especially if the content is delivered by healthcare professionals they know. Social media has also been declared a health concern due to rampant cyberbullying, whose effects could be psychological (Batani et al., 2022; Paul et al., 2022; Sadiq et al., 2021).

Mobile phone ownership

Mobile phone ownership among mothers of under-fives is estimated to be as high as 90 per cent in some areas like Matoranjera, 85 per cent in Mutala, 70-80 per cent in Portlet, 70 per cent in Umboe, 50 per cent in Nyamugomba and 30 per cent in Doma as estimated by the healthcare professionals working in those areas. Smartphone ownership among the mothers of under-fives who participated in this study was over 81 per cent, while 66.48 per cent of the women who participated in the MICS study by the ZIMSTA in 2019 owned mobile phones. Generally, the ICT indicators for Zimbabwe are good, especially internet and mobile phone penetration, which are above 60 per cent and 90 per cent, respectively (POTRAZ, 2019, 2020). High mobile phone ownership presents opportunities for disseminating health educational information to parents and guardians of under-fives. Health education could help change behaviours, including health-seeking behaviours (Chadoka-Mutanda & Odimegwu, 2017) and equip parents and guardians with disease prevention knowledge (Sharma & Gupta, 2017).

Resistance to change

A shift to emerging technologies might face resistance from mothers of under-fives and healthcare professionals. During the introduction of the electronic health record in public healthcare institutions in Makonde District, some patients resisted the technology as they considered the technology slow and delaying them. Healthcare professionals complained that the electronic health record system was unfriendly, leading to delays. This led to complaints against nurses to their superiors, asking them to abolish the technology. Moreover, some of the parents had not been sensitised about the new technology. Nurses complained that since parents had not been sensitised to the new development, some of them thought the healthcare professionals were on WhatsApp using tablets, yet they were entering patient data.

However, a specialist paediatrician argued that resistance is always expected, but education and sensitisation can minimise it through behaviour change. Resistance has always been mentioned in virtually all studies on factors affecting digital health adoption (Furusa & Coleman, 2018; Sagaro et al., 2020). When the Chinhoyi Provincial Hospital introduced the Neotree system, cases of resistance were reported. However, healthcare professionals slowly and willingly adopted the technology after realising its benefits to those who were using it. As explained by the DOI theory, technology users do not all accept it simultaneously; rather, there are early adopters, early majority, late minority and laggards (Rogers, 1983a). The behaviour of those healthcare professionals who initially resisted the Neotree but later adopted it after observing its benefits could be explained by the DOI's observability variable, which is the extent to which the benefits of the technologies are visible to others (Rogers, 1983a). Most mothers of under-fives indicated that they would adopt the technologies provided they are convinced that they are good for their babies. They said they would accept anything that makes their babies live longer and improves their health and well-being. Involving healthcare workers in designing digital interventions for minimising under-five mortality in Makonde District could reduce resistance as they would have a sense of ownership of the technologies. Some respondents argued that even the fear of medico-legal hazards was merely a form of resistance, given that the health professionals' work is already mired in medico-legal hazards.

Lack of trust

Some patients do not trust the technologies and might think their information is being used for other purposes, according to some nurses. Lack of trust in digital health interventions is often influenced by ethical issues like repurposing (Mbunge, 2020; Sun et al., 2018). Moreover, others might be less confident in the technologies' ability to deliver quality healthcare, making them reject the emerging technologies in preference for physical interaction with physicians (Ibekwe & Fasunla, 2020). Healthcare institutions should produce comprehensive terms and conditions that explicitly explain how patients' data will be used, conveyed and stored, allowing patients to make informed consent (Mbunge, Batani, et al., 2022). A lack of trust has been an issue in several studies related to digital health adoption (Abid et al., 2022; Farao, 2020; Furusa & Coleman, 2018; Mbunge, 2020; Mbunge, Fashoto, Akinnuwesi, et al., 2021; Mbunge, Millham, Sibiya, Fashoto, et al., 2021).

Resource shortages

The under-resourcing of public healthcare institutions in the Makonde District was perceived as a potential impediment to the adoption of emerging technologies. The health facilities are understaffed as some healthcare professionals are leaving the country for greener pastures, with nurses mentioning that some of their colleagues recently left the country. This finding is consistent with that of Nyandoro et al. (2016), who carried out a study on the retention of healthcare professionals in Zimbabwe's rural areas. Emerging technologies could provide relief to the shortage of workforce (Haley et al., 2017) through technologies that facilitate diagnosis support (Alcantara et al., 2017; Salman et al., 2020; Souid et al., 2021) and remote consultation (Mbunge, Muchemwa, et al., 2022). However, there is a shortage of ICT equipment in Zimbabwe's rural healthcare institutions. For instance, it was reported that departments share tablets to use for electronic health records. The sharing of gadgets means patient data cannot always be captured at the time of collection. As a result, nurses have to record the data on paper and then transfer them to the electronic health record system. This double entry was making the already demotivated healthcare professionals shun the electronic health record as they considered it extra work. Resource shortages are a perennial problem in low-resource settings. Previous studies in e-health adoption in Zimbabwe also found resource shortages to be an impediment (Bishi et al., 2017; Furusa & Coleman, 2018). Thus, the adoption of emerging technologies was viewed as requiring sufficient funding to provide enough resources. However, it is noteworthy that tablets and network connections were being provided to facilitate the deployment of the electronic health record system, marginally improving access to and availability of ICT resources in public health facilities in Makonde District.

Lack of involvement

Public healthcare professionals in Makonde District decried their lack of involvement in digital technologies' design and the whole process. Their lack of involvement was perceived as contributing to the design of user-unfriendly systems. They want to be involved from design throughout the entire process, not just to be trained on the use of the technologies. One nurse asked if the people who designed the electronic health record were healthcare professionals at all due to the way it is designed. Involving both healthcare professionals and patients in digital health systems' design would them have a sense of ownership (Mbunge, Muchemwa, Jiyane, & Batani, 2021), increasing the chances of adoption. Stakeholder involvement is important in bringing a sense of ownership of the technology to the healthcare professionals.

Lack of training and knowledge inadequacy

Several public healthcare professionals in Makonde District lack computer skills. They complained that the hasty training sessions they attend are too short for them to grasp the concepts, asking for at least a fortnight's training. They indicated that they are not trained in using digital technologies at the nursing colleges; thus, they are not techno-savvy. They would want more time to understand these technologies. For instance, nurses were trained on the electronic health record for one week, and some considered it too short to grasp everything. Some healthcare professionals in Makonde District lack knowledge of the potential benefits of emerging technologies. The lack of knowledge is a source of resistance to change; as such, people will resist emerging technologies. This was the case when Neotree was introduced at Chinhoyi Provincial Hospital. People rejected it due to a lack of knowledge, but after seeing others using it and the benefits it brought, they later accepted the technology. Training healthcare professionals to be proficient users of digital health systems is essential (Furusa & Coleman, 2018; Olok et al., 2015).

Demotivation

Public healthcare professionals in Makonde District expressed frustration and demoralisation fuelled by poor working conditions. This frustration could make them reject technologies introduced at health facilities. The apathy is exacerbated by the involvement of managers in training on how to use digital health systems when they do not work with the systems themselves but attend training seminars for allowances. While there are some healthcare professionals who indicated that they would adopt the emerging technologies, others indicated that they would not want anything further added to their work.

User-friendliness

Some healthcare professionals in Makonde District are inept computer users, while other health facilities are understaffed. Consequently, they are unwilling to use any technologies that are unfriendly and make them appear to be working more than they would without the technologies. It is crucial to ensure that the deployed digital health systems are user-friendly in terms of ease of use, response time, input capturing and easy-to-learn.

Power supply

Digital health systems need to be powered. However, some clinics in Makonde District do not have electricity, for instance, Nyamugomba clinic. The clinic was using solar energy, but it developed a fault in 2021 and had not been fixed. It destroyed the batteries, inverter and charging control. They only had two working solar panels that they bought using the clinic's results-based financing (RBF) funds. Though they were working with the Zimbabwe Electricity Supply Authority (ZESA) to electrify the clinic, they still needed solar panels as backup power. Even at those clinics with electricity supply, it is unreliable due to load shedding. Zimbabwe has experienced load shedding for years (Batani et al., 2017) as Zimbabwe Electricity Transmission and Distribution Company (ZETDC) grapples with meeting the national electricity demands. However, some sites, like Chinhoyi Provincial Hospital, have solar panels for backup. The problem is it took too long to fix malfunctioned solar systems.

Cost of acquisition, resource shortages and lack of funding

The cost of acquiring, maintaining and sustaining emerging technologies at every public healthcare institution in Makonde District was perceived to be higher than what the government could afford. Moreover, the training costs were also viewed as a potential impediment due to the underfunding of healthcare institutions by the government. Due to underfunding, public healthcare institutions are under-resourced. However, Zimbabwe's healthcare is usually funded by donors, as mentioned by the participants. Nonetheless, emerging technologies can reduce operational costs (Malila & Mutsvangwa, 2019). Cloud computing could help reduce hardware and maintenance costs (Sarangi et al., 2021).

Unstable network

Makonde District has urban, semi-urban and rural areas. While there is a relatively stable mobile network and internet connectivity in some areas, other areas have poor mobile and internet connections, where people have to walk to certain spots to access a network. It was noted that in Kazangarare, there is completely no network, as stated by one of the respondents stationed at Chinhoyi Provincial Hospital. Connectivity has been consistently mentioned as a challenge in Zimbabwe whenever the adoption of digital innovations in rural areas is mentioned (Batani et al., 2019; Furusa & Coleman, 2018). However, 70 per cent of the clinics in Makonde have a fairly stable mobile network connectivity, according to the DMO's office. The poor network connection was also indicated by doctors in previous studies as an impediment to digital health adoption in Zimbabwe (Furusa & Coleman, 2018; Nyandoro et al., 2016). Network connection in low-resource settings is usually a challenge. However, satellite internet solutions could enhance connectivity in rural and disaster-stricken areas as well as war zones (Carpenter, 2022; Lerman & Zakrzewski, 2022). Starlink, a satellite internet provider, successfully provided internet access to Ukraine during Russia's invasion (Carpenter, 2022). Instead of providing clinics with 50GB monthly data allocation, which usually depletes before the month ends, the Government of Zimbabwe and/or its supporting partners could consider shifting to satellite internet.

7.3.4 Research Objective 4: Identify the perceived potential role of emerging technologies in reducing U5M in Makonde District's public healthcare

The perceived role of emerging technologies in reducing under-five mortality in Makonde District's public healthcare institutions is presented from three perspectives, namely, disease prevention, management and improving quality of care. Figure 25, Figure 26 and Figure 27 depict the perceived potential role of emerging technologies in reducing under-five mortality in Makonde District's public healthcare institutions from the perspective of healthcare professionals.

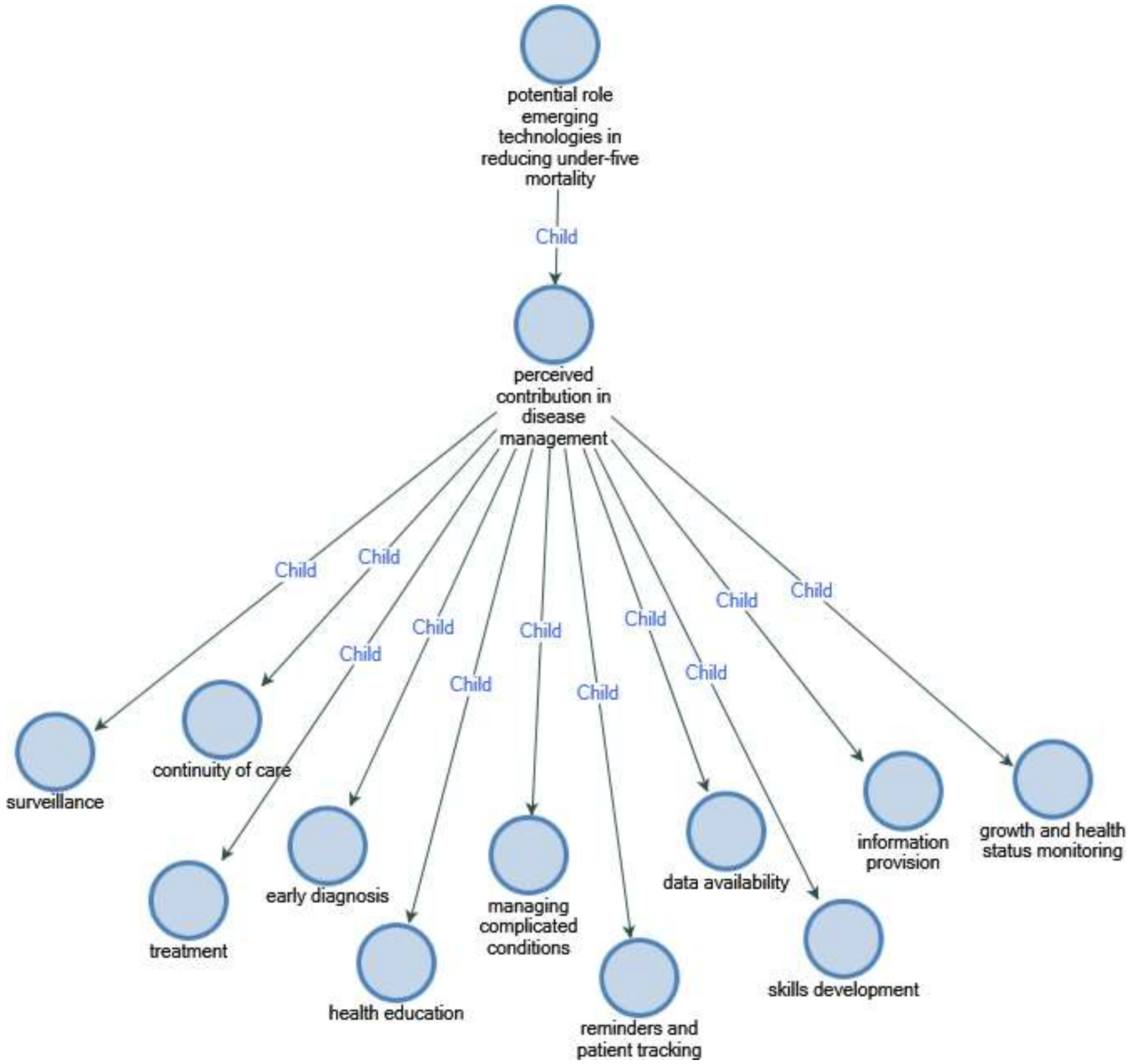

Figure 25: Perceived role of emerging technologies in managing diseases among under-fives in Makonde Dsitrict public healthcare institutions

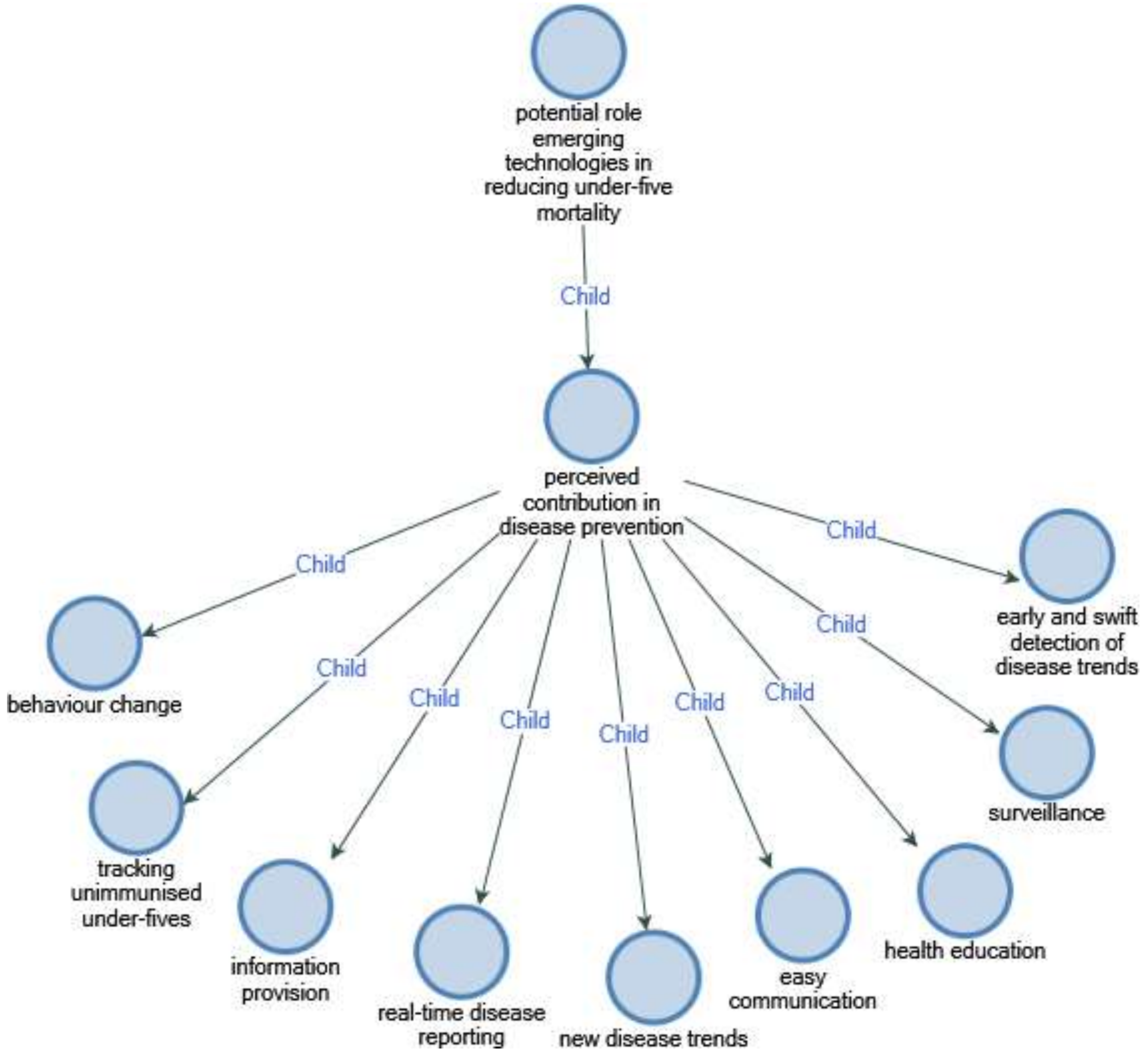

Figure 26: Perceived role of emerging technologies in preventing diseases among under-fives in Makonde District

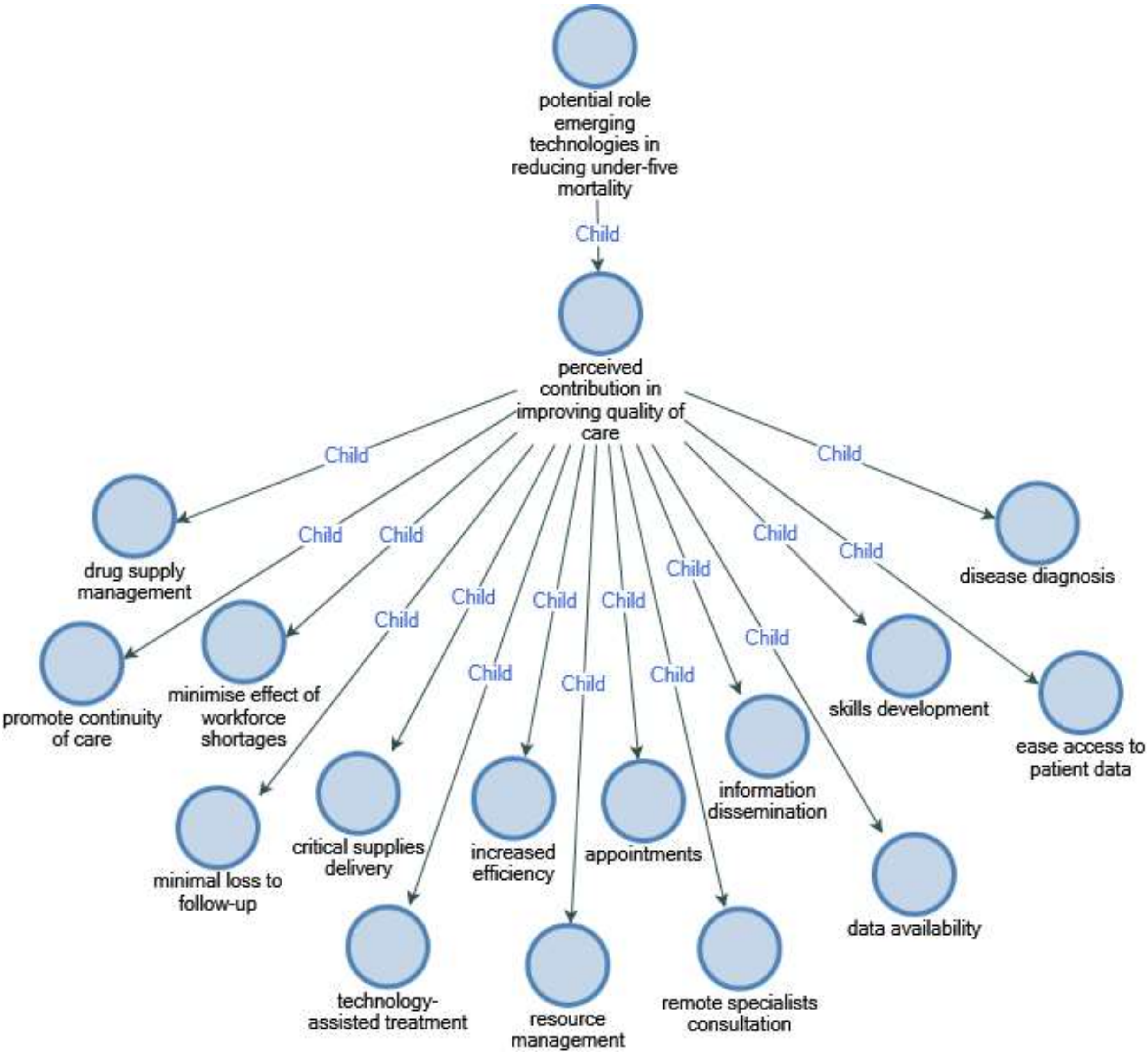

Figure 27: Perceived role of emerging technologies in improving the quality of care

While some of the roles/themes are cross-cutting, the way they contribute to each of the three pillars is different. However, the researcher bundled the roles, with the discussion of each showing how technology contributes to each pillar.

Health Education

Health education is critical in promoting public health (Sharma & Gupta, 2017) and influencing behaviour, such as maternal, neonatal and child health-seeking behaviour (Chadoka-Mutanda & Odimegwu, 2017; WHO, 2014). This study revealed that emerging technologies could be used to provide health education to mothers and guardians of under-fives on disease prevention and management of certain conditions. Educational information on how to prevent diseases among under-fives, the importance and duration of exclusive breastfeeding, immunisation and early treatment seeking could be easily spread from genuine and trustworthy sources through emerging technologies. One respondent claimed that there was a case of a grandmother who would apply cowdung to a baby's (her grandchild) wound, claiming that it was a way of treating it. However, that exposes babies to further infection, and that was attributed to a lack of knowledge on public healthcare issues. The role of mass media in public health education has been studied by many researchers, the findings of which all attest to the positive contribution of the technologies in improving healthy behaviours (Alshammari et al., 2017; Balamurugan, 2018; Naveena, 2015; Sharma & Gupta, 2017). Behaviour and attitude change is critical in promoting disease prevention (Sharma & Gupta, 2017).

As they often say in health circles, "prevention is better than cure". Educating parents and guardians on how to prevent diseases among under-fives (such as boiling water before drinking, serving food while still hot and washing hands before handling food) could help reduce mortality. Through education and awareness programmes, healthcare institutions can persuade target audiences to change behaviours, remind them of critical health information and update them about new diseases and where to seek medical help (Balamurugan, 2018). Zimbabwe has experienced outbreaks of preventable diseases like measles due to children missing immunisation (ZLHR Legal Monitor, 2010). Health education and awareness can influence behaviour and change attitudes towards health and healthy behaviours; for instance, healthcare institutions can educate pregnant women on the importance of having regular check-ups throughout the duration of pregnancy and mothers of under-fives on the importance of ensuring that their babies get all the essential vaccines (Sharma & Gupta, 2017).

Parents and guardians could also be taught about child rights and the criminality of denying children access to healthcare. Moreover, the study revealed that some people in Makonde District use unscientific home remedies like using cow dung to treat wounds, which would lead to infection. Mass media technologies like social media, TV, radio and electronic billboards could help disseminate health educational information. Electronic billboards could provide visual health education, like how to manage certain minor conditions, how to make homes and the environment clean, how to stop mosquito breeding sites and the benefits of family planning. However, these electronic billboards should be strategically positioned. They need to be placed in busy places, such as where people queue up for services since some of the queues take too long to be cleared, and people could be left with no option but to watch what will be displayed on the electronic billboards.

Tracking Unimmunised Children

Globally, many children missed essential immunisations due to COVID-19-induced challenges like resource redirection and national lockdowns (S. Gupta & Jawanda, 2020; Roberton et al., 2020). Access to critical immunisations and vaccines for under-fives was disrupted, impacting access to measles immunisation in at least twenty-seven countries in 2020 (UN News, 2020). As the world lifted COVID-19 restrictions and infections lowered due to vaccines (Chitungo et al., 2021; Mbunge, Fashoto, & Batani, 2021), it is critical to administer all the missed immunisations by under-fives. However, manually tracking all unimmunised children is difficult. Tracking the immunisation statuses of under-fives is a challenge faced by public healthcare institutions in Makonde District. Using hard copy records makes it difficult to quickly generate reports of who is due for what immunisation at any specific time. Moreover, it is difficult for them to identify defaulters quickly. The respondents stated that immunisation is crucial in preventing diseases among children, and those who miss it will be susceptible to diseases and infections. Emerging technologies could help keep track of who is yet to receive what vaccine, making it easier for them to ensure every eligible child gets the necessary vaccines and boost disease prevention.

Early Disease Trends Detection

Detecting disease trends and identifying outbreaks would help take preventive and precautionary measures. Healthcare professionals viewed emerging technologies as useful in detecting disease trends on time. It is possible to track disease outbreaks in real-time (Carneiro & Mylonakis, 2009) and plot outbreak maps (Schmidt, 2012). Emerging technologies can detect disease outbreaks faster than traditional Centres for Disease Control and Surveillance Systems (Carneiro & Mylonakis, 2009).

Surveillance and Real-time Reporting

Surveillance and real-time reporting of disease outbreaks were said to be critical components of disease prevention. At the time of data collection, public healthcare institutions were using SMSs to report on diseases weekly (Weekly Disease Surveillance System). However, the respondents argued that real-time surveillance and reporting would be more effective than weekly reporting. A doctor from Chinhoyi Provincial who is interested in big data analytics mentioned that real-time surveillance and reporting would quickly show the distribution and concentration of disease outbreaks, making it easier to prioritise and make timely interventions. Disease surveillance helps quickly identify outbreaks and make timely interventions (O'Mara Sage et al., 2019).

Managing Complicated Conditions

It was noted that some of the under-fives cannot talk to tell their symptoms to help determine the appropriate methods to deal with the ailments. Moreover, all the clinics in Makonde District do not have resident doctors as all the doctors are stationed at the provincial hospital. The unavailability of doctors at clinics means if the nurses fail to manage and treat a condition, they refer the patients to the provincial hospital. However, the time it takes to get to the nearest referral hospital is usually long due to bad roads and transport problems. As a result, some under-fives die due to delayed access to medical services. With emerging technologies, the respondents believed nurses could quickly and remotely get assistance from specialists stationed not only at the provincial hospital but even beyond. This would reduce the number of referrals to the provincial hospital, help nurses manage complicated conditions and save lives. Moreover, the medical internet of things could help ubiquitously monitor under-five patients with special needs. IoT-based innovations are increasingly emerging in healthcare in areas such as the remote collection of patient health data and monitoring adherence to medication and treatment (Islam et al., 2015). Through IoT, applications have been developed to remotely monitor health parameters for pregnant women and foetuses, leading to reduced maternal, prenatal and under-five mortality (Amala & Mythili, 2017). Furthermore, IoT is being used to provide input data to patient care systems to discover new disease information that feeds into early disease detection and critical decision-making to improve quality of life (Jagadeeswari et al., 2018). Using wearable devices, patients can monitor the health status of their under-fives with special needs. Moreover, healthcare professionals could be automatically alerted when patients deteriorate or their physiological parameter readings go beyond normal ranges. The benefits of IoT in healthcare include higher service quality, lower service cost, reliable preventive care (Fayez, 2018; Islam et al., 2015), personalisation of healthcare (Jagadeeswari et al., 2018), remote monitoring of patients' health, adherence to medication and treatment by patients at home, enriching users' experience and improving the quality of life (Islam et al., 2015).

Early Disease Diagnosis/ Diagnosis support

Some diseases require specialists to diagnose or interpret test results. However, low-resource settings inherently lack specialists. Emerging technologies help with disease diagnosis, with reports of technologies like deep learning outperforming human experts in diagnosing malignant tumours (Davenport & Kalakota, 2019). An experienced paediatrician indicated that the basic management of under-fives requires timely interventions whenever they are sick.

Consequently, early diagnosis of diseases among under-fives is key in ensuring timely medical interventions. The paediatrician stated that technology could help parents get medical advice remotely from physicians without having to walk long distances to the nearest health facility, especially for minor problems. Moreover, Makonde District clinics were said to be understaffed with a lack of access to doctors and specialists except at the provincial hospital. Deep learning is helping medical experts in detecting clinically relevant features in imaging data beyond what the human eye can perceive (Vial et al., 2018). AI has already proven its remarkable capability to be useful in the healthcare domain, but the biggest challenge is ensuring its adoption in daily clinical practice (Davenport & Kalakota, 2019, p. 97). Moreover, emerging technologies can support health workers in carrying out clinician duties in the absence of doctors, can help keep track of patients and enable remote consultations (Blaya et al., 2010). AI was perceived to reduce misdiagnoses by both nurses and doctors, helping them make good judgements and manage patients. Improving diagnosis would reduce human errors and potentially save the lives of under-fives. Moreover, 3D printing improves efficiency and enables the personalisation and customisation of care (Shilo et al., 2018; Ventola, 2014). However, a low-resource area like Makonde District could struggle to have the sufficient computing power to execute AI models, hence, the need to use cloud computing. With cloud computing, the models will run on the cloud and healthcare professionals can access them on a device.

Some of the uses of this technology in health include surgery pre-planning, surgery customisation and patient-specific implants design (Shilo et al., 2018), bioprinting of organs and tissues, tissue and organ fabrication, creation of customised prosthetics, pharmaceutical research on drug dose and forms, delivery and detection (Ventola, 2014). 3D printing technology has numerous advantages in healthcare, including customisation and personalisation of healthcare (products, drugs and equipment), cost-effectiveness, and increased productivity (Ventola, 2014). One of the midwives stated that emerging technologies like 3D printing could help provide personalised paediatrics.

Emerging technologies could minimise false positives and false negatives when interpreting test results. Moreover, they could reduce the need for specialists' deployment in clinics as nurses could use technology to help them and prescribe the correct medication. Nurses and doctors at Chinhoyi Provincial Hospital have benefitted from the Neotree system that was deployed in the Neonates ward.

Growth and Health Status Monitoring

Emerging technologies could help monitor the growth and health status of under-fives, helping to identify challenges and anomalies early enough to improve the management of such children. Generating growth reports is relatively easier using technologies. Healthcare institutions can monitor the growth of children remotely, including graphic monitoring, to quickly visualise children's growth (Shiffman et al., 2001) and take appropriate, timely corrective action if there is a need.

Information Provision

Emerging technologies can provide useful information upon which healthcare institutions can premise their decisions and inform their disease management strategies. Moreover, the technologies could help provide current information to healthcare professionals, such as new behaviour of certain pathogens and diseases and how to manage them. Similarly, technology can help disseminate information among healthcare institutions, healthcare professionals and patients. The respondents said ease of information access among healthcare professionals could improve service quality. Healthcare professionals can easily share notes among themselves, resulting in improved diagnosis and quality of care. Emerging technologies in healthcare can help medical professionals share the latest ideas on treating particular problems (West, 2015).

Skills Development

Managing diseases among under-fives happens in and out of healthcare facilities. For under-fives with special conditions, their parents and guardians would need to be educated on how to manage the conditions at home. One paediatrician (Respondent 10) stated that a lack of knowledge on how to manage certain conditions could worsen the babies before they get medical help. Moreover, participants from rural health facilities expatiated on the possibilities of healthcare professionals virtually attending training on how to manage new conditions for under-fives without having to leave their workstations. They claimed that some of the clinics are in remote areas, making them understaffed as professionals shun them. Allowing nurses to travel for training would worsen the staff shortages since even if the training would be for an hour or so, travelling from the clinics to Chinhoyi would take longer due to bad roads and terrains. Remote training sessions would allow nurses to be immediately available to their patients soon after the training. Remote training of healthcare professionals would improve their skills and improve the quality of care. They can learn how to handle certain conditions that could be newer, improving their skills. Community (village) health workers could also benefit from the training. Though continuous professional development is crucial, it is important to ensure that healthcare professionals remain onsite by limiting travel for both training and meetings (Bishi et al., 2017). Through technology, healthcare professionals can attend training sessions virtually while onsite. Ensuring that healthcare professionals remain on site is even more critical in developing countries like Zimbabwe, where there is a shortage of medical doctors (Ministry of Health and Child Care & University of Oslo, 2015; Ministry of Health and Child Care, 2016; Ministry of Health and Child Welfare, 2013).

Data Availability

Availability of and ease of access to patients' data was viewed as potentially helping with providing appropriate and personalised care and providing continuity of care to under-fives in Makonde District. Moreover, a paediatric cardiologist from Chinhoyi Provincial Hospital stated that with more patient data available, big data analytics could be performed to learn new trends and inform disease management methods. Responsible sharing of patients' medical data across institutions and healthcare professionals through electronic health records and health portals (Blaya et al., 2010) enables medical professionals to access patients' medical history and also creates opportunities for data-driven paediatrics (Bourgeois, 2022; Gout et al., 2021). Public healthcare institutions in Makonde District were introducing the electronic health record system at the time of data collection for this study. The deployment of the system started around November 2021 and was still ongoing, with some clinics yet to have it. The respondents expected this technology to improve data availability, helping in providing effective care to under-five patients.

Continuity of Care

Emerging technologies were perceived to promote continuity of care for under-fives, facilitated by the availability of patient data. Once captured, the data would be easier to share and access among healthcare professionals. Easy access to a patient's treatment history would enable continuity of care rather than when using paper-based records that can easily be torn or lost. However, emerging technologies by themselves may fail to promote the continuity of care if healthcare systems are fragmented (Mostert-Phipps, 2011). Ease of access, accuracy and accessibility of patient medical data are critical to facilitating continuity of care (Lemon et al., 2014). Using cloud storage could help improve data accessibility and thus facilitate continuity of care for under-fives in the Makonde District. Proper integration of the digital health systems is critical in facilitating technology-driven continuity of care (Maresca et al., 2019).

Behaviour change

Emerging technologies could help change the minds of those mothers and/or guardians of under-fives with poor health-seeking behaviours (Chadoka-Mutanda & Odimegwu, 2017; WHO, 2014). They could help people appreciate the importance of seeking medical help early (Chadoka-Mutanda & Odimegwu, 2017). For instance, watching television advertisements and educational videos on disease outbreaks, negative impact, prevention and control of diseased under-fives could change peoples' behaviours for the better, leading to reduced diseases among under-fives.

Reminders and patient tracking

Some respondents stated that emerging technologies would help manage diseases among under-fives in Makonde District by sending reminders and tracking patients. If an under-five patient is due for review, emerging technologies could identify them and alert the mothers and healthcare professionals, helping reduce loss-to-follow-ups. Patients could also be tracked, and their health statuses continuously monitored using emerging technologies. Sending reminders can influence patients' health-seeking behaviour (Watterson et al., 2015) and improve child health outcomes and maternal health by reminding women when they are due for antenatal, prenatal or postnatal care (WHO, 2014). When sending the reminders, it could be impactful to include a note on why that visit is important.

Treatment support/ Technology-assisted treatment and surveillance

One nurse indicated that technology-assisted treatment could improve the quality of care for under-fives in the Makonde District. They perceived emerging technology to reduce the chances of wrong treatment. Emerging technologies are supporting the treatment of patients both remotely and physically. Ventola (2014) explains how 3D printing shortens the duration of surgical operations, improves precision, and is used for personalised medicine by choosing appropriate therapies based on the genetic makeup or other molecular analysis of a patient.

Some medical researchers and healthcare institutions are using emerging technologies to track disease outbreaks (Carneiro & Mylonakis, 2009; Schmidt, 2012). Some patients attempt self-diagnosis by searching on the Internet, and that search provides a data point that medical researchers can use to track disease outbreaks and respond to pandemics (Schmidt, 2012). Moreover, it is possible to track disease outbreaks in real-time (Carneiro & Mylonakis, 2009) and plot outbreak maps (Schmidt, 2012). Emerging technologies can detect disease outbreaks faster than traditional Centres for Disease Control and Surveillance Systems (Carneiro & Mylonakis, 2009). The participants viewed technology-assisted treatment and surveillance as useful in improving disease management and quality of care for under-fives. Surveillance would help remotely and continuously monitor under-fives with special conditions.

Quick Delivery of Critical Medical Supplies

While some of the clinics are not very far from town, the roads are bad. A nurse stationed at Nyamugomba clinic, 38 kilometres from Chinhoyi, said that the road network is dilapidated, with two bridges near collapse, making it hard for them to get critical medication frequently. Another nurse at a clinic 48 kilometres from Chinhoyi said that because of the poor state of the roads, it would take them close to 3 hours from Umboe clinic to Chinhoyi Provincial Hospital. These challenges were associated with some under-fives dying due to delayed access to medication because even if they referred them to the nearest referral hospital, it would take a long time before getting there. Resultantly, healthcare professionals believed that using drone technology to deliver medication could help save lives and improve the quality of services offered at clinics. During the COVID-19 pandemic, the healthcare domain has witnessed a surge in the usage of digital technologies like autonomous machines, such as robots and drones (Mbunge, Muchemwa, Jiyane, & Batani, 2021). Some countries have used drones to enforce the observance of COVID-19 protocols like movement restrictions (Khan et al., 2021), disinfection of contaminated places and delivery of critical supplies like food and medicines (Restás et al., 2021; Zeng et al., 2020). Using drones for critical supplies delivery could help in disaster-struck and inaccessible areas. Though Zimbabwe's public healthcare is not presently using drones, the technology has been used in disaster recovery efforts in Cyclone Idai-hit Chimanimani (Mudzingwa, 2019). This technology may not only be useful to deliver essential supplies in rural clinics with bad roads but also the dispensary of critical medicines from the national pharmacies to where they are urgently needed.

Resource Management

Managing resources required to reduce under-five mortality was indicated as critical. For instance, there are drugs that would be needed by healthcare institutions to manage certain conditions to reduce under-five mortality, but they are not always available. Nurses at clinics mentioned that they receive drug consignments quarterly. Even if some essential medicines run out of stock, they will have to wait for the next consignment and meanwhile, they will be asking parents to go buy medicines from the pharmacies in Chinhoyi. Because most of the parents will be broke, they will not go buy the medicines, leading to the babies' conditions worsening. Moreover, the distribution of drugs to the clinics is not based on data and demand, resulting in some clinics getting drugs they already have and insufficient quantities for the drugs they need more. Emerging technologies could help provide insights on drug demands, provide real-time monitoring of stock levels and inform the district, provincial and national pharmacies on which drugs are used more at different sites. The data-driven pharmacy management would help respond to demands when distributing medical essentials. Though it was reported that the Chinhoyi Provincial Hospital was adopting an eLMIS funded by UNDP Zimbabwe for pharmacy management, the system does not monitor stock levels at remote health facilities in real-time (Hare & Snow, 2012).

Increased efficiency

The participants stated that using emerging technologies would reduce the queuing times of under-five patients at healthcare institutions. They said that technology would improve their efficiency and cut costs. Moreover, they said that if telemedicine could be introduced to connect clinics to the provincial hospital, it would help reduce the number of referrals since specialists could remotely diagnose under-fives and prescribe medication which the nurses could then dispense for free, as is the government's policy to offer free health services to under-fives. How technology can improve the efficiency of healthcare systems is succinctly explained by various researchers (Islam et al., 2015; Shilo et al., 2018; Ventola, 2014). Emerging technologies can help to efficiently schedule and allocate resources (Islam et al., 2015), unlike inefficient paper-based systems (UNDP Zimbabwe, 2015b, 2015a). Improving efficiency is immensely important, especially in resource-limited settings like Makonde District.

Minimal loss to follow-up (Quick identification of defaulters)

Nurses indicated that some women in rural areas are illiterate and cannot read dates written on their babies' health cards. Some are literate but forget important dates that they should visit health facilities, resulting in some under-fives missing important vaccinations and reviews. Such patients can easily default without the healthcare professionals noticing if they are using paper-based systems. However, with emerging technologies, healthcare professionals and mothers of under-fives can be alerted of impending or missed visits, making it easier for healthcare professionals to follow up on defaulters.

Remote specialists' consultation

With no doctors at clinics, nurses often refer patients to the nearest referral hospital for cases they find difficult to handle. However, bad roads and the parents' failure to afford to go to Chinhoyi result in them just staying at home even after the referral. With remote consultations using teleconsultation, the nurses believed that it would help improve the quality of care without patients having to travel. Telemedicine and the medical internet of things are typical technologies that could facilitate remote and pervasive patient care and consultation (Mbunge, Muchemwa, et al., 2022; Ndhlovu, 2021). According to Jutras and Duckett (1957), as cited in Marlene et al. (2002, p. 2), telemedicine refers to the use of telecommunication technology for providing healthcare services, "clinical information and education" remotely; for instance, transmitting medical images. Through telemedicine, healthcare professionals can remotely monitor, treat and diagnose patients.

What needs to be done for emerging technologies to be adopted in Makonde District's public healthcare institutions to reduce under-five mortality?

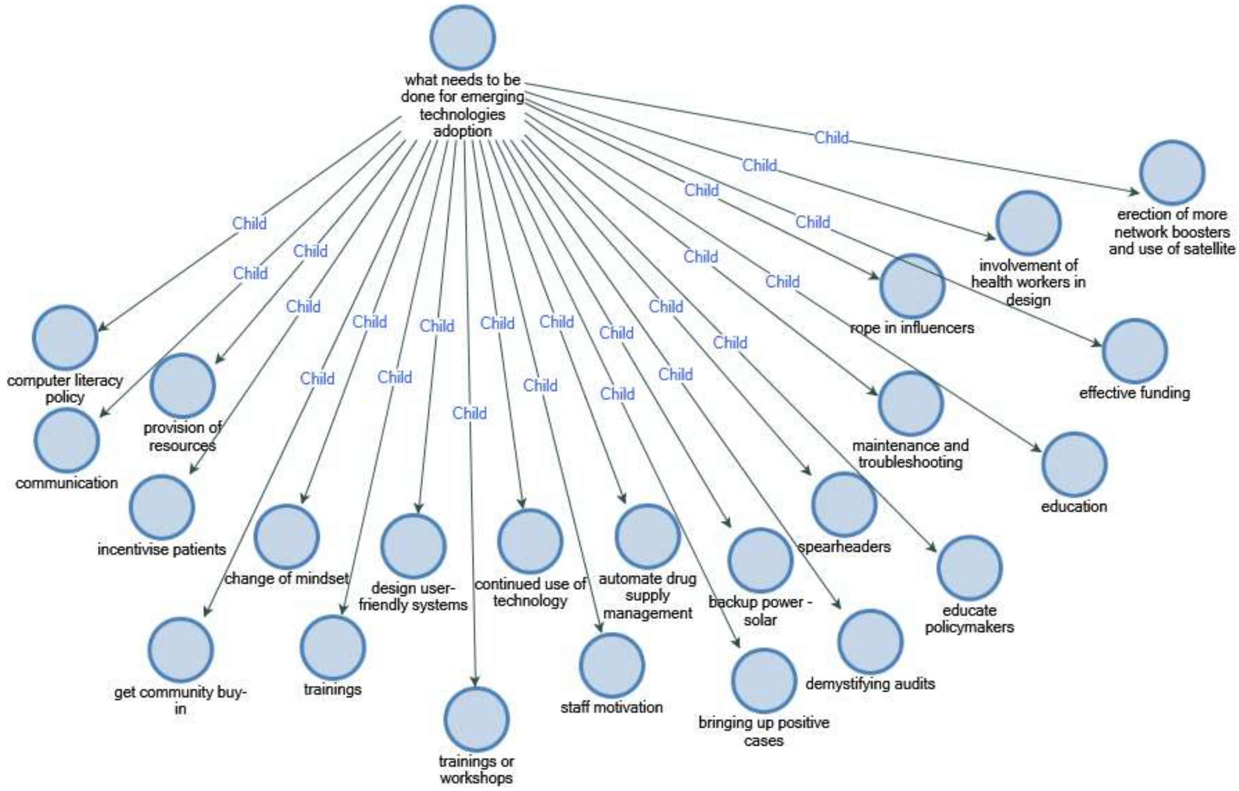

Figure 28: What to do for emerging technologies to be adopted in Makonde District's public healthcare institutions to reduce under-five mortality

The adoption of emerging technologies in public healthcare institutions in the Makonde District is still low. There is a dearth of digital healthcare systems, with the few that are available focusing on general healthcare and not specific to paediatrics, except the Neotree system that is only deployed at the provincial hospital. Several barriers to emerging technologies adoption were identified, and this section presents possible solutions that could improve the development, use and adoption of emerging technologies to reduce under-five mortality, as shown in Figure 28. Several impediments to emerging technologies adoption were identified in this study, including resistance to change, lack of computer skills, unreliable electricity, lack of knowledge about digital health technologies and their capabilities, fear of medico-legal hazards, lack of funding, unstable or unavailability of mobile phone network in some rural areas, centralisation of digital health decision-making, religious and cultural beliefs, shortage of resources, demoralised workforce, the influence of social leaders and understaffed health facilities. Unfriendly digital systems were also cited as a barrier.

The findings revealed that sensitisation and education could significantly reduce resistance to change. In some instances, observability of the benefits of using emerging technologies could also help reduce resistance. With understaffing and demoralisation, some public healthcare professionals in Makonde District are unwilling to adopt technologies out of frustration and the perception that they add more work. However, this is a case of ignorance, as was demonstrated in the case of the Neotree system. Initially, some nurses rejected the system, with a few adopting it. However, the adoption rate has gone up after those who rejected it observed the benefits enjoyed by those using it. The lesson from this case is that, if technology is good for healthcare professionals and the benefits are observable, those rejecting the technology could adopt it later. Another significant lesson from this was that when introducing technology, start with the few who are onboard and let the apparent benefits attract more users. The demotivation and frustration of public healthcare professionals could present unprecedented opportunities to introduce technologies that reduce their workload, improve efficiency, and minimise their effort.

Religiosity is often a hurdle not just when introducing technologies but proved to be a stumbling block even in administering the COVID-19 vaccines (Chu et al., 2021; Viskupič & Wiltse, 2022). Utterances by religious leaders and influential community members like social media influencers, politicians, traditional leaders, local business people and headmasters can affect their followers' intention to adopt emerging technologies. It is crucial to ensure that these influencers get the right information and do not misinform people. These have to be absorbed in digital health deployment programmes to help influence people's perceptions, intentions and actions. These could be important to change people's mindsets and allay any fears, doubts and suspicions people could be having.

Education is a crucial pillar in improving the chances of emerging technologies adoption in the Makonde District. All stakeholders require education, from policy-makers to patients and healthcare professionals. Policy-makers need to be educated about emerging technologies, how they work and how they could improve under-five health outcomes. Case studies of where these technologies positively contributed toward child health outcomes could arguably help convince policy-makers to have technology-driven paediatrics in the district. The Ministry of Health and Child Care could also consider having local communities on digital technology to spearhead the implementation of digital paediatrics.

Effective funding, demystification of the purpose of audits, training healthcare professionals on computer literacy, continued use of technology, provision of backup power, design of user-friendly systems and decentralisation of digital health decision-making could arguably improve the chances of emerging technologies adoption in Makonde District's public healthcare institutions.

7.3.5 Research Objective 5: To develop an emerging technologies adoption framework to help reduce under-five mortality in public healthcare facilities in Makonde District

An emerging technologies adoption framework to reduce under-five mortality in Makonde District's public healthcare institutions

The dearth of adoption of emerging technologies in Makonde District's public healthcare institutions to reduce under-five mortality motivated the design of an adoption framework to help reduce under-five mortality. The bases of the proposed framework's design are the study's findings and discussion. The framework focuses on how to handle the identified impediments to emerging technologies adoption.

Healthcare is a highly regulated domain due to its nature and the direness of the consequences of a lack of guidelines and regulations. The national ICT policy, cyber security bill and national e-health strategy are critical components of digital health innovations. However, these should be up-to-date with technological innovations to ensure that patients reap the benefits of technology while minimising any technological consequences they may suffer as a result. Zimbabwe's regulatory frameworks recognise and promote digital health innovations, though they do not clearly define the scope of the permissible innovations. However, any emerging technologies that may be introduced to reduce under-five mortality in Makonde District must fall within the confines of the law and regulatory frameworks.

The impediments to adoption include resistance, fear of medico-legal hazards, resource constraints, religiosity, lack of computer skills, centralisation of digital health decision-making, network challenges in rural areas, unreliable power supply and demoralised workforce. This proposed framework suggests ways of minimising the impact of these impediments. The framework recognises the enablers of emerging technologies adoption in the form of high penetration rates of mobile phones and the Internet, the high willingness by healthcare professionals and mothers of under-fives to adopt technologies to promote the health and wellbeing of under-fives, the introduction of the electronic health record, high social media presence and the availability of community information centres for computer skills training. The community information centres (CICs) are open to everyone for basic computer skills training, without any minimum educational requirements placed. The CICs present computer skills training opportunities for healthcare professionals, helping bridge the computer skills gap currently existing.

Effective funding is required for the adoption of emerging technologies. The funding sources include the Government of Zimbabwe, public-private partnerships, donors and results-based financing (RBF). RBF funds were used at Nyamugomba clinic, for example, to provide solar power. Funding is required to purchase ICT equipment, software licenses, training users, and general systems support, maintenance and upgrading.

Presently, the central government is involved in all digital health decision-making regarding what technologies are introduced, where and when. This results in red tape with elongated processes followed that involve the minister's office. The framework suggests this should be revised and decision-making devolved to local offices like district and provincial offices. Localisation would allow the local people to prioritise and introduce systems that are more critical in their environments. Technical task teams should be established and mandated to spearhead the local digital health drive. The Minister's office should be mandated with designing regulatory frameworks to clearly guide any digital health interventions and ensure they fall within the legal dictates of the country.

There is a need to address the unreliability or unavailability of mobile phone networks in rural areas. While erecting more base stations could help, mobile phone operators may not be interested in doing so since the areas could not be profitable. Thus, satellite internet should be considered as it does not require mobile phone operators to invest in infrastructure like base stations (Lerman & Zakrzewski, 2022). This could help reduce the digital divide and create an enabling environment for digital health introduction in rural areas.

While addressing the identified impediments could arguably encourage the adoption of emerging technologies to improve disease prevention, management and quality of care for under-fives in Makonde District, the determinants of adoption in the form of the DOI and UTAUT constructs should not be ignored as they also influence the willingness to adopt the technologies. These constructs include knowledge variables, observability and trialability, as well as facilitating conditions, effort, and performance expectancy constructs.

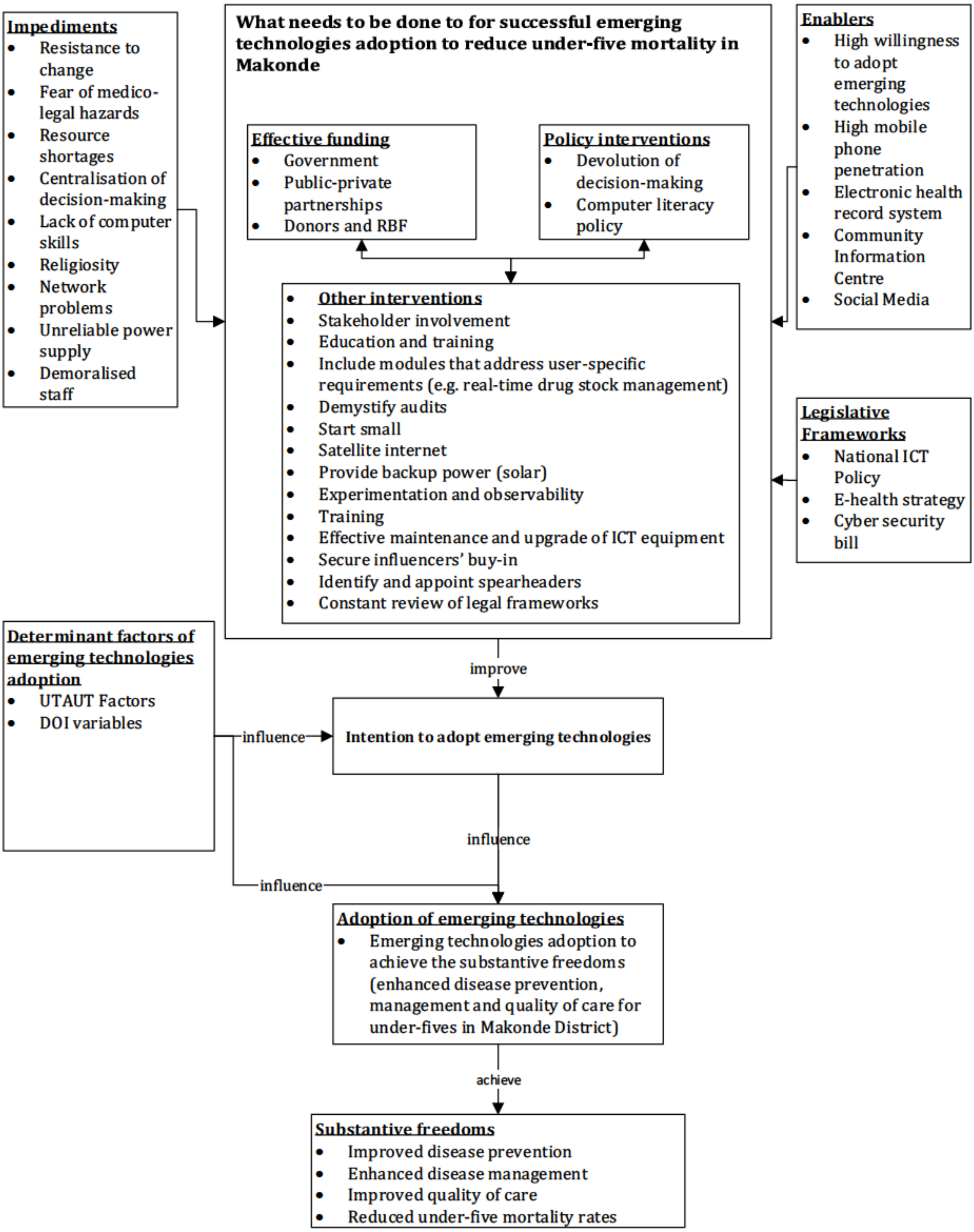

Figure 29: Emerging technologies adoption framework to reduce under-five mortality in Makonde District's public healthcare institutions

Related frameworks have been developed before, such as by Leonard et al. (2018), Ndayizigamiye and Maharaj (2016), and Nikou et al. (2020). However, a framework by Nikou et al. (2020) only had three constructs, capabilities, intention to use and the importance of digital technology among the elderly. Similarly, other frameworks did not include proposed interventions, like Ndayizigamiye and Maharaj (2016). Some of the frameworks did not include capabilities (Leonard et al., 2018), while others incorporated fewer theories (Nikou et al., 2020) or were based on literature review (Almalki et al., 2022). Moreover, a "one size fits all" approach to digital health adoption may not work since circumstances differ. Hence, this framework is unique as it speaks to the needs and circumstances of Zimbabwe's public healthcare, informed by the findings of the exploration. Nonetheless, it could be applicable to similar contexts.

The proposed framework is likely to enhance emerging technologies adoption and use by parents and guardians of under-fives and public healthcare professionals in Zimbabwe. Using emerging technologies could reduce misdiagnoses, and enhance the quality of care, efficiency and access to paediatric care. Usage of emerging technologies could pave way for data-driven digital paediatrics in the public health domain in Zimbabwe, unlocking opportunities in personalised and pervasive paediatrics. Chiefly, the success of this framework would increase Zimbabwe's chances of achieving the SDG 3.2 target on under-five mortality rates.

However, implementing the framework requires political will and commitment by the Government of Zimbabwe. Devolving digital health decision-making, for example, takes government commitment and will as it entails handling down control to lower offices. Moreover, religiosity is likely to present the hugest challenge, unless implementers obtain the buy-in of religious leaders whose followers tend to blindly follow them.

7.4 The Most Feasible Technologies to Reduce Under-Five Mortality in Makonde District's Public Healthcare Institutions

The results indicated that the respondents perceived the most feasible technologies to integrate in public paediatrics in Makonde District as mass media (radios, televisions and electronic billboards), social media, mobile technologies, medical chatbots, cloud computing and artificial intelligence. With the high mobile phone and internet penetration rates in Zimbabwe (POTRAZ, 2021a), there are high chances of such technologies like SMS, social media and mobile applications could succeed in public paediatrics in Zimbabwe. Zimbabwe introduced the electronic health record in public healthcare institutions. This system came with tablets to be used for data entry, increasing the availability of ICT gadgets in public healthcare institutions.

The private sector is already using social media, mainly WhatsApp and Facebook, to provide prenatal and postnatal health education to pregnant and nursing mothers. For instance, it emerged that the First Mutual Health, a private health insurance company in Zimbabwe, has WhatsApp groups for that purposes. These groups are administered by qualified healthcare professionals, including midwives. Such groups are helping provide health education and facilitate healthy behaviours by mothers of under-fives. However, the public health sector is lagging behind, with no such groups administered by public healthcare institutions in Makonde District. Community radios could also be used to provide public health education (Sharma & Gupta, 2017) on how to care for under-fives. Unlike with radios where some areas have community radio stations, Zimbabwe has only one national television channel and a few internet TV channels like the Zimbabwe Television Network (ZTN). However, access to television in rural areas is limited. Nonetheless, the national TV could also be used to provide health education to the public on child care and wellbeing. Moreover, the participants viewed electronic billboards as useful in providing visual health education on how to care for and prevent diseases in under-fives. However, they emphasised the need to use the main local languages and strategically position the electronic billboards. Using electronic billboards for public health education helps patients learn better through visuals, especially where the education involves demonstrating how to do certain things. Visuals may help attract people's attention, thus, facilitating learning.

Medical chatbots (medical virtual assistants) were also viewed as a feasible technology for reducing under-five mortality in Makonde District. Medical chatbots enable interaction between the system and patients use artificial intelligence to provide intelligence to the system. Virtual assistants proved their usefulness during the COVID-19 pandemic, with several healthcare authorities (such as in South Africa) and the World Health Organisation using them to provide an interactive platform for the public to access official COVID-19 information and statistics (Mbunge, Batani, et al., 2022). These could be used to provide educational and statistical information on child care and under-five mortality as well as disease outbreaks among under-fives in different places. They are normally integrated to social media platforms like WhatsApp and Facebook, requiring no special and additional technologies for users currently on social media. However, the medical chatbots could need to be hosted on the cloud so that the processing is not done on users' phones.

Cloud computing helps reduce costs by eliminating the need to have inhouse servers and providing ubiquitous data access (Batani & Maharaj, 2022a). Cloud computing usage in digital healthcare is rising with several applications hosted on the cloud (Aceto et al., 2020; Fong & Chung, 2013; Griebel et al., 2015; Kumari et al., 2018; Sarangi et al., 2021). However, the storage of patients' data on the cloud has raised security and privacy concerns among other patients (Jagadeeswari et al., 2018). These issues call for the enhancement of security in cloud-based digital health systems, such as using strong encryption (Batani & Maharaj, 2022a) and the blockchain technology (Bhattacharya et al., 2019; Malila & Mutsvangwa, 2019). Apart from medical chatbots, artificial intelligence is gaining traction as a diagnosis enhancement tool. Its applications in paediatrics include paediatric cancer detection (Gout et al., 2021), precision medicine modelling in paediatric acute liver failure (Zamora et al., 2016) and analysis of paediatric clinical trials (Bourgeois, 2022). Studies have shown that artificial intelligence models are outperforming human experts in detecting malignant tumours (Davenport & Kalakota, 2019).

7.5 Chapter Summary

This chapter discusses the study's findings, presenting them by research objectives. The chapter began by recapping the study from the perspective of the research questions and the study's theoretical framework. While the respondents indicated a high willingness to adopt emerging technologies to enhance disease prevention, management and quality of care for under-fives, perceived impediments exist. The study revealed that the role of emerging technologies in reducing under-five mortality in the Makonde District could be viewed from three perspectives, namely, disease prevention, management and quality of care. These perspectives are the "substantive freedoms to achieve" from the Capabilities Approach perspective. The specific identified roles include public health education and awareness, diagnosis support, technology-assisted treatment, training and education, minimising loss to follow-up, tracking immunisation status of under-fives, behavioural change, making doctors' appointments, managing complicated conditions, disease surveillance and prevention, enhancing the quality of care, data-driven paediatrics, real-time drug stock management and growth and health status monitoring.

The study revealed that there is a dearth of paediatrics-specific digital health systems in the Makonde District's public health institutions. While the Neotree was recently introduced, the system is only available at the provincial hospital and focuses on neonates only. The electronic health record system that was recently introduced could provide a basis for data-driven paediatrics. However, there is a need to utilise the collected data with paediatrics-specific digital systems that would help provide evidence-based care and treatment. The electronic health record in its current form may not provide useful insights to improve the quality of care specifically for under-fives.

The chapter also presents a framework to enhance the adoption of emerging technologies to reduce under-five mortality in Makonde District's public healthcare institutions. The proposed framework suggests ways of enhancing digital paediatrics adoption by devolving decision-making, enhancing healthcare professionals' ICT skills, demystifying the purpose of audits, stakeholder involvement and appointment of digital health spearheaders. Moreover, the UTAUT and DOI constructs were revealed as also affecting the potential adoption of emerging technologies. Affordability of the technologies is one of the critical factors to consider before introducing emerging technologies, especially if the mothers or guardians of under-fives have to pay. Though some respondents had indicated that incentives were essential for healthcare professionals and mothers of under-fives to adopt emerging technologies, the quantitative data collection findings revealed that most of the respondents did not need incentives. Mothers of under-fives argued that they did not need incentives to make the best choices for their babies, while some healthcare professionals argued that they did not need any incentives to do the work they had called to do. The following chapter concludes this study, proffers recommendations and discusses the study's limitations and contributions.

CHAPTER 8: Conclusions and Recommendations

8.1 Introduction

This study explored the potential role of emerging technologies in reducing under-five mortality in the Makonde District. The study focused on public healthcare professionals and mothers and guardians of under-fives whose under-five babies attend public healthcare institutions. An exploratory sequential mixed-methods research design was used for this study, with twenty healthcare professionals participating in interviews and focus group discussion and 481 respondents to interviews. The study revealed the potential role of emerging technologies from the perspectives of disease prevention, management and enhancing the quality of care. The determinants and impediments to emerging technologies' adoption were also revealed. The Capabilities Approach, Diffusion of Innovation and UTAUT models were used to design a hybrid theoretical model that guided this study. A framework to guide and enhance the adoption of emerging technologies to reduce under-five mortality in the Makonde District was proposed. This chapter sums up the study by presenting the conclusions, recommendations, limitations, future research and contribution of the study.

8.2 Conclusion Based on Findings and Chapters

Despite Zimbabwe being in the top fifty countries with the highest under-five mortality globally (UNICEF, 2010) and failing to achieve the under-five mortality targets of the MDGs (UNDP Zimbabwe, 2016), the country lacks the adoption of emerging technologies in public paediatrics despite emerging technologies having demonstrated a positive influence on reducing under-five mortality in other countries (Accenture Labs, 2019; Adedini & Odimegwu, 2014; Al-Qudah et al., 2017; Ilevbare, 2019; Lund et al., 2014; Nyamawe & Seif, 2014; WHO, 2014), there is a lack of adoption of emerging technologies for paediatric care in the country. The perceived potential role of emerging technologies by public healthcare professionals in reducing under-five mortality in Zimbabwe had not been explored prior to this study. Hence, this study explored the potential role of emerging technologies in reducing under-five mortality in Makonde District's public healthcare institutions.

The study sought to develop a framework to enhance the adoption of emerging technologies to reduce under-five mortality in Makonde District's public healthcare institutions. To achieve this, the study was informed by three theoretical frameworks and employed an exploratory sequential mixed-methods research design. The Capabilities Approach, supported by the DOI and UTAUT models guided the theoretical lens on which the study was based. The Capabilities Approach was the main theory that guided this study. The capabilities of emerging technologies include supporting disease diagnosis, monitoring patients, tracking disease outbreaks, providing treatment support, reminding patients of important information, collecting and sharing patients' medical data, and communicating and training healthcare professionals.

Interviews, focus groups and questionnaires were used for data elicitation. The data collection was two-staged, the first of which was qualitative, in which interviews and focus groups were used. Overall, 501 respondents participated in this study, 391 of which were mothers of under-fives while the rest were public healthcare professionals. Data were collected virtually using Zoom, Microsoft Teams and WhatsApp calls for interviews and focus groups, depending on the participants' preferences. Due to COVID-19, the MRCZ had restrictions, including non-physical interactions between researchers and healthcare practitioners. Participants were drawn from the provincial, district and health facility levels. Decision-makers were purposively selected to get managerial insights of the processes of digital health introduction and policy issues. Since the provincial hospital, the Chinhoyi Provincial Hospital, is located in Makonde District, it made it easier for people like the Provincial Specialist Paediatrician to qualify in the study's population and enrich the findings.

NVivo version 12 was used to facilitate qualitative data analysis, while SPSS version 27 was used for quantitative data analysis. Reliability and validity tests were conducted to validate the research instruments and data quality. The study revealed that there is a high willingness among healthcare professionals and mothers of under-fives to adopt emerging technologies to reduce under-fives in Makonde District's public healthcare institutions. Seventy per cent of the public healthcare institutions in Makonde District have a relatively stable internet and mobile phone network. Coupled with the high willingness to adopt emerging technologies, these present facilitating conditions for emerging technologies adoption, arguably presenting opportunities for preparedness to adopt emerging technologies. Nonetheless, the reliability and adequacy of ICT infrastructure need attention as these can pose threats to the successful adoption of technology. Moreover, there are impediments to emerging technologies adoption in Makonde, such as the fear of medico-legal hazards, centralisation of digital health decisions and policy-making, computer skills inadequacy, unreliable network and electricity supply, and knowledge deficit about emerging technologies and their potential. The UTAUT and DOI constructs also determine the potential adoption of technologies in the Makonde District. The identified digital health technologies in Zimbabwe, as mentioned by the respondents, include the eLMIS, ePMS, DHSI-2, CCTVs, video intercom, electronic health record, Neotree, and Weekly Disease Surveillance (using SMS). However, the literature search also showed the other digital systems in Zimbabwe's public healthcare, which are telemedicine (not fully fledged, limited to educational and piloting settings at the University of Zimbabwe and in Nyanga and Chimanimani in Manicaland Province), Human Resource Information System, National Health Management Information System, Integrated Disease Surveillance and Response and Inpatient Mortality and Morbidity Information System. Most of the systems are used for administrative purposes, making them less known to non-administrative healthcare professionals. There is a dearth of digital health systems for enhancing disease management, quality of care and disease prevention, let alone those specific to paediatrics.

The perceived role of emerging technologies by public healthcare professionals was presented based on three pillars. The pillars are disease prevention, disease management and quality of care. The identified roles include enhanced disease diagnosis, reducing loss to follow-ups, technology-assisted treatment, improved patient data accessibility, enhanced continuity of care, public health education, improved access to specialists, pervasive paediatric care and enhanced surveillance and disease detection trends and identification. A framework to enhance the adoption of emerging technologies to reduce under-five mortality in public healthcare institutions was proposed based on the study's findings and discussion.

8.3 Recommendations

1. The Ministry of Health and Child Care should collaborate with the Ministry of ICT, Postal and Courier Services and the Postal and Telecommunications Authority of Zimbabwe to enhance the computer skills of public healthcare professionals. This could be done through the Community Information Centres.

2. The Government of Zimbabwe should devolve digital health decision-making to district and provincial offices. The Ministry of Health and Child Care should take the oversight role but allow local offices to have executive decision-making powers. This could arguably expedite emerging technologies adoption and allow local officials to focus on what is more relevant to their locations.

3. Nursing schools should introduce a module on digital health or emerging technologies in healthcare to enhance nurses' appreciation of digital health, its roles and the impact it is having in other countries. That appreciation could arguably change the perceptions of healthcare practitioners toward digital health and influence their willingness to adopt emerging technologies in healthcare.

4. When introducing digital technologies, the innovators should conduct surveys to determine the requirements of healthcare professionals, after which they should include some modules on the system that address the needs of the intended users. For instance, nurses indicated that they would need a digital system that monitors stock levels every time they dispense medicines. Addressing the specific needs of users could give them an incentive to want to adopt the technologies, hence, increasing the chances of a successful adoption.

5. Healthcare institutions and digital health innovators should involve healthcare professionals when designing digital health systems to improve user-friendliness and give healthcare professionals a sense of ownership and entitlement. Moreover, healthcare institutions should rope in influential people in communities and get their buy-in by holding training workshops with them to give accurate information and then make them ambassadors or spearheaders of the programmes. This could reduce the hesitancy to adopt emerging technologies as it matters who delivers the message, especially to religious people.

6. The Government of Zimbabwe should consider switching to satellite internet in rural areas to bridge the digital divide. Mobile phone operators and internet service providers may not be motivated to erect infrastructure in some rural areas that may be less lucrative to them. Satellite internet could help make the rural inhabitants connected.

7. The Ministry of Health and Child Care should consider adopting cloud computing. This would minimise ICT manpower needs, reduce hardware costs for storage and processing and enable ubiquitous access to digital health systems. Technologies like deep learning that require high computing power could be run on the cloud and accessed on less powerful gadgets like mobile phones and tablets.

8. The Ministry of Health and Child Care should consider establishing localised research teams made up of medical and ICT experts to drive innovations that are context-specific. These could be in PMD's or the DMO's office. They could also help draft legislative frameworks that govern technology adoption to timeously respond to newer but tried and tested technologies.

9. The Ministry of Health and Child Care in collaboration with the Ministry of ICT, Postal and Courier Services should form technical teams that constantly review and draft legislative frameworks governing digital health innovations and adoption.

10. The Government of Zimbabwe should provide backup power to all public health institutions. Makonde District is hot for most of the year, and the government could take advantage of that solar energy to provide clean energy in the event of power cuts.

11. The Ministry of Health and Child Care should have a culture using technology to drive most of its operations to instil the culture in its employees to minimise resistance to technology use. They should continue digitising their operations until every employee of theirs realises that technology is there to stay in the organisation.

12. The Ministry of Health and Child Care should sensitise healthcare professionals on digital health policies to increase awareness.

13. The Ministry of Health and Child Care, in collaboration with mobile phone operators, should design public health educational Unstructured Supplementary Service Data (USSD) applications to allow easy access to child care health information by mothers and guardians of under-fives. USSD applications can be accessed without data, free of charge and ubiquitously.

8.4 Limitations of the Study and Future Research

The study explored the perceived potential role of emerging technologies in reducing under-five mortality in Makonde District's public healthcare institutions. Due to the COVID-19-induced restrictions, the researcher could not physically collect data. The MRCZ research guidelines forced the researcher to change from the planned physical data collection to virtual. Focus group and interviews were conducted online using Zoom, Microsoft Teams and WhatsApp based on participants' preferences. Moreover, online questionnaires were administered using Google forms. With a few health facilities in Makonde District located in very remote areas where the network is a challenge, it was difficult to contact healthcare professionals from such areas and hence they were excluded from the study. Moreover, some mothers of under-fives do not have internet-enabled devices or have no devices at all, leading to their views being technically excluded. However, the researcher made deliberate efforts to ensure that the use of digital platforms for data collection did not significantly influence the findings by excluding those in areas with poor networks or those without mobile phones. This was done by arranging with healthcare professionals in poor network areas to schedule interviews around their paydays when they will be in town for salary withdrawals and shopping. Even so, a few of the healthcare professionals had WhatsApp-enabled mobile phones that could not open Google forms or PDF files. The researcher took screenshots of the research instruments and sent them images, and they responded to the questions through WhatsApp text messages. For mothers of under-fives without mobile phones, the researcher arranged with healthcare professionals to temporarily lend their mobile phones to such mothers to fill out the online questionnaires. The researcher bought the nurses weekly data bundles to allow them to lend their mobile phones to mothers of under-fives on days reserved for the babies' clinic at their health facilities. Future studies could focus on other districts in Mashonaland West or other provinces like the Midlands Province. The Midlands Province had the same high under-five mortality rate as Mashonaland West. Moreover, private health institutions could also be included to investigate how digitised their paediatric units are. The studies could be comparative, descriptive or exploratory. Lessons could be drawn from either the private or public health sector to improve the other.

8.5 Contribution of the Study

The study was a pioneer exploratory investigation into the potential role of emerging technologies in Makonde District's public healthcare institutions. The findings of this study contribute towards enhancing the adoption of emerging technologies to reduce under-five mortality in Makonde District, Zimbabwe and similar resource-constrained contexts; thus, contributing to the achievement of the United Nations Sustainable Development Goal (UN SDG) 3, which seeks to reduce under-five mortality rates to at most 23 per 1 000 live births. It extends the frontiers of knowledge by adding the voice of public healthcare professionals in Makonde District on their perceived role of emerging technologies in reducing under-five mortality, the perceived adoption deterrents and determinants and what needs to be done to enhance technology adoption in Makonde District's public paediatrics care. Moreover, the study produced five research papers that contribute to data-driven paediatrics in Zimbabwe and Sub-Saharan Africa. A fifth paper is in progress that applies deep learning to predict under-five mortality in Zimbabwe. Moreover, the study produced a framework for the adoption of emerging technologies to reduce under-five mortality in resource-constrained settings like the Makonde District, and the framework was recently presented at the 2023 Information Communication Technology and Society, whose proceedings will be published the IEEE.

8.6 Personal Reflections

This doctoral study journey has been challenging, yet fulfilling. Prior to this journey, the researcher had some understanding of research, its importance and principles. The researcher had published a few papers, but mostly in predatory journals, unknowingly. However, engaging in this work significantly enhanced the researcher's understanding of how research is conducted, and the importance of publishing in renowned outlets. Consequently, the researcher published at least fifteen journal papers, book chapters and conference proceedings in esteemed outlets, such as Springer and IEEE. Moreover, five papers were written as part of this study, indicating the real impact this journey has had on the researcher. The researcher's first ever conference presentation was during the course of this study.

The importance of conducting research ethically was another important aspect that the researcher learnt in this journey. The study required ethical clearance at different levels, and the delays encountered also enhanced the researcher's patience. However, the researcher learnt that there are no shortcuts regarding conducting research ethically.

Moreover, independence was also another attribute that the researcher learnt, seeking guidance where necessary. Several skills were learnt in this journey, through the several workshops and seminars conducted by the University, such as on academic writing, and how to write a systematic literature review.

However, this journey has not been without challenges. Barely a semester after commencing the study, COVID-19 emerged and it changed everything for the worse, making the future gloomy. Organisations had to temporarily close, or went fully virtual. This delayed response times of many organisations, delaying the researcher in getting ethical clearance. Though, healthcare institutions remained operational during such an unprecedented hard time of this century, conducting research that required participation of healthcare professionals, like this one, was a daunting task. All efforts were concerted on preserving lives from the COVID-19 existential threat, making it difficult to enroll participants for this study. Many healthcare professionals were redeployed as governments worked round the clock to contain the pandemic (Batani & Maharaj, 2022b).

The 2022 national census exacerbated the situation as some public healthcare professionals were deployed to conduct the census, essentially making them unavailable for the study. All these challenges delayed data collection. However, some healthcare professionals were cooperative and sacrificed the little time they had to rest to participate in this study. Some participated late in the evenings, while others on weekends.

There were some few deviations from the original plan, such as reducing the number of focus groups from two to one due to difficulties in getting participants together at same times. Moreover, scheduling an interview with the DMO was a futile effort and a wild goose chase due to his exceedingly busy schedule. This led to the researcher converting the interview schedule into a Google form to allow him to respond to the questions whenever he would be free.

Though these delays frustrated the researcher, they were a blessing in disguise as the researcher took that time to write systematic review papers, something that the researcher learnt during the course of this journey. The researcher enhanced his research and academic writing skills during this period, and published one review paper related to this study in a Scopus-indexed journal.

Thus, though the journey and long and tortuous mainly due to the COVID-19 pandemic, it was generally fulfilling with lots of learning experiences. Indeed, this academic journey sufficiently trained the researcher to be an independent researcher who also is able to work collaboratively.

8.7 Chapter Summary

This chapter summed up the study by presenting conclusions, recommendations, limitations and contributions of the study. The study revealed that there are various impediments to the adoption of emerging technologies to reduce under-five mortality in Makonde's public healthcare institutions, such as fear of medico-legal hazards, centralisation of decision-making on digital health, unreliable electricity supply, erratic network connection, demoralised workforce and lack of ICT skills. However, the willingness to adopt emerging technologies to reduce under-five mortality in Makonde district was high among both mothers of under-fives and healthcare professionals. The identified enablers of emerging technologies adoption to reduce under-five mortality in Makonde included the high mobile phone and internet penetration rates, willingness to adopt the technologies by both healthcare professionals and mothers of under-fives, the introduction of the electronic health record in all public health institutions, and a surge in the relevant ICT infrastructure in the form of electronic tablets and Wi-Fi provision. Thirteen implementable recommendations were presented, informed by the findings.

Moreover, the researcher presented the study's limitations and constraints, including the COVID-19-induced restrictions and redeployment of potential respondents. The contribution of the study include a framework for the adoption of emerging technologies, and five publication works. The proposed framework was accepted and presented at a conference and will be published by IEEE.

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Appendices

Appendix I: Interview Guide – Healthcare Professionals

I. English version

Interview Guide to Medical Practitioners in Makonde District's Public Healthcare Institutions

1. What is your present designation?
2. What are the challenges faced in reducing under-five mortality (U5M) in Makonde District's public healthcare institutions?
    a. How do you think emerging information technologies can address these challenges?
3. State any emerging information technologies in healthcare that you know.
4. If emerging information technologies were to be introduced at your workplace to promote under-five children's health, would you use them? Why?
5. How do you think emerging information technologies can help reduce U5M in Makonde District's public healthcare institutions?
6. What policies are in place to promote the use of emerging information technologies for promoting child health and well-being?
7. What do you consider the hindrances to the successful adoption of emerging information technologies to reduce U5M in Makonde District's public healthcare institutions?
8. How do you think these hindrances can be addressed?
9. What role do you think emerging information technologies can play in disease prevention among under-five children in Makonde District?
10. What is your perceived contribution of emerging technologies in improving the quality of healthcare for under-five children in Makonde District?
11. What is your perceived contribution of emerging technologies in managing diseases among under-five children in Makonde District?
12. What do you think needs to be done for emerging technologies to be adopted in Makonde District's public health institutions to reduce U5M?

**********************Thank you for your time and responses*******************

II. Shona version

Gwaro rebvunzurudzo kune Varapi muzvipatara nemakiriniki eve ruzhinji mudunhu reMakonde

1. Mune chinzvimbo chinonzi chii pari zvino kubasa?
2. Ndeapi matambudziko akatarisana nekuderedza kufa kwevasati vasvika makore mashanu (U5M) muMakonde muzvipatara nemakiriniki eruzhinji edunhu?
    a. Munofunga kuti hunyanzvi nemishina yechizvinozvino zvingagona kugarisa matambudziko aya nenzira dzipi?
3. Ndeupi hunyanzi nemishina yechizvinozvino zviri kushandiswa mune zvehutano zvamunoziva?
4. Kana ruzivo matekinoroji zviri kubuda mazuvano zvaizounzwa kubasa kwako kuti tikurudzire hutano hwevana vari pasi pemakore mashanu, ungazvishandisa here? Sei?
5. Iwe unofunga kuti ruzivo matekinoroji anogona kubatsira kuderedza dzambudziko rekufa kwevana vane makore ari pasi pemashanu nenzira dzipi mudunhu reMakonde?
6. Ndeipi mitemo nemabumbiro aripo ekusimudzira kushandiswa kwemichina yeruzivo iri kubuda mazuvano kusimudzira hutano nekugara zvakanaka kwevana?
7. Iwe unofunga ndezvipi zvipingamupinyi zvekubudirira kwekugamuchirwa kwematekinoroji eruzivo ekudzikisa U5M mudunhu reMakonde munzvimbo dzinorapwa veruzhinji?
8. Unofunga kuti zvimhingamipinyi izvi zvingagadziriswa sei?
9. Nderipi basa raunofunga kuti ruzivo matekinoroji ari kusimukira anogona kuita mukudziviria zvirwere kuvana vari pasi pemakore mashanu mudunhu reMakonde?
10. Nderipi basa raunofunga kuti ruzivo matekinoroji ari kusimukira anogona kuita mukuvandudza hutano nekurapwa kwevana vari pasi pemakore mashanu mudunhu reMakonde?
11. Nderipi basa raunofunga kuti ruzivo matekinoroji ari kusimukira anogona kuita mukuvandudza kwemanejewa kwezvirwere kuvana vari pasi pemakore mashanu mudunhu reMakonde?

12. Iwe unofunga kuti chii chinoda kuitwa kuti matekinoroji ari kusimukira agamuchirwe mukati zvipatara zveveruzhinji mudunhu reMakonde kuderedza kufa kwevanhu vari pasi pemakore mashanu?

*********************Ndatenda nemhinduro dzenyu*******************************

Appendix II: MRCZ Ethical Clearance

Telephone: 08644072773/791193
E-mail: mrcz@mrcz.org.zw
Website: http://www.mrcz.org.zw

Medical Research Council of Zimbabwe
Josiah Tongogara / Mazowe Street
P. O. Box CY 573
Causeway
Harare

APPROVAL

MRCZ/A/2782

21 September, 2021

John Batani
14253 Brundish
Chinhoyi

RE: - Reducing under-five mortality in Makonde District's public healthcare institutions: An exploratory investigation into the potential role of emerging technologies

Thank you for the application for review of research activity that you submitted to the Medical Research Council of Zimbabwe (MRCZ). Please be advised that the Medical Research Council of Zimbabwe has **reviewed** and **approved** your application to conduct the above titled study.

This approval is based on the review and approval of the following documents that were submitted to MRCZ for review: -

a) Completed MRCZ Application Form 101
b) Protocol version 2.0, dated 21 September, 2021
c) Information Sheet and Informed Consent Form (English and Shona) Version 1.0, dated 21 September, 2021
d) FGDs (English and Shona) Version 1.0, dated 21 September, 2021
e) Interview Guides (English and Shona) Version 1.0, dated 21 September, 2021
f) Data Collection Tools

- **APPROVAL NUMBER** : **MRCZ/A/2782**

This number should be used on all correspondence, consent forms and documents as appropriate.

- **TYPE OF MEETING** : **Full Board**
- **MEETING DATE** : **26 August, 2021**
- **APPROVAL DATE** : **21 September, 2021**
- **EXPIRATION DATE** : **20 September, 2022**

After this date, this project may only commence upon renewal. For purposes of renewal, a progress report on a standard form obtainable from the MRCZ Offices should be submitted three months before the expiration date for continuing review.

- **SERIOUS ADVERSE EVENT REPORTING**: All serious problems having to do with subject safety must be reported to the Institutional Ethical Review Committee (IERC) as well as the MRCZ within 3 working days using standard forms obtainable from the MRCZ Offices or website.
- **MODIFICATIONS**: Prior MRCZ and IERC approval using standard forms obtainable from the MRCZ Offices is required before implementing any changes in the Protocol (including changes in the consent documents).
- **TERMINATION OF STUDY**: On termination of a study, a report has to be submitted to the MRCZ using standard forms obtainable from the MRCZ Offices or website.
- **QUESTIONS**: Please contact the MRCZ on Telephone No. (0242) 791193/08644073772 or by e-mail on mrcz@mrcz.org.zw

Other

- Please be reminded to send in copies of your research results for our records as well as for Health Research Database.
- You're also encouraged to submit electronic copies of your publications in peer-reviewed journals that may emanate from this study.
- In addition to this approval, all clinical trials involving drugs, devices and biologics (including other studies focusing on registered drugs) require approval of Medicines Control Authority of Zimbabwe (MCAZ) before commencement.

Yours Faithfully

....

MRCZ SECRETARIAT
FOR CHAIRPERSON
MEDICAL RESEARCH COUNCIL OF ZIMBABWE

MEDICAL RESEARCH COUNCIL OF ZIMBABWE
2021 -09- 21
APPROVED

PROMOTING THE ETHICAL CONDUCT OF HEALTH RESEARCH

Appendix III: Gatekeeper's Pass

Telephone: 23211-6
Telegraphic Address:
"PROVMED" Chinhoyi
Fax: 23218

E-mail: pmdmashwest@gmail.com

ZIMBABWE

MINISTRY OF HEALTH AND CHILD CARE
PROVINCIAL MEDICAL DIRECTOR
(Mashonaland West Province)
P.O Box 139
Chinhoyi
Zimbabwe

28 September 2020

TO WHOM IT MAY CONCERN

RE: PERMISSION TO CONDUCT RESEARCH: JOHN BATANI: STUDENT NO. 21180200009)

You have been granted permission to conduct a research on the thesis title "Reducing under-five mortality in Makonde District's public healthcare institutions: An explanatory investigation into the potential role emerging technologies" subject to approval by MRCZ.

MINISTRY OF HEALTH & CHILD CARE
PROVINCIAL MEDICAL DIRECTOR
MASHONALAND WEST PROVINCE
28 SEP 2020
P.O. BOX 139, CHINHOYI
ZIMBABWE TEL: 067-23218

Dr G. Masoja
A/PROVINCIAL MEDICAL DIRECTOR MASHONALAND WEST PROVINCE

Appendix IV: Permission Letter from Makonde Rural District Council

RAL DISTRICT COUNCIL

TELEPHONES 0712 876 539
0717 816 078

OFFICE:
FAX 5631
E mail: makonderdc@gmail.com
Website makonderdc.org.zw

P. O. BOX 296
Mhangura
ZIMBABWE

Our Ref......

Your Ref......

All Correspondence Should Be Addressed To The Chief Executive Officer

ATTENTION: JOHN BATANAI
Thetsane Le-coop
Maseru
Lesotho

22 March 2022

REF: REQUEST TO CONDUCT RESEARCH WITHIN MAKONDE DISTRICT:

Reference is made to your letter dated 14 March 2022 where you requested for permission to conduct a research **on reducing under five mortality in Makonde district public health care institutions: An explanatory investigation into the potential role of emerging technologies.** Makonde Rural District Council has no objection and is kindly granting the authority to carry out the research. Council also expects you to share your findings once the research is complete.

SOCIAL SERVICES OFFICER
MAKONDE RURAL DISTRICT COUNCIL
22 MAR 2022
P. O. BOX 296
MHANGURA

P Munyede (ACIS;RPAcc).
pp Ntwela.

A Service Sanctuary With A Flourishing Socio-economic And Participative Community Of Choice By December 2025

Appendix V: Interview Guide – DMO Makonde District

I. English Version

Interview Schedule- Makonde District Medical Officer (DMO)

Section A: General Information

1. For how long have you been in this position of Makonde District Medical Officer?
2. State any digital technologies that are used in Makonde District's public health institutions to promote the health of, manage and diagnose diseases in, under-five children?
3. (a) What role do you play in the introduction of digital health technologies in your district?
   (b) Do you think your role is central or peripheral to the entire process?
4. Please describe the role of the central government in the introduction of digital technologies in public healthcare institutions.
5. (a) Is it possible to introduce digital health systems at the district level without the involvement of the central government?
   (b) If the response to 5(a) above is "yes",
      i. What technologies can be introduced at the district level without the central government's involvement?
      ii. Describe the process followed when introducing digital health at a district level.
   (c) If the response to 5(a) above is "no", describe the process followed when introducing digital health in public healthcare institutions in Zimbabwe.
6. (a) What e-health systems are you currently using in the district, and what are they being used for?
   (b) Of these e-health systems in Makonde District, which ones are meant to monitor and manage under-five children's health?
7. State the digital technologies that you would consider more feasible in Makonde District's public health institutions to aid in disease management, surveillance, diagnosis and treatment in under-five children.
8. What make(s) the technologies you mentioned above more feasible in Makonde District?

Section B: Preparedness to adopt emerging technologies

9. (a) Are you working on introducing any digital technologies in the Makonde District? If yes, please state them.
   (b) If yes to 9(a) above:
      i. Which ones are meant to enhance disease management, control and prevention among under-five children?
      ii. What is the timeline for introducing the technologies?
      iii. Is there any budget allocated for the introduction of these technologies?
         a. If yes, do you think the budget is adequate?
         b. Why do you say so?
   (c) If your answer to 9(a) above is 'no', why do you think it is so?

10. If emerging technologies were to be deployed in Makonde District's public health institutions, what do you think are the strengths of the public health workers that would make the adoption and utilisation of such technologies successful?
11. If emerging technologies were to be deployed in Makonde District's public health institutions, what do you think are the weaknesses of the healthcare workers or the environment that could impede the successful adoption and utilisation of such technologies?

Section C: Factors affecting the adoption of emerging technologies in Makonde

12. What is your view regarding using emerging digital technologies to improve disease management, diagnosis and treatment in under-five children in Makonde District's public health institutions?
13. How do the policies of the Ministry of Health and Child Care impact the potential introduction of digital health in public healthcare institutions to enhance disease management and control, and improve the quality of healthcare to under-five children in Makonde District?
14. How do the policies, procedures and management styles in Makonde District's public health institutions impact the potential introduction and utilisation of emerging technologies to promote under-five children's health and care?
15. Please state the ICT infrastructure that you have to support the introduction of emerging technologies in Makonde District.
16. What additional ICT infrastructure would you need for the successful deployment of emerging technologies in public healthcare institutions in Makonde District?
17. (a) What other factors would you say are impeding the adoption of emerging technologies in public healthcare institutions to improve disease management and service quality for under-five children in Makonde District?

    (b) How do you think these factors can be addressed?
18. What do you think should be done for the successful adoption of emerging technologies in public healthcare institutions to enhance service quality, disease management, prevention and control among under-five children in Makonde District?
19. Which of the following technologies do you think are viable and feasible in Makonde District's public health institutions?
    a. Telemedicine and telehealth
    b. Artificial intelligence
    c. Electronic billboards
    d. SMS-based solutions
    e. Internet of things
    f. mobile applications
    g. virtual assistants / medical chatbots
    h. big data analytics
    i. cloud computing
    j. mass media
    k. social media
    l. Other (specify)

********************Thank you for your participation*******************

II. Shona Version

Interview Schedule- Makonde District Medical Officer (DMO)

Section A: General Information

1. Mava nenguva yakareba zvakadii muri panzvimbo ya DMO Makonde District?
2. Ndehupi hunyanzvi hwechizvinozvino huri kushandiswa muzvipatara nemakirini ehurumende mudunhu reMakonde huri kushandiswa kusimuridzira hutano hwevana vane makore asingapfuuri mashanu?
3. (a) Nderipi basa (role) ramunoita saPMD kana pachida kuunzwa hunyanzvi nemishina yechizvinozvino mune zvehutano mudunhu (district) renyu?
   (c) Munofunga kuti basa ramunoita iri rakakosha zvakadii mukuunzwa kwehunyanzvi hwechizvinozvino uhwu? Sei muchidaro?
4. Hurumende inoita basa ripi mukuunzwa kwehunyanzvi nemishina yechizvinozvino muzvipatara zvehurumende muZimbabwe?
5. (a) Zvinogoneka here kuti muunze hunyanzvi nemishina yechizvinozvino mudunhu renyu pasina kupindira kwehurumende?
   (d) Kana mhinduro yenyu ku 5(a) iri "hongu",
      i. Ndehupi hunyanzvi hunogona kuunzwa mudunhu renyu pasina kupindira (involvement) kwehurumende?
      ii. Tsanangurai matanho anoteverwa kana pachiunzwa hunyanzvi nemishina yechizvinozvino pa district kana province.
   (e) Kana mhinduro yenyu ku 5(a) iri "kwete", nditsananguri reiwo matanho anoteverwa kana pachiunzwa hunyanzvi nemishina yechizvinozvino muZimbabwe muzvipatara zvehurumende muZimbabwe?
6. (a) Ndehupi hunyanzvi nemishina yechizvinozvino iri kushandiswa muzvipatara nemakiriniki ehurumende mudunhu reMakonde? Iri kushandiswei mishina nehunyanzvi uhwu?
   (d) Pane hunyanzvi uhwu mudunhu reMakonde, ndehupi huri kushandiswa pakudhayagunoza (diagnosis), kumonita (monitoring) uye kumaneja (managing) hutano hwevana vari pasi pemakore ari pasi pemashanu?
7. Ndehupi hunyanzvi nemishina yechizvinozvino yamunofunga kuti inogona kushanda mudunhu reMakonde mukusimudzira hutano hwevana vane makore ari pasi pemashanu?
8. Zvii zvinoita kuti mufunde kuti hunyanzvi nemishina yechiWhat make(s) the technologies you mentioned above more feasible in Makonde District?

Section B: Preparedness to adopt emerging technologies

9. (a) Muri mubishi rekuronga kuti muunze hunyanzvi nemishina yechizvinozvino here mudunhu reMakonde District kana Mashonaland West? Kana mhinduro yenyu iri, hongu, ndeipi mishina nehunyanzvi uhwu?
   (b) Kana mhinduro yenyu ku 9(a) iri hongu:
      iv. Pane hunyanzvi uhwu, ndehupi hunyanzvi hwechizvinozvino hwakanakangana nekusimudzira hutano hwevana vane makore ari pasi pemashanu?
      v. Zvichatora nguva yakareba zvakadii kuti hunyanzvi uhwu hutange kushanda?
      vi. Pane mari here yakaiswa padivi yakamirira hurongwa hwekuunzwa kwehunyanzvi nemishina yechizvinozvino iyi?
         a. Kana iripo, Munofunga kuti mari iyi inokwana here?

b. Sei muchidaro?

(e) Kana mhinduro yenyu ku 9(a) iri kwete, sei muchifunga kudaro?

10. Ndezvipi zvamunofunga kuti ma strengths zvinogona kuita kuti vashandi vehutano muzvipatara zvehurumende mudunhu reMakonde vagone kushandisa hunyanzvi nemishina yechizvinozvino zvikabudirira mudunhu reMakonde?
11. Ndezvipi zvamunofunga kuti ma weaknesses anogona kuita kuti vashandi vehutano muzvipatara zvehurumende mudunhu reMakonde vasagone kushandisa hunyanzvi nemishina yechizvinozvino zvikasabudirira mudunhu reMakonde?

Section C: Factors affecting the adoption of emerging technologies in

12. Munoonawo sei maringe nekushandiswa kwehunyanzvi nemishina yechizvinozvino mukusimudzira disease management, diagnosis nekurapwa kwevana vari pasi pemakore mashanu muzvipatara zvehurumende muMakonde District?
13. Ma policies ebazi rehutano nekurerwa zvakanakana kwevana (Ministry of Health and Child Care) anosimudzira kana kukanganisa sei kushandiswa nekuunzwa kwehunyanzvi nemishina yechizvinozvino muzvipatara zvehurumede kusimudzira disease management and control, uye kusimudzira quality yehutano hwevana vari pasi pemakore mashanu mudunhu reMakonde?
14. Ndeipi ICT infrastructure yamunayo mudunhu reMakonde District inogona kubatsira kuunzwa nekushandiswa kwehunyanzvi nemishina yechizvinozvino?
15. Ndeipi imwe ICT infrastructure yamungada mudunhu reMakonde kuti hunyanzvi nemishina yechizvinozvino zvigone kuunzwa nekushandiswa zvikabudirira muzvipatara zvehurumende?
16. (a) Ndezvipi zvimwe zvamungati zviri kukanganisa kuunzwa nekushandiswa kwehunyanzvi hwemishina yechizvinozvino kusimudzira disease management uye service quality kuvana vane makore ari pasi pemashanu mudunhu reMakonde?

    (b) Munofunga kuti zvimhingamipinyi izvi zvingagadziriswa sei?
17. Zvii zvamunofunga kuti zvinofanirwa kuita kuti pasimudzirwe mikana yekugashirwa nekushandiswa kwehunyanzvi nemishina yechizvinozvino mukusimudzira hutano hwevana vane makore asingapfuuri mashanu?
18. Munofunga hunyanzvi nemishina yechizvinozvino zvingabatsira sei mukurwisa dambudziko rekufa kwevana vane makore ari pasi pemashanu muMakonde District?
19. Pane hunyanzvi nemishina yechizvinozvino inotevera, ndeipi yamunofunga kuti inogona kushandisika muzvipatara zvehurumende mudunhu reMakonde District?
    a. Telemedicine and telehealth
    b. Artificial intelligence
    c. Electronic billboards
    d. SMS-based solutions
    e. Internet of things
    f. mobile applications
    g. virtual assistants / medical chatbots
    h. big data analytics
    i. cloud computing
    j. mass media
    k. social media
    l. Other (specify) ______________________________

********************Ndinotenda**********************

Appendix VI: Interview Guide – PMD Mashonaland West

I. English Version

Interview Schedule- Provincial Medical Director (PMD) Mashonaland West

Section A: General Information

1. For how long have you been in this position of PMD Mashonaland West?
2. (a) State any digital technologies that are used in Mashonaland West's public health institutions to promote the health of, manage and diagnose diseases in, under-five children?
   (b) Of these technologies, which ones are also available in Makonde District?
3. (a) What role do you play in the introduction of digital health technologies in your province?
   (d) Do you think your role is central or peripheral to the entire process? Why do you say so?
4. Please describe the role of the central government in the introduction of digital technologies in public healthcare institutions.
5. (a) Is it possible to introduce digital health systems at the district/provincial level without the involvement of the central government?
   (f) If the response to 5(a) above is "yes",
      i. What technologies can be introduced at the district/provincial level without the central government's involvement?
      ii. Describe the process followed when introducing digital health at a district/provincial level.
   (g) If the response to 5(a) above is "no", describe the process followed when introducing digital health in public healthcare institutions in Zimbabwe.
6. (a) What e-health systems are you currently using in the province and what are they being used for?
   (f) Of these e-health systems in the province, which ones are meant to diagnose, monitor, and manage under-five children's health?
7. State the digital technologies that you would consider more feasible in Makonde District's public health institutions to aid in disease management, surveillance, diagnosis and treatment in under-five children.
8. What make(s) the technologies you mentioned above more feasible in Makonde District?

Section B: Preparedness to adopt emerging technologies

9. (a) Are you working on introducing any digital technologies in the Makonde District or Mashonaland West? If yes, please state them.
   (b) If yes to 9(a) above:
      vii. Which ones are meant to enhance disease management, control and prevention among under-five children?
      viii. What is the timeline for introducing the technologies?
      ix. Is there any budget allocated for the introduction of these technologies?
         a. If yes, do you think the budget is adequate?

b. Why do you say so?

(g) If your answer to 9(a) above is ‘no’, why do you think it is so?

10. If emerging technologies were to be deployed in Makonde District’s public health institutions, what do you think are the strengths of the public health workers that would make the adoption and utilisation of such technologies successful?
11. If emerging technologies were to be deployed in Makonde District’s public health institutions, what do you think are the weaknesses of the healthcare workers or the environment that could impede the adoption and utilisation of such technologies?

Section C: Factors affecting the adoption of emerging technologies in

12. What is your view regarding using emerging digital technologies to improve disease management, diagnosis and treatment in under-five children in Makonde District’s public health institutions?
13. How do the policies of the Ministry of Health and Child Care impact the potential introduction of digital health in public healthcare institutions to enhance disease management and control, and improve the quality of healthcare to under-five children in Makonde District?
14. How do the policies, procedures and management styles in Makonde District’s public health institutions impact the potential introduction and utilisation of emerging technologies to promote under-five children’s health and care?
15. Please state the ICT infrastructure that you have to support the introduction of emerging technologies in Makonde District.
16. What additional ICT infrastructure would you need for the successful deployment of emerging technologies in public healthcare institutions in Makonde District?
17. (a) What other factors would you say are impeding the adoption of emerging technologies in public healthcare institutions to improve disease management and service quality for under-five children in Makonde District?

    (b) How do you think these factors can be addressed?
18. What do you think should be done to successfully adopt emerging technologies in public healthcare institutions to enhance service quality, disease management, prevention and control among under-five children in Makonde District?
19. What role do you think emerging technologies can play in reducing under-five mortality in Makonde District?
20. Which of the following technologies do you think are viable and feasible in Makonde District’s public health institutions?
    a. Telemedicine and telehealth
    b. Artificial intelligence
    c. Electronic billboards
    d. SMS-based solutions
    e. Internet of things
    f. mobile applications
    g. virtual assistants / medical chatbots
    h. big data analytics
    i. cloud computing
    j. mass media

k. social media
l. Other (specify)

*******************Thank you for your participation*********************

II. Shona Version

Interview Schedule- Provincial Medical Director (PMD) Mashonaland West

Section A: General Information

1. Mava nenguva yakareba zvakadii muri panzvimbo ya PMD Mashonaland West?
2. (a) Ndehupi hunyanzvi hwechizvinozvino huri kushandiswa muzvipatara nemakirini ehurumende mudunhu reMashonaland West huri kushandiswa kusimuridzira hutano hwevana vane makore asingapfuuri mashanu?
   (b) Pahunyanzvi uhwu, ndehupi huri kushandiswa mudunhu reMakonde District?
3. (a) Nderipi basa (role) ramunoita saPMD kana pachida kuunzwa hunyanzvi nemishina yechizvinozvino mune zvehutano mudunhu (province) renyu?
   (e) Munofunga kuti basa ramunoita iri rakakosha zvakadii mukuunzwa kwehunyanzvi hwechizvinozvino uhwu? Sei muchidaro?
4. Hurumende inoita basa ripi mukuunzwa kwehunyanzvi nemishina yechizvinozvino muzvipatara zvehurumende muZimbabwe?
5. (a) Zvinogoneka here kuti muunze hunyanzvi nemishina yechizvinozvino mudunhu renyu pasina kupindira kwehurumende?
   (h) Kana mhinduro yenyu ku 5(a) iri "hongu",
      i. Ndehupi hunyanzvi hunogona kuunzwa mudunhu renyu pasina kupindira (involvement) kwehurumende?
      ii. Tsanangurai matanho anoteverwa kana pachiunzwa hunyanzvi nemishina yechizvinozvino pa district kana province.
   (i) Kana mhinduro yenyu ku 5(a) iri "kwete", nditsananguririreiwo matanho anoteverwa kana pachiunzwa hunyanzvi nemishina yechizvinozvino muZimbabwe muzvipatara zvehurumende muZimbabwe?
6. (a) Ndehupi hunyanzvi nemishina yechizvinozvino iri kushandiswa muzvipatara nemakiriniki ehurumende mudunhu reMashonaland West? Iri kushandiswei mishina nehunyanzvi uhwu?
   (h) Pane hunyanzvi uhwu mudunhu reMashonaland West, ndehupi huri kushandiswa pakudhayagunoza (diagnosis), kumonita (monitoring) uye kumaneja (managing) hutano hwevana vari pasi pemakore ari pasi pemashanu?
7. Ndehupi hunyanzvi nemishina yechizvinozvino yamunofunga kuti inogona kushanda mudunhu reMakonde mukusimudzira hutano hwevana vane makore ari pasi pemashanu?
8. Zvii zvinoita kuti mufunde kuti hunyanzvi nemishina yechiWhat make(s) the technologies you mentioned above more feasible in Makonde District?

Section B: Preparedness to adopt emerging technologies

9. (a) Muri mubishi rekuronga kuti muunze hunyanzvi nemishina yechizvinozvino here mudunhu reMakonde District kana Mashonaland West? Kana mhinduro yenyu iri, hongu, ndeipi mishina nehunyanzvi uhwu?

   (b) Kana mhinduro yenyu ku 9(a) iri hongu:

   x. Pane hunyanzvi uhwu, ndehupi hunyanzvi hwechizvinozvino hwakanakangana nekusimudzira hutano hwevana vane makore ari pasi pemashanu?

   xi. Zvichatora nguva yakareba zvakadii kuti hunyanzvi uhwu hutange kushanda?

   xii. Pane mari here yakaiswa padivi yakamirira hurongwa hwekuunzwa kwehunyanzvi nemishina yechizvinozvino iyi?

      a. Kana iripo, Munofunga kuti mari iyi inokwana here?

      b. Sei muchidaro?

   (i) Kana mhinduro yenyu ku 9(a) iri kwete, sei muchifunga kudaro?

10. Ndezvipi zvamunofunga kuti ma strengths zvinogona kuita kuti vashandi vehutano muzvipatara zvehurumende mudunhu reMakonde vagone kushandisa hunyanzvi nemishina yechizvinozvino zvikabudirira mudunhu reMakonde?
11. Ndezvipi zvamunofunga kuti ma weaknesses anogona kuita kuti vashandi vehutano muzvipatara zvehurumende mudunhu reMakonde vasagone kushandisa hunyanzvi nemishina yechizvinozvino zvikasabudirira mudunhu reMakonde?

Section C: Factors affecting the adoption of emerging technologies in

12. Munoonawo sei maringe nekushandiswa kwehunyanzvi nemishina yechizvinozvino mukusimudzira disease management, diagnosis nekurapwa kwevana vari pasi pemakore mashanu muzvipatara zvehurumende muMakonde District?
13. Ma policies ebazi rehutano nekurerwa zvakanakana kwevana (Ministry of Health and Child Care) anosimudzira kana kukanganisa sei kushandiswa nekuunzwa kwehunyanzvi nemishina yechizvinozvino muzvipatara zvehurumede kusimudzira disease management and control, uye kusimudzira quality yehutano hwevana vari pasi pemakore mashanu mudunhu reMakonde?
14. Ndeipi ICT infrastructure yamunayo mudunhu reMakonde District inogona kubatsira kuunzwa nekushandiswa kwehunyanzvi nemishina yechizvinozvino?
15. Ndeipi imwe ICT infrastructure yamungada mudunhu reMakonde kuti hunyanzvi nemishina yechizvinozvino zvigone kuunzwa nekushandiswa zvikabudirira muzvipatara zvehurumende?
16. (a) Ndezvipi zvimwe zvamungati zviri kukanganisa kuunzwa nekushandiswa kwehunyanzvi hwemishina yechizvinozvino kusimudzira disease management uye service quality kuvana vane makore ari pasi pemashanu mudunhu reMakonde?

    (b) Munofunga kuti zvimhingamipinyi izvi zvingagadziriswa sei?
17. Zvii zvamunofunga kuti zvinofanirwa kuita kuti pasimudzirwe mikana yekugashirwa nekushandiswa kwehunyanzvi nemishina yechizvinozvino mukusimudzira hutano hwevana vane makore asingapfuuri mashanu?
18. Munofunga hunyanzvi nemishina yechizvinozvino zvingabatsira sei mukurwisa dambudziko rekufa kwevana vane makore ari pasi pemashanu muMakonde District?

19. Pane hunyanzvi nemishina yechizvinozvino inotevera, ndeipi yamunofunga kuti inogona kushandisika muzvipatara zvehurumende mudunhu reMakonde District?
    a. Telemedicine and telehealth
    b. Artificial intelligence
    c. Electronic billboards
    d. SMS-based solutions
    e. Internet of things
    f. mobile applications
    g. virtual assistants / medical chatbots
    h. big data analytics
    i. cloud computing
    j. mass media
    k. social media
    l. Other (specify) ____

*******************Ndinotenda**********************

Appendix VII: Interview Guide – Provincial Health Information Officer

I. English Version

Interview Schedule- Mashonaland West Provincial ICT Officer

Section A: General Information

1. For how long have you been in this position of Provincial ICT Officer- Mashonaland West Province?
   2. (a) What e-health systems are you currently using in the province and what are they being used for?
      (j) Of these e-health systems, which ones are available in Makonde District?
      (k) Of these e-health systems in Makonde District, which ones are meant for monitoring and managing the health of under-five children?
      (l) Please state any emerging technologies that are being used in public healthcare in Zimbabwe.
   3. (a) Are you working on introducing any emerging technologies in the Makonde District? If yes, please state them.
      (b) If yes to 3(a) above, which ones are meant to enhance disease management, control and prevention among under-five children?

Section B: Factors affecting the adoption of emerging technologies in

1. How does the current national ICT policy impact on the potential introduction of emerging technologies in public healthcare institutions to enhance disease management, prevention and control among under-five children in Makonde District?
   2. How do the policies of the Ministry of Health and Child Care impact the potential introduction of emerging technologies in public healthcare institutions to enhance disease management and control, and improve the quality of healthcare to under-five children in Makonde District?
   3. Please state the ICT infrastructure that you have to support the introduction of emerging technologies in Makonde District.
   4. What additional ICT infrastructure would you need for the successful deployment of emerging technologies in public healthcare institutions in Makonde District?
   5. (a) What other factors would you say are impeding the adoption of emerging technologies in public healthcare institutions to improve disease management and service quality for under-five children in Makonde District?

(b) How do you think these factors can be addressed?

9. What do you think should be done for the successful adoption of emerging technologies in public healthcare institutions to enhance service quality, disease management, prevention and control among under-five children in Makonde District?

******************Thank you for your participation*********************

II. Shona Version

Hurukuro na PHIOr wedunhu reMashonaland West (Interview Schedule- Mashonaland West Provincial Health Information Officer)

Chikamu A: Ruzivo rwakawanda (General Profile)

1. Mava neguva yakareba zvakadii muchiita basa iri ra Provincial ICT Officer wedunhu reMashonaland West?
   2. (a) Ndehupi hunyanzi nemishina yechizvinozvino mune zvehutano huri kushandiswa mudunhu reMashonaland West, uye hunyanzvi uhwu huri kushandswa pakudii chaizvo?
      (m) Pane hunyanzvi nemishina yechizvinozvino iri kushandiswa mudunhu re Mashonaland West iyi, ndeipi iri kushandiswa mudunhu re Makonde?
      (n) Pane hunyanzvi nemishina yechizvinozvino iri kushandiswa mudunhu reMakonde iyi, ndehupi hunyanzvi nemishina yechizvinozvino iri kushandiswa pakuongorora nekubata hutano hwevan vane makore ari pasi pemashanu?
      (o) Ndehupi humwe hunyanzvi nemishina yechizvinozvino iri kushandiswa mune zvehutano munyika yeZimbabwe?
   3. (a) Muri kugadzirira kuunza humwe hunyanzi nemishina yechizvinozvino here mudunhu re Makonde? Kana mhinduro yenyu iri hongu, ndehupi hunyanzi nemishina yechizvinozvino iyi?

(c) Kana mhinduro yako pamubvunzo 3(a) iri hongu, ndehupi hunyanzvi nemishina yechizvinozvino yamuri kugadzirira kuunza mudunhu reMakonde nechinangwa chekuvandudza uye kusimudzira kudzvivirirwa kwezvirwere, hutano nekurapwa kwevana vane makore ari pasi pemashanu okuberekwa?

Chikamu B: Zvinhu zvinokanganisa kugamuchirwa kwehunyanzvi nemishina yechizvinozvino mudunhu reMakonde

4. Gwaro riripo iko zvino re national ICT policy rinosimudzira kana kudzivisa kuunzwa kwehunyanzvi nemishina yechizvinozvino yekuvandudza kudzivirirwa kwezvirwere nekurapwa kwevana vane makore mashanu muzvipatara nemakiriniki ehurumende mudunhu reMakonde nenzira dzipi?
5. Mungati mitemo yemashandiro ebazi rezvehutano nekurerwa zvakanaka kwevana inosimudzira kana kudzivisa kuunzwa kwehunyanzvi nemishina yechizvinozvino yekuvandudza kudzivirirwa kwezvirwere nekurapwa kwevana vane makore mashanu muzvipatara nemakiriniki ehurumende mudunhu reMakonde nenzira dzipi?
6. Ndezvipi zvinodikanwa (ICT infrastructure muchirungu) kusimudzira kuunzwa kwehunyanzvi nemishina yechizvinozvino zvamunazvo mudunhu reMakonde?
7. Kuwedzera pane zvinodikanwa (ICT infrastructure) kusimudzira kuunzwa kwehunyanzvi nemishina yechizvinozvino zvamunazvo mudunhu reMakonde, ndezvipizve zvimwe zvamungada kuti mugokwanisa kubudirira kuunza hunyanzi nemishina yechizvinozvino mudunhu reMakonde?
8. (a) Ndezvipi zvimwe zvamungati zviri kudzivisa kushandiswa kwehunyanzvi nemishina yechizvinozvino muzvipatara nemakiriniki ehurumende mukuedza kuvandudza kurapwa uye kudzivirirwa kwezvirwere muvana vane makore asingadariki mashanu mudunhu reMakonde?

   (b) Munofunga kuti zvimhingaidzo nezvimhingamipinyi izvi zvingagadziriswa sei?

9. Munofunga kuti zvii zvinofanirwa kuitwa kuti kuunzwa nekushandiswa kwehunyanzvi nemishina yechizvinozvino kubudirire mukuvandudza nekusimudzira hutano hwevana vane makore asingapfuuri mashanu mudunhu reMakonde?

********************Tinokutendai nemhinduro dzenyu**********************

Appendix VIII: Questionnaire – Makonde District Healthcare Professionals

I. English Version

Questionnaire for Healthcare Professionals in Makonde District

Section A: General Profile

1. What is your age (in years)? Between 18 and 25 ☐ between 26 and 35 ☐ between 36 and 45 ☐ above 45 ☐
2. Please indicate your gender: Male ☐ Female ☐
3. At which healthcare facility are you based? ______________________________
4. Are you in the paediatrics department? Yes ☐ No ☐
5. Do you work with children or pregnant women? Yes ☐ No ☐
6. Please state your current designation ___________________________________
7. Which of the following ICT devices do you own? (*Please tick in the 'Yes' cell if you have the device, or 'No' if you do not*)

Device	Yes	No
i. Smartphone		
ii. Laptop		
iii. Desktop		
iv. Feature (simple) phone		
v. Tablet		
Other device (*please state*)____		

8. Which of the following ICT devices do you use at work (provided by your employer)?

Device	Yes	No
i. Smartphone		
ii. Laptop		
iii. Desktop		
iv. Feature (simple) phone		
v. Tablet		
Other device (*please state*)____ ____ ____		

Section B: Adoption Readiness

9. Please state any Information and Communication Technologies (ICTs) that are being used in public healthcare in Zimbabwe to promote healthcare for children under the age of 5
   ____
   ____
   ____
10. Please state any ICTs that are being used in Makonde District's public healthcare institutions to promote the health of children under the age of 5
   ____
   ____
   ____
11. Which of the following emerging technologies in healthcare are you aware of?

Emerging Technology	**I know about it**	**I have used it previously**	**I do not know anything about it**
i. Artificial Intelligence			
ii. Internet of Things			
iii. Telemedicine			
iv. Telehealth			
v. 3D Printing			
vi. Mass media *e.g. radio, TV, electronic billboards*			
vii. Social media *e.g. Facebook, WhatsApp, Twitter*			
viii. Cloud computing			
ix. 5G technology			
x. Blockchain technology			
xi. Robotics			
xii. Other: *(please list them below and tick in the appropriate boxes)* __________ __________ __________			

12. Which of the following emerging technologies would you use if introduced in Makonde District's public healthcare institutions to promote child health?

Emerging Technology		No	Maybe	Yes
i.	Artificial Intelligence			
ii.	Internet of Things			
iii.	Telemedicine			
iv.	Telehealth			
v.	3D Printing			
vi.	Mass media *e.g. radio, TV, electronic billboards*			
vii.	Social media *e.g. Facebook, WhatsApp, Twitter*			
viii.	SMS-based systems/ solutions			
ix.	Mobile applications (mobile apps)			
x.	Virtual assistants/ chatbots			
xi.	Cloud computing			
xii.	Blockchain technology			
xiii.	Robotics			
xiv.	Other: *(please list them below and tick in the appropriate boxes)* ____ ____ ____			

13. (a) If emerging ICTs were to be introduced in Makonde District to reduce under-five mortality in public healthcare institutions, how likely are you to use them? (*Please tick)*

I won't use them	**slightly likely**	**Likely**	**Very likely**	**Less likely**

(b) Please explain why you selected the option you have chosen above

____

____

____

14. Which of the following capabilities of emerging technologies in improving the health of under-five children do you know? (*Please tick the ones you know*)

Capability	Tick if you know about it	Tick if you do not know about it
12.1 Remotely monitoring of patients		
12.2 Computerised diagnosis/ diagnosis support		
12.3 Tracking disease outbreaks		
12.4 Personalisation of healthcare		
12.5 Collecting health data remotely that can be used by medical practitioners to offer healthcare to patients		
12.6 Education and awareness on healthy living, disease prevention and good child care		
12.7 Treating patients remotely		
12.8 Training of healthcare professionals		
12.9 Communication between medical practitioners and parents/guardians of under-five children and sharing of important health information		

Section C: Potential Adoption of Emerging Technologies in Makonde District

15. Please indicate your level of agreement or disagreement with each of the following statements by ticking in an appropriate cell.
    Key: SD= Strongly Disagree; D=Disagree; N= I am not sure; A=Agree; SA= Strongly Agree

	SD	D	N	A	SA
13.1 I would use emerging technologies to deliver healthcare to under-five children in Makonde if the technologies ensure confidentiality and privacy of patient data					
13.2 The policies of my organisation support the use of emerging technologies to deliver healthcare to children under the age of 5					
13.3 The national legislation supports the use of emerging technologies to deliver healthcare to children under the age of 5					
13.4 Affordability plays an important role in the potential adoption of emerging technologies to reduce under-five mortality (U5M) in Makonde District's public healthcare institutions					

13.5 The required infrastructure (e.g. computers, networks, mobile phones) to support the deployment of emerging technologies is available in Makonde District's public healthcare institutions					
13.6 The ICT infrastructure available in Makonde District's public healthcare institutions is reliable					
13.7 There are enough mobile phones in Makonde District to support the deployment of emerging technologies to support healthcare delivery to under-five children					
13.8 I would use emerging technologies if they improve my efficiency in doing my work					
13.9I would use emerging technologies if they enable me to reach a wider audience					
13.10 I would use emerging technologies if they improve my service's quality					
13.11 I would use emerging technologies if they automate the diagnosis of diseases in patients					
13.12 I would use emerging technologies if they diagnose diseases accurately					
13.13 I would use emerging technologies if they are easier to use					

Section D: Perceptions on the role of emerging technologies

16. Please indicate your level of agreement or disagreement with each of the following statements by ticking in an appropriate cell.
    Key: SD= Strongly Disagree; D=Disagree; N= I am not sure; A=Agree; SA= Strongly Agree

	SD	D	N	A	SA
14.1 Using emerging technologies to support disease diagnosis in under-five children would improve the quality of healthcare service in Makonde District					
14.2 Using emerging technologies to remotely monitor the health of under-five children by medical practitioners would enhance disease control and management in Makonde District					
14.3 Using emerging technologies to track disease outbreaks in under-5 children would improve disease management and control in Makonde District					

14.4 Educating and awareness promotion on disease prevention and management methods for under-five children would enhance disease management and control in under-five children in Makonde District					
14.5 Using emerging technologies to support the treatment of patients by medical practitioners would improve service quality and/or enable nurses to diagnose complex diseases in the absence of doctors					
14.6 Reminding mothers or guardians of under-five children of important health information (such as dates to visit healthcare institutions for reviews, methods of preventing and managing diseases in children) would improve disease management in under-five children in Makonde District					
14.7 Using emerging technologies to remotely collect medical patient data all the times would improve disease management and/or quality of service by medical practitioners as it would provide richer patient and disease data.					
14.8 Sharing patients' data across healthcare institutions would improve service delivery, patient care and/or quality of service to under-five children in Makonde District					
14.9 Using technology to facilitate and enable information sharing among healthcare professionals would enhance disease management and diagnosis of under-five children in Makonde District					
14.10 Constant communication between healthcare institutions and parents/ guardians of under-five children in Makonde District would enhance disease control, management and prevention among under-five children in Makonde District					
14.11 Using emerging technologies to train healthcare professionals would improve service quality in the treatment of under-five children in Makonde District					

Section E: Determinants of emerging technologies adoption in Makonde District

17. Please indicate your level of agreement or disagreement with each of the following statements. *Key: SD= Strongly Disagree; D=Disagree; N= I am not sure; A=Agree; SA= Strongly Agree*

	SD	D	N	A	SA
15.1 Confidentiality and privacy of patient data are factors I would consider before adopting emerging technologies					
15.2 Ease of use of emerging technologies applications is a factor I would consider before adopting emerging technologies.					
15.3 I would consider the compatibility of emerging technologies to my duties before using them.					
15.4 Convenience is a factor I would consider before adopting emerging technologies.					
15.5 Reliability of emerging technologies is a factor I would consider before adopting emerging technologies.					
15.6 I would consider if the government is supporting the use of emerging technologies (e.g. providing resources) before I can adopt them.					
15.7 I would consider if the emerging technologies are standardised to global health standards before adopting them					
15.8 I would consider if the emerging technologies applications are well integrated with other e-health systems in my organisation before adopting them.					

Section F: Impediments to emerging technologies adoption in Makonde District

18. Please indicate your level of agreement or disagreement with each of the following statements. *Key: SD= Strongly Disagree; D=Disagree; N= I am not sure; A=Agree; SA= Strongly Agree*

	SD	D	N	A	SA
18.1 Lack of ICT infrastructure in public healthcare institutions in Makonde District impedes emerging technologies adoption.					
18.2 Security, data privacy and confidentiality issues in technological innovations impede the adoption of emerging technologies in Makonde District's public healthcare institutions.					
18.3 Lack of ICT skills among healthcare professionals is impeding the adoption of emerging technologies in public healthcare institutions in Makonde District					

18.4 Public healthcare policies are impeding the adoption of emerging technologies in public healthcare institutions in Makonde District.					
18.5 Unreliable network coverage is impeding the adoption of emerging technologies in Makonde District's public healthcare institutions.					
18.6 Low ownership of mobile phones by Makonde District's residents is impeding the adoption emerging technologies in public healthcare institutions.					

19. Which of the following technologies do you think are viable and feasible in Makonde District's public health institutions? [*Please tick*]
    a. Telemedicine and telehealth
    b. Artificial intelligence
    c. Electronic billboards
    d. SMS-based solutions
    e. Internet of things
    f. mobile applications
    g. virtual assistants / medical chatbots
    h. big data analytics
    i. cloud computing
    j. mass media
    k. social media
    l. Other (specify) ____

Thank you for your participation

II Shona Version

Gwaro retsvakurudzo kuvashandi vezvehutano vemuzvipatara nemakiriniki ehurumende mudunhu reMakonde

Chikamu A: Ruzivo rwakawanda

1. Mune makore manganic okuzvarwa? Ari pakati pe 18 ne 25 ☐ Ari pakati pe 26 ne 35 ☐ Ari pakati pe 36 ne 45 ☐ abnopfuuta 45 ☐
2. Ratidzai kuti muri munhu rudzii: Murume ☐ Mukadzi ☐
3. Munoshandira pachipatara kana kiriniki ipi? ________________________________
4. Munoshandira muchikamu chinoona nezvehutano hwevana here? Hongu ☐ Kwete ☐
5. Unoshanda nevana here kana vakadzi vane pamuviri? Hongu ☐ kwete ☐

6. Chinzvimbo chamunacho kubasa kwenyu chinonzii? ____

7. Ndeupi wemidziyo yeICT inotevera yaunayo? (Ndokumbira utarise mu'Hongu' sero kana uine mudziyo, kana 'Kwete' kana usina)

Mudziyo	Hongu	Kwete
i. Nharembozha inoita WhatsApp		
ii. Kombiyutambozha		
iii. Kombiyuta		
iv. Nharembozha isingaiti WhatsApp (Kambudzi)		
v. Tabhureti		
Mimwewo midziyo ye ICT (nyora mazita ayo) ____		

8. Ndeip midziyo ye ICT yamunopihwa kubasa kuti mushandise pane inotevera? (isai tiki pana Hongu kana Kwete zvichienderana nekuti munayo here).

Mudziyo	Hongu	Kwete
i. Nharembozha inoita WhatsApp		
ii. Kombiyutambozha		
iii. Kombiyuta		
iv. Nharembozha isingaiti WhatsApp (Kambudzi)		
Mimwewo midziyo ye ICT (nyora mazita ayo ____ ____		

Chikamu B: Kugadzirira Kugamuchira hunyanzvi nemishina yechizvinozvino

9. Ndapota taurai chero maInformation and Communication Technologies (ICTs) ari kushandiswa mukuchengetedzwa kweveruzhinji muZimbabwe kusimudzira hutano kuvana vari pasi pemakore mashanu.____
____
____
____

10. Ndapota taurai chero maICT ari kushandiswa muzvipatara nemikirinik ehurumende mudunhu reMakonde kusimudzira hutano hwevana vari pasi pemakore mashanu.____
____
____
____

11. Ndeipi yeanotevera tekinoroji iri kusimukira mukuchengetedza hutano yaunoziva?

Tekinoroji irikusimukira	**Ndinoziva nezvayo**	**Ndakamboishandisa**	**Handizivi nezvayo**
i. Artificial Intelligence			
ii. Internet of Things			
iii. Telemedicine			
iv. Telehealth			
v. 3D Printing			
vi. Mass media *e.g. radio, TV, electronic billboards*			
vii. Social media *e.g. Facebook, WhatsApp, Twitter*			
viii. Cloud computing			
ix. 5G technology			
x. Blockchain technology			
xi. Robotics			
xii. Zvimwe: (ndokumbira zvinyore pazasi womaka mumabhokisi akakodzera)			

12. Ndeupi pane anotevera tekinoroji achiri kusimukira waungashandisa kana ukaunzwa mudunhu reMakonde kuti usimudzire hutano hwevana vari pasi pemakore mashanu?

tekinoroji achiri kusimukira	**Kwete**	**Zvichida**	**Hongu**

i. Artificial Intelligence			
ii. Internet of Things			
iii. Telemedicine			
iv. Telehealth			
v. 3D Printing			
vi. Mass media *e.g. radio, TV, electronic billboards*			
vii. Social media *e.g. Facebook, WhatsApp, Twitter*			
viii. SMS-based systems/ solutions			
ix. Mobile applications (mobile apps)			
x. Virtual assistants/ chatbots			
xi. Cloud computing			
xii. Blockchain technology			
xiii. Robhotikisi (robotics)			
xiv. Zvimwe: (ndokumbira zvinyore pazasi womaka mumabhokisi akakodzera) ______ ______			

13. (a) Dai hunyanzvi nemishina yechizvinozvino zviri kusimukira aizounzwa mudunhu reMakonde kuderedza kufa kwevana vari pasi pemakore mashanu muzvipatara zvehurumende, munokwanisa kuashandisa sei? (Ndokumbira utarise)

Ini handisi kuzovashandisa	**Zvingangoitika zvishoma**	**Zvingangoitika**	**Zvingangoitika zvikuru**	**Zvingangoitika zvishoma**

(b) Ndapota tsanangura kuti sei wasarudza sarudzo yawasarudza pamusoro

______

______

______

14. Ndeupi wezvikwanisiro zvinotevera zvemichina iri kusimukira mukuvandudza hutano hwevana vari pasi pemakore mashanu waunoziva? (Ndokumbira utarise avo vaunoziva)

Chigonekwa	**Isa tiki kana uchichiziva**	**Isa tiki kana usingachizive**
14.1 Kutarisa varwere vari kure		
14.2 Kushandiswa kwemakombiyuta mukuongorora varwere		

14.3 Kuronda kupararira kwezvirwere		
14.4 Kurapa varwere zvichienderana nedungamunhu (personalisation of care)		
14.5 Kuunganidza data yehutano kure iyo inogona kushandiswa nevarapi kupa hutano kuvarwere		
14.6 Dzidzo neruzivo pamusoro pekugara kune hutano, kudzivirira zvirwere nekuchengeta vana kwakanaka		
14.7 Kurapa varwere vari kure		
14.8 Kudzidziswa kwevashandi vehutano		
14.9 Kukurukurirana pakati pevarapi nevabereki/vachengeti vevana vari pasi pemakore mashanu uye kugoverana ruzivo rwakakosha nezveutano		

15. **Chikamu C: Zvingagona kuitwa nehunyanzvi nemishina yechizvinozvino ichiri kusimukira muMakonde District**

Ndokumbira utaridze nhanho yako yekubvumirana kana kusawirirana nechimwe nechimwe chezvirevo zvinotevera nekumaka muchitokisi chakakodzera.

Kiyi: SD= Haubvumirani Zvakanyanya; D=Kusabvumirana; N = Handina chokwadi; A=Bvumira; SA= Bvumirana Kwazvo

	SD	**D**	**N**	**A**	**SA**
15.1 Ini ndaizoshandisa matekinoroji ari kusimukira kuendesa hutano kuvana vari pasi pemakore mashanu muMakonde kana tekinoroji ichiona kuvanzika uye kuvanzika kwedata revarwere.					
15.2 Mitemo yesangano rangu inotsigira kushandiswa kwemichina yemazuva ano kuendesa hutano kuvana vari pasi pemakore mashanu.					
15.3 Mutemo wenyika unotsigira kushandiswa kwemichina iri kusimukira kuendesa hutano kuvana vari pasi pemakore mashanu.					
15.4 Kutengeka kwakakosha mukutorwa kwehunyanzvi huri kusimukira kudzikisa kufa kwevasati vasvika makore mashanu (U5M) munzvimbo dzeMakonde District healthcare institution.					
15.5 Zvivakwa zvinodikanwa (semuenzaniso makomputa, network, nharembozha) kutsigira kuendeswa kwehunyanzvi huri kusimukira huri kuwanikwa munzvimbo dzeMakonde District healthcare institution.					

15.6 Zvivakwa nezvikwanisiro zveICT zvinowanikwa muMakonde District's public healthcare institution zvinovimbika					
15.7 Kune nharembozha dzakakwana mudunhu reMakonde kutsigira kufambiswa kwemichina iri kusimukira yekutsigira hutano kuvana vari pasi pemakore mashanu.					
15.8 Ini ndaizoshandisa matekinoroji ari kusimukira kana akavandudza kugona kwangu mukuita basa rangu					
15.9 Ini ndaizoshandisa matekinoroji ari kusimukira kana akandigonesa kusvika kune vateereri vakawanda					
15.10 Ini ndaizoshandisa ari kubuda matekinoroji kana akavandudza sevhisi yangu mhando					
15.11 Ini ndaizoshandisa ari kubuda matekinoroji kana ivo automate kuongororwa kwezvirwere muvarwere					
15.12 ni ndaizoshandisa matekinoroji ari kusimukira kana vakaongorora zvirwere nemazvo					
15.13 Ini ndaizoshandisa tekinoroji dziri kubuda kana dziri nyore kushandisa					

16. **Chikamu D: Maonero pamusoro pebasa rema tekinoroji ari kusimukira**
Ndokumbira utaridze nhanho yako yekubvumirana kana kusawirirana nechimwe nechimwe chezvirevo zvinotevera nekumaka muchitokisi chakakodzera.
Kiyi: SD= Haubvumirani Zvakanyanya; D=Kusabvumirana; N = Handina chokwadi; A=Bvumira; SA= Bvumirana Kwazvo

	SD	D	N	A	SA
16.1 Kushandisa matekinoroji ari kusimukira kutsigira kuongororwa kwechirwere muvana vari pasi pemakore mashanu kunovandudza kunaka kwehutano hwehutano mudunhu reMakonde.					
16.2 Kushandisa matekinoroji ari kusimukira kutarisa kure kure hutano hwevana vari pasi pemakore mashanu nevarapi kunosimudzira kudzora nekutonga kwezvirwere mudunhu reMakonde.					
16.3 Kushandisa matekinoroji ari kusimukira kuronda kupararira kwezvirwere muvana vari pasi pemakore mashanu kunovandudza hutungamiriri hwezvirwere mudunhu reMakonde.					
16.4 Kudzidzisa nekusimudzira nzira dzekudzivirira nekudzivirira zvirwere kuvana vari pasi pemakore mashanu kunosimudzira kuchengetedzwa kwezvirwere					

muvana vari pasi pemakore mashanu mudunhu reMakonde.					
16.5 Kushandisa matekinoroji ari kusimukira kutsigira kurapwa kwevarwere nevarapi kunovandudza kunaka kwesevhisi uye / kana kuita kuti vanamukoti vaone zvirwere zvakaoma pasina vanachiremba.					
16.6 Kuyeuchidza vanaamai kana vachengeti vevana vari pasi pemakore mashanu ruzivo rwakakosha nezvehutano (semazuva ekushanyira masangano ezvehutano kuti aongororwe, nzira dzekudzivirira nekudzora zvirwere muvana) kunovandudza hutungamiri hwezvirwere muvana vari pasi pemakore mashanu mudunhu reMakonde.					
16.7 Kushandisa matekinoroji ari kusimukira kuunganidza kure kure data yevarwere vekurapa nguva dzese kwaizovandudza manejimendi echirwere uye/kana mhando yebasa nevarapi vekurapa sezvo zvaizopa murwere akapfuma uye data yechirwere.					
16.8 Kugovera data revarwere munzvimbo dzese dzehutano kwaizovandudza kuendeswa kwesevhisi, kuchengetwa kwevarwere uye / kana mhando yebasa kuvana vari pasi pemakore mashanu mudunhu reMakonde.					
16.9 Kushandisa tekinoroji kufambisa uye kugonesa kugovana ruzivo pakati pevashandi vezvehutano kunosimudzira kutonga kwechirwere uye kuongororwa kwevana vari pasi pemakore mashanu mudunhu reMakonde.					
16.10 Kugara kutaurirana pakati pemasangano ezveutano nevabereki/vachengeti vevana vari pasi pemakore mashanu mudunhu reMakonde kunosimudzira kudzora, kutaridzirwa nekudzivirira zvirwere pakati pevana vari pasi pemakore mashanu mudunhu reMakonde.					
16.11 Kushandisa matekinoroji ari kusimukira kudzidzisa vashandi vezvehutano kunovandudza kunaka kwerubatsiro mukurapwa kwevana vari pasi pemakore mashanu mudunhu reMakonde.					

Chikamu E: Zvisarudzo zvekutorwa kwematekinoroji ari kusimukira mudunhu reMakonde

17. Ndokumbira utarise mwero wako wekubvumirana kana kusabvumirana nechimwe nechimwe chezvirevo zvinotevera. Kiyi: SD= Haubvumirani Zvakanyanya; D=Kusabvumirana; N = Handina chokwadi; A=Bvumira; SA= Bvumirana Kwazvo

	SD	D	N	A	SA

17.1 Kuvanzika uye kuvanzika kwedata remurwere zvinhu zvandaizofunga ndisati ndatora matekinoroji ari kubuda					
17.2 Kureruka kwekushandiswa kweachiri kusimukira matekinoroji kunyorera chinhu chandingafunga ndisati ndatora tekinoroji.					
17.3 Ini ndaizofunga kuenderana kwema tekinoroji ari kusimukira kumabasa angu ndisati ndaashandisa.					
17.4 Kurerukira chinhu chandingafunga ndisati ndatora matekinoroji ari kusimukira.					
17.5 Kuvimbika kwehunyanzvi huri kusimukira chinhu chandingafunga ndisati ndatora matekinoroji ari kusimukira.					
17.6 Ndingatarise kana hurumende iri kutsigira kushandiswa kwehunyanzvi huri kubuda (semuenzaniso kupa zviwanikwa) ndisati ndazvigamuchira.					
17.7 Ini ndaizofunga kana matekinoroji ari kusimukira akamisikidzwa kumazinga ehutano epasi rose ndisati ndaatora					
17.8 Ini ndaizofunga kana ari kubuda matekinoroji akanyatsobatanidzwa nemamwe e-hutano masisitimu musangano rangu ndisati ndaatora.					

Chikamu F: Zvipingamupinyi pakutorwa kwematekinoroji ari kusimukira mudunhu reMakonde

18. Ndokumbira utarise mwero wako wekubvumirana kana kusabvumirana nechimwe nechimwe chezvirevo zvinotevera. Kiyi: SD= Haubvumirani Zvakanyanya; D=Kusabvumirana; N = Handina chokwadi; A=Bvumira; SA= Bvumirana Kwazvo

	SD	D	N	A	SA
18.1 Kushaikwa kwezvivakwa zveICT muzvipatara zveveruzhinji mudunhu reMakonde zvinokanganisa kutorwa kwehunyanzvi huri kusimukira.					
18.2 Chengetedzo, kuvanzika kwedata uye nyaya dzekuvanzika muhunyanzvi hwekuvandudza tekinoroji zvinokanganisa kutorwa kwematekinoroji ari kusimukira munzvimbo dzeMakonde District healthcare institution.					
18.3 Kushaikwa kwehunyanzvi hweICT pakati pevashandi vehutano kuri kukanganisa kutorwa kwematekinoroji ari kusimukira munzvimbo dzeveruzhinji dzehutano mudunhu reMakonde.					

18.4 Matekinoroji ehutano hweveruzhinji ari kutadzisa kutorwa kwematekinoroji ari kusimukira munzvimbo dzehutano dzeveruzhinji mudunhu reMakonde..					
18.5 Kusavimbika kuvharika kwenetiweki kuri kukanganisa kutorwa kwematekinoroji ari kusimukira muMakonde District's healthcare institution.					
18.6 Kudzikira nharembozha nevagari vemudunhu reMakonde kuri kukanganisa kutorwa kwehunyanzvi huri kusimukira muzvipatara zveveruzhinji..					

19. Ndeupi pane anotevera tekinoroji waunofunga kuti unoshanda uye unogoneka muMakonde District's health health institution? [Ndokumbira uise tiki]
    a. Telemedicine and telehealth
    b. Artificial intelligence
    c. Electronic billboards
    d. SMS-based solutions
    e. Internet of things
    f. mobile applications
    g. virtual assistants / medical chatbots
    h. big data analytics
    i. cloud computing
    j. mass media
    k. social media
    l. Other (specify) ________________________________

Thank you for your participation

Appendix IX: Questionnaire – Mothers of Under-5 Children

I. English Version

Questionnaire for Mothers of Under-Five Children in Makonde District

Section A: General Profile

1. What is your age (in years)? Below 18 ☐ between 18 and 25 ☐ between 26 and 35 ☐ between 36 and 45 ☐ above 45 ☐
2. At which healthcare facility are you based? ________________________________
3. Which of the following devices/gadgets do you own?

Device	Please tick the ones you have
3.1 Smartphone	
3.2 Laptop/Desktop	
3.3 Radio/TV	
3.4 Feature (simple) phone	
3.5 Tablet	
3.6 Other device (*please state*)____	

4. What is your highest level of education?

Educational Level	Please tick
4.1 Never been to school	
4.2 Primary	
4.3 Secondary	
4.4 Tertiary	
4.5 Other (*Please specify)*____________________________	

5. How many children under the age of 5 do you have? Zero ☐ One ☐ Two ☐ Three ☐
6. How many children, other than yours, do you look after and are under the age of 5 years? Zero ☐ One ☐ Two ☐ Three ☐ Other (Please state)____ ☐

7. Do you think under-five mortality is really a problem in Makonde District? No

   Yes ☐ Not sure ☐

8. If your clinic or hospital was to introduce emerging technologies to monitor and manage your under-five child/children's health, would you agree to use them?
   No ☐ Yes ☐ Not sure ☐

9. Which of the following social media platforms do you an account with?

Social Media Platform	**Please tick**
9.1 WhatsApp	
9.2 Facebook	
9.3 Twitter	
9.4 Other (*please specify)*	

Section B: Factors impeding the adoption of emerging technologies by mothers of under-five children in Makonde District

10. Please indicate your extent of agreement/disagreement to each of the following statements.
    Key: SD=Strong Disagree, D=Disagree, N=Not sure, A= Agree, SA=Strongly Agree

	SD	**D**	**N**	**A**	**SA**
10.1 I would accept to use emerging technologies to monitor and manage my under-five child's health if my healthcare institution introduces them					
10.2 There is a stable phone network in my area					
10.3 I would agree to have my under-five child's health continuously monitored by healthcare professionals using technology					
10.4 I would use emerging technology to monitor my under-five child's health if I am trained on how to use it					
10.5 I would use technology to book appointments with doctors if such technology is introduced					
10.6 I would use emerging technologies to monitor my under-five child's health if my close friends and relatives are using them					
10.7 The reason I am not using emerging technologies for my under-five child's health is because there are no such technologies					
10.8 I trust the use of technology in monitoring people's health					
10.9 I am able to operate a mobile phone					

10.10 I am able to use a computer					
10.11 I am intrinsically motivated to use technology to monitor my under-five child's health					
10.12 I would use emerging technologies to monitor my child's health if I am shown the positive results such technologies have produced elsewhere					
10.13 I would use emerging technologies to monitor and manage my under-five child's health if the technologies are easy to use					
10.14 Emerging technologies applications for healthcare are difficult to use					
10.15 I would adopt emerging technologies for under-five children's healthcare if I can be allowed to experiment with such technologies first					
10.16 I would adopt emerging technologies for under-five children's health if the technologies are cheaper or for free					

***************Thank you for your participation*********************

II. Shona Version

Mibvunzo Yetsvakurudzo Kuna Vanamai Vane Vana Vane Makore Asingapfuuri Mashanu Vachigara Mudunhu reMakonde (Questionnaire to Mothers of Under-Five Children in Makonde District)

Chikamu A: General Profile

1. Mune makore manganic okuberekwa? Ari pasi pe18 ☐ pakati pe 18 ne 25 ☐ pakati pe 26 ne 35 ☐ pakati pe 36 ne 45 ☐ kupfuura 45 ☐
2. Munorapirwa pachipatara kana kiriniki ipi? ________________________________
3. Ndeipi midziyo yamunayo pane inotevera? [*Isai tiki mubhokisi rinoratidza midziyo yamunayo*]

Mudziyo	Isai tiki (√)
3.1 Nharembozha inoita Internet neWhatsApp(Smart phone)	
3.2 Kombiyuta (Computer/ Laptop kana Desktop)	
3.3 Dzimudzangara/ terevhizhoni (Radio/TV)	
3.4 Nharembozha isingaiti Internet kana WhatsApp/ 'kambudzi'(Feature/simple phone)	

3.5 Tabhureti (Tablet)	
3.6 Zvimwewo (*nyorai mazita azvo*) ____	

4. Makadzidza kusvika papi? [*Isai tiki mubhokisi rinoratidza midziyo yamunayo*]

Chikamu chedzidzo	**Isai tiki (√)**
4.1 handina kumbobva ndaenda kuchikoro	
4.2 ndakagumira Primary	
4.3 ndakaugimra Secondary	
4.4 ndakagumira Tertiary	
4.5 Imwewo (*nyora zita rayo*___________________________	

5. Mune vana vangani vari pasi pemakore mashanu? Handina (0) ☐
   Mumwechet (1) ☐ Vaviri (2) ☐ vatatu (Three) ☐
6. Mune vana vangani, vasiri venyu, vamuri kuchengeta vane makore asingapfuuri 5?
   0 ☐ 1 ☐ 2 ☐ 3 ☐ Imwewo nhamba (*inyorei*)____
7. Munofunga kuti kushaya kwevana vane makore ari pasi pemashanu ringanzi idambudziko here mudunhu reMakonde? Kwete ☐ hongu ☐ handinyatsoziva ☐
8. Chipatara kana kiriniki yenyu ikaunza hunyanzi nemishina yechizvinozvino kuti vagozvishandisa mukuongorora, kuchengetedza hutano nekurapa mwana kana vana venyu vari pasi pemakore mashanu, mungabvuma here kuti hunyanzvi nemishina iyi zvishandiswe pamwana kana vana venyu? Kwete ☐ hongu ☐
   handinyatsoziva ☐

9. Ndeipi social media yamunoshandisa pane anotevera? [*Isai tiki mubhokisi riri pamberi pe social media yaunoshandisa*]

(Mhando yehunyanzvi hwekutandara pamhepo) Social Media Platform	**Isai tiki (Please tick)**
9.1 WhatsApp	
9.2 Facebook	
9.3 Twitter	
9.4 Imwe (*Nyorai zita rayo)*______________________________	

Chikamu B: Zvinhu zvinokanganisa kugamuchirwa kwehunyanzvi nemishina yechizvinozvino mudunhu reMakonde

10. Ratidzai danho rekubvumirana kana kusabvumirana kwenyu nemitsara inotevera. Isai tiki mubhokisi rine mhinduro yamunoda pamutsara mumwe nemumwe.
Key: SD=Ndinozviramba zvakasimba, D=Ndinozviramba, N=Handinyatsoziva, A= Ndinozvibvuma, SA=Ndinozvibvuma zvakasimba

Mitsara	**SD**	**D**	**N**	**A**	**SA**
10.1 Ndinobvuma kuti hunyanzi nemishina yechizvinozvino zvishandiswa kuongorora, kutarisa nekuchengetedza hutano hwemwana wangu ane makore ari pasi pemashanu kana chipatara/kiriniki yangu ikazviunza.					
10.2 Kune masaisai enharembozha akasimba kunzvimbo kwandogara					
10.3 Ndinobvuma kuti mwana wangu ane makore ari pasi pemashanu okuberekwa aongororwe hutano hwake nguva dzose neve hutano vachishandisa hunyanzvi nemishina yechizvinozvino					
10.4 Kana ndikadzidziswa mashandisirwo ehunyanzvi nemishina yechizvinozvino mukuongorora nekuchengetedza hutano hwemwana wangu ane makore asingasviki mashanu, ndingashandisa hunyanzi nemishina yechizvinozvino iyi.					
10.5 Kana hunyanzvi nemishina yechizvinozvino zvinoshandiswa kubatira nguva yekuona chiremba zvikaunzwa, ndingashandisa hunyanzi nemishina yechinozvinozvino iyi.					
10.6 Kana shamwari nehama dzangu dzepedyo dzikashandisa hunyanzvi nemishina yechizvinozvino mukuongorora nekusimudzira hutano hwevana vavo vane makore asingapfuuri mashanu, neniwo ndinobva ndashandisawo pane wangu mwana.					
10.7 Chikonzero ndisiri kushandiswa hunyanzvi nemishina yechizvinozvino kuongorora, kuchengetedza nekuvandudza hutano hwemwana wangu ane makore ari pasi pemashanu ndechekuti hunyanzvi nemishina yechizvinozvino iyi hazvisati zvavapo munzvimbo yandogara.					
10.8 Ndine chivimbo mukushandiswa kwehunyanzvi nemishina yechizvinozvino mukuongorora hutano hwevanhu					
10.9 Ndinokwanisa kushandiswa nharembozha					
10.10 Ndinokwanisa kushandiswa kombiyuta.					

10.11 Ndine chidokwadokwa chekushandisa hunyanzvi nemishina yechizvinozvino mukuongorora hutano hwemwana wangu ane makore asingapfuuri mashanu.					
10.12 Kana ndikaratidzwa zvakanakira kushandiswa kwehunyanzvi nemishina yechizvinozvino pakuchengetedza, kuongorora nekuvandudza hutano hwevana vane makore asingapfuuri mashanu zvinobatika kubva kune dzimwe nyika, neniwo ndingashandisawo hunyanzvi nemishina yechizvinozvino iyi pamwana wangu.					
10.13 Ndingashandisa hunyanzvi nemishina yechizvinozvino mukuvandudza, kuongorora nekusimudzira hutano hwemwana wangu ane makore asingapfuuri mashanu kana hunyanzvi nemishina yechizvinozvino iyi zviri nyore kushandiswa.					
10.14 Hunyanzvi nemishina yechizvinozvino inoshandiswa mune zvehutano haisi nyore kushandisa.					
10.15 Ndingagamuchira hunyanzvi nemishina yechizvinozvino inoshandiswa pane zvehutano hwevana vane makore asingapfuuri mashanu kana ndikatanga ndawaniswa mukana wekumboongorora kuti hunyanzvi nemishina iyi zvinonyatsoshanda sei chaizvo.					
10.16 Ndingagamuchira hunyanzvi nemishina yechizvinozvino inoshandiswa pane zvehutano hwevana vane makore asingapfuuri mashanu kana hunyanzvi nemishina iyi zvisingadhuri kushandisa kana kuti zvichishandiswa pachena pasina muripo					

***************Tinotenda nekupinda kwenyu mutsvakurudzo ino*********

Appendix X: Informed Consent Form

I. English Version

MRCZ Protocol Number: MRCZ/A/2782 **UKZN Protocol Number: HSSREC/00002132/2020**

Project Title: Reducing under-five mortality in Makonde District's public healthcare institutions: An exploratory investigation into the potential role of emerging technologies

Protocol Version 1/05092021

CONSENT TO PARTICIPATE

I ……………………………………………………………..(Name) have been informed about the study entitled

Reducing under-five mortality in Makonde District's public healthcare institutions: An exploratory investigation into the potential role of emerging technologies by **John Batani.**

I understand the purpose and procedures of the study, which is to develop an emerging technologies framework to help reduce under-five mortality in public healthcare facilities in Makonde District.

I have been given an opportunity to ask questions about the study and have had answers to my satisfaction.

I declare that my participation in this study is entirely voluntary and that I may withdraw at any time without affecting any of the benefits that I usually am entitled to.

I have been informed about any available compensation or medical treatment if injury occurs to me as a result of study-related procedures.

If I have any further questions/concerns or queries related to the study I understand that I may contact the researcher on the mobile numbers +266 63494922 | +263 775 996 116 and/or the email addresses 218020009@stu.ukzn.ac.za or jonj188@gmail.com

If I have any questions or concerns about my rights as a study participant, or if I am concerned about an aspect of the study or the researchers then I may contact:

HUMANITIES & SOCIAL SCIENCES RESEARCH ETHICS ADMINISTRATION

Research Office, Westville Campus

Govan Mbeki Building

Private Bag X 54001

Durban

4000

KwaZulu-Natal, SOUTH AFRICA

Tel: 27 31 2604557 - Fax: 27 31 2604609

Email: HSSREC@ukzn.ac.za

OR

THE MEDICAL RESEARCH COUNCIL OF ZIMBABWE

National Institute of Research

Corner Josiah Tongogara and Mazowe Avenue

Hararare

Zimbabwe

Tel: (242)791792 | 791193 Cell: 0784 956 128

Email Address: mrcz@mrcz.org.zw

OFFER TO ANSWER QUESTIONS

Before you sign this form, please ask any questions on any aspect of this study that is unclear to you. You may take as much time as necessary to think it over.

AUTHORIZATION

You are making a decision whether or not to participate in this study. Your signature indicates that you have read and understood the information provided above, have had all your questions answered, and have decided to participate.

Additional consent, where applicable

I hereby provide consent to:

Audio-record my interview / focus group discussion	YES / NO
Video-record my interview / focus group discussion	YES / NO
Use of my photographs for research purposes	YES / NO

____________________	____________________	______________
Name of Participant (Please Print)	**Signature of Participant**	**Date**
____________________	____________________	______________
Name of Witness (Please Print)	**Signature of Witness**	**Date**
(Where applicable)		
____________________	____________________	______________
Name of Translator (Please Print)	**Signature of Translator**	**Date**
(Where applicable)		

YOU WILL BE OFFERED A COPY OF THIS CONSENT FORM TO KEEP.

If you have any questions concerning this study or consent form beyond those answered by the investigator, including questions about the research, your rights as a research participant or research-related injuries; or if you feel that you have been treated unfairly and would like to talk to someone other than a member of the research team, please feel free to contact the Medical Research Council of Zimbabwe (MRCZ) on telephone (04)791792 or (04) 791193 and cell phone lines 0784 956 128. The MRCZ Offices are located at the National Institute of Health Research premises at Corner Josiah Tongogara and Mazowe Avenue in Harare.

II. Shona Version

Project Title: Reducing under-five mortality in Makonde District's public healthcare institutions:

An exploratory investigation into the potential role of emerging technologies

Protocol Version 1/05092021

MVUMO YEKUPINDA MUTSVAKURUDZO INO (CONSENT TO PARTICIPATE)

Ini ………………………………………………………………..(Zita) ndatsananguririrwa nezvetsvakurudzo inonzi

Reducing under-five mortality in Makonde District's public healthcare institutions: An exploratory investigation into the potential role of emerging technologies iyo iri kuitwa na **John Batani.**

Ndinonzwisisa chinangwa nemaitirwo achaitwa tsvakurudzo ino, chinova kubuda negwaro rinotsanangura mashandisirwo angaitwa hunyanzvi nemishina yechizvinozvino mukuedza kuderedza dambudziko revana vanofa vasati vasvika makore mashanu muzvipatara nemakiriniki mudunhu reMakonde.

Ndapihwa mukana wekubvunza mibvunzo iyo yapindurwa zvandigutsa.

Handina kumanikidzwa kupinda mutsvakurudzo ino uye ndinoziva kuti ndinogona kungobuda chero nguva, zvisingandikanganisi.

Ndatsanangurirwa nezvekutsiviwa kana kuri kuti ndakuvara nekuda kwetsvakurudzo ino.

Kana ndine mibvunzo inoenderana netsvakurudzo ino, Ndinonzwisisa kuti ndinogona kubata mutsvakurudzi panharembozha panhamba dzinoti +266 63494922 | +263 775 996 116 kana pakero yetsambambozha inoti 218020009@stu.ukzn.ac.za kana jonj188@gmail.com

Kana ndine zvandingada kuziva kana kunyunyuta maringe nemutsvakurudzi kana kodzero dzangu semumwe wevanhu vari mutsvakurudzo ino, ndinogona kubata:

HUMANITIES & SOCIAL SCIENCES RESEARCH ETHICS ADMINISTRATION

Research Office, Westville Campus

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4000

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OR

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National Institute of Research

Corner Josiah Tongogara and Mazowe Avenue

Hararare

Zimbabwe

Tel: (242)791792 | 791193 Cell: 0784 956 128

Email Address: mrcz@mrcz.org.zw

KUZVIPIRA KUPINDURA MIBVUNZO

Musati maisa runyoro rwenyu/ mhiyepiye (signature) pafomu rino, bvunzai mibvunzo yose yamungava nayo maringe netsvakurudzo ino. Munogona kumbotora nguva yenyu muchifunga.

MVUMO

Muri kuita sarudzo yekuti mopinda here kana kwete mutsvakurudzo ino. Runyoro (signature) rwenyu rwunoratidza kuti maverenga gwaro rino, mibvunzo yamanga munayo yapindurwa uye masarudza kupinda mutsvakurudzo ino.

Dzimwewo mvumo, kana zvichienderana.

Ndinopa mvumo yeku:

Rekodha izwi rangu pahurukuro kana nhaurirano / focus group discussion	HONGU / KWETE
Rekodha vhidhiyo yangu pahurukuro kana nhaurirano	HONGU /KWETE
Kushandiswa kwemifananidzo yangu patsvukurudzo ino	HONGU / KWETE

____________________	____________________	______________
Zita renyu (Please Print)	**Signature/mhiyepiye yenyu**	**Date (Musi)**
____________________	____________________	_____________
Zita remufakazi (Please Print) **(Where applicable)**	**Mhiyepiye (Signature) yemufakazi**	**Date (Musi)**
____________________	_____________________	_____________
Zita remuturikiri (Please Print) **(Where applicable)**	**Signature (Mhinyepiye) yemuturikiri**	**Date (Musi)**

MUCHAPIWA KOPI (COPY) YEGWARO RINO KUTI MUCHENGETE, KANA MUCHIRIDA.

Kana mune mibvunzo maringe netsvakurudzo ino kana gwaro rino zvisina kukwanisa kupindurwa nemutsvakurudzi, kusanganisira mibvunzo ine chekuita nekodzero dzenyu mutsvakurudzo ino, kana kuti kana muchifunga kuti hamuna kubatwa zvakanaka uye munoda kutaura nemumwewo munhu asiri mutsvakurudzi, makasanunguka kubata ve Medical Research Council of Zimbabwe (MRCZ) panhare panhamba dzinoti (04)791792 or (04) 791193 kana panharembozha 0784 956 128. Mahofisi eMRCZ anowanikwa paNational Institute of Health Research premises pana Corner Josiah Tongogara na Mazowe Avenue muHarare.

Appendix XI: Introductory Letter to Respondents

I. English Version

Introductory Letter to Respondents

Dear Respondent,

My name is John Batani, a PhD student in the School of Management, IT and Governance studying towards a PhD in Information Systems and Technology at the University of KwaZulu Natal (South Africa). My research title is "**Reducing under-five mortality in public healthcare facilities in Makonde District: An exploratory investigation into the potential role of emerging technologies**". This study aims to explore the potential role of emerging technologies and provide pragmatic emerging technologies based solutions to the problem of high under-five mortality in Zimbabwe.

In this study, the term "emerging technology" means an ICT innovation that has the potential to transform health delivery and patient care for under-five children, and it is still relatively new in Zimbabwe's public healthcare or paediatrics. Below are some of the emerging technologies (not exhaustive).

(i) Artificial Intelligence (AI) -AI is a collection of technologies that seek to make computers intelligent, for example, machine learning, artificial neural networks and deep learning. Some of its uses include improving and automating diagnosis (such as cancer diagnosis using imaging data) and treatment, recommending patient engagement, adherence and administration.

(ii) Internet of things (IoT) - refers to the use of the existing Internet infrastructure to connect everyday objects (things) to the Internet using sensors, wireless sensor networks (WSN), Bluetooth enabled devices and includes powerful back-end servers data analysis and knowledge extraction (Khodadadi et al., 2016). IoT is helps in monitoring patient health remotely in real-time by reading bodily parameters like temperature, heart beat, blood pressure and oxygen saturation and sending the readings to healthcare institutions in real-time.

(iii) 3D printing is an emerging technology in healthcare that is improving efficiency, enabling personalisation and customisation of healthcare. The uses of this technology in health include surgery pre-planning, virtual planning and customisation of surgery and surgical guides, patient-specific implants, bioprinting of organs and tissues, tissue and organ fabrication, creating customised prosthetics, pharmaceutical research on drug dose and forms, delivery and detection.

(iv) Telemedicine - Telemedicine is the diagnosis and treatment of patients by means of information and telecommunications technology. Telemedicine has several technological toolkits that can deliver cutting-edge solutions to healthcare services delivery. Teleconsultation, telemonitoring, tele-expertise, teledermatology, teleradiology, telecardiology, tele-oncology and telepsychiatry are some of the many services provided with telemedicine. Telerehabilitation is a post-diagnosis or post-admission service offered to patients that require rehabilitation as a part of their treatment or general wellbeing.

(v) Mass media communication technologies - are communication technologies intended to reach large numbers of people, such as electronic/digital billboards, radios, televisions and social media. Mass media technologies have shown to improve people's behaviour, perceptions and attitudes towards health issues (B. J. Saunders & Goddard, 2002). Mass media plays an important role in disease prevention by educating the public on health matters and disease prevention methods (Balamurugan, 2018; Naveena, 2015; B. J. Saunders & Goddard, 2002; Sharma & Gupta, 2017)

(vi) Telehealth - Telehealth is defined as the use of medical information that could be exchanged from one point to another via electronic communication to promote the health conditions of patients. It also uses various technologies and services to provide patient care and enhance healthcare delivery.

(vii) Big data analytics - Big data refers to vast and complex data which cannot be easily analysed and managed with traditional software and hardware. Big data analytics comprises controlling data quality, integrating heterogeneous data, analysing, modelling, interpreting and validating. Through big data analytics, huge datasets of thousands or millions of patients can be analysed, and clusters and correlations identified to develop predictive models using data mining techniques.

(viii) SMS-based solutions - SMS-text messages have a wider reach than mobile apps since they can reach any user with a mobile phone, whether a smart or feature phone. They are useful in sending out reminders and health information.

(ix) WhatsApp-based systems – with its growing popularity, WhatsApp can be used just like SMSs to send important information and reminders to mothers or guardians of under-five children. However, unlike with SMSs, WhatsApp can be used with medical chatbots (virtual assistants), making them more interactive.

(x) Electronic billboards –help with information dissemination to the public, which may lead to behavioural changes.

My kind request to you regards your participation in this study by in this interview/focus group. I guarantee that your responses to this questionnaire shall solely be used for the purposes of this study, and your anonymity shall also be preserved. In undertaking this research, I am being guided by Professor Maharaj Manoj.

If you need any clarification regarding this study or questionnaire, feel free to contact:

John Batani Email: jonj188@gmail.com Cell: +266 63494922

Prof. Manoj Maharaj: maharajms@ukzn.ac.za

Your responses are highly appreciated.

John Batani

Ph.D Information Systems and Technology Student

The University of KwaZulu-Natal

II. Shona Version

Tsamba yekusuma kune vapinduri

Wadiwa mupinduri,

Kwaziwai,

Ini ndinonzi John Batani, mudzidzi ari kuita zvidzidzo zvepamusoro zvemishina nehunyanzvi hwechizvinozvino (Information Systems and Technology) payunivhesiti yeku South Africa inonzi University of KwaZulu-Natal (UKZN). Musoro wetsvakurudzo ino unoti "**Reducing under-five mortality in public healthcare facilities in Makonde District: An exploratory investigation into the potential role of emerging technologies**". Chinangwa chetsvakurudzo ino kuongorora kuti nderipi ringagona kuva basa rehunyanzvi nemishina yechizvinozvino (emerging technologies) mukurwisa dambudziko rekufa kwevana vane makore ari pasi pemashanu muZimbabwe.

Mutsvakurudzo ino, mazwi okuti "emerging technology" anoshandirwa kuti agoreva "hunyanzvi nemishina yechizvinozvino". Mazwi aya anoreva hunyanzvi nemishina yechizvinozvino yeku information technology inogona kushandiswa kusimudzira hutano nekurapwa kwevana vane makore mashanu zvichidzika, uye isati yanyanyoshandiswa mune zvehutano muzvipatara zvehurumende muZimbabwe, kunyanya kudavi kana bazi rinoita nezvehutano hwevana vadiki (paediatrics department). Umwe hwehunyanzvi hwechizvinozvino uhwu ndinohwutsanangura pasi, asi sandihwo hwese:

(i) Artificial Intelligence (AI) -AI muunganidzwa wematekinoroji anotsvaga kuita kuti makombiyuta ave nehungwaru. Zvinoshandiswa matekinoroji aya zvinosanganisira kuvandudza kwekuongororwa kwezvirwere (senge kenza kuongororwa uchishandisa imaging data) uye kurapwa, kukurudzira murwere kubatanidzwa, kutevedzera uye manejimendi yezvirwere.

(ii) Internet of things (IoT) - uku kushandiswa kwema sensor, Bluetooth, nemamwe matekinoroji anoita kuti vezvehutano vakwanisa kugara vachiona mamiriro akaita hutano hwevarwere nguva dzose, chero vasiri pavari.Hunyanzvi uhwu hunogona kushandiswa kuongorora mapisiro emuviri, mashandiro emwoyo, huwandu hwemweya wekufema hunenge huri muropa remurwere nezvimwewo. Izvi zvinogoneka murwere ari chero kwaari, asiri pachipatar uye chero nguva ipi zvayo.

(iii) 3D printing – iyi itekinoroji iri kubuda mune zvehutano iri kuvandudza mashandiro, ichigonesa kuita kwemunhu uye kugadzirisa kwehutano.

(iv) Telemedicine – Telemedicine ndiko kuongororwa uye kurapwa kwevarwere nenzira yeruzivo uye tekinoroji yekufona. Telemedicine ine akati wandei maturusi ayo anobatsira mukurapwa kwevarwere vasiri panzvimbo.

(v) Mass media communication technologies – ndiwo matekinoroji ehunyanzvi anoitirwa kusvika kune vanhu vazhinji. Anosanganisira madzimu dzangara, materevhizhoni, uye social media (Facebook, WhatsApp, nezvimwewo). Matekinoroji aya anobatsira kufambisa mashoko, zvinobatsira kuti vanhu vararame zvine hutano.

Chikumbiro change kwamuri kuti mupinde mutsvakurudzo ino kuburikidza nekupinda muhurukuro yatichaita (interview/ focus group discussion) kana kupindura gwaro remibvunzo (questionnaire). Mhinduro dzenyu hadzizoshandiswi chimwe chinhu asi tsvakurudzo ino yoga. Sunungukai kupa mhinduro dzenyu muchiziva kuti hapana achazoziva kuti ndimi makataura kuti chii. Mukuita tsvakurudzo ino, ndiri kushanda ndichiungamirirwa naMuzvinafundo Manoj Maharaj.

Kana muchida kuziva zvizhinji nezvetsvakurudzo ino, tibatei panhamba kana kero yetsambambozha zvinotevera:

John Batani Email: jonj188@gmail.com Cell: +266 63494922

Prof. Manoj Maharaj: maharajms@ukzn.ac.za

Tinokutendai nenguva yenyu yamuchatora kupindura mibvunzo ino.

Wenyu,

John Batani

PhD Information Systems and Technology Student

The University of KwaZulu-Natal

Appendix XII: Focus Group Discussion Guide

i. English

Focus Group Discussion Guide

Section 1: Welcome, Consent Process and Introductions

(a). Welcome

Greetings to you all, and welcome to our focus group discussion session.

I appreciate your interest in participating in this focus group discussion that aims to explore the potential role of emerging technologies in reducing under-five mortality (U5M) in Makonde District's public healthcare institutions. My name is John Batani, a PhD student in Information Systems and Technology at the University of KwaZulu Natal (UKZN). The purpose of this discussion is to explore issues in the delivery of healthcare to children under the age of five in Makonde District's public health institutions to meet the aforementioned aim. Emerging technology in healthcare is an ICT innovation that has the potential to transform health delivery and patient care, and it is still relatively new in Zimbabwe's public healthcare or paediatrics. Examples of such emerging technologies are telemedicine, telehealth, artificial intelligence, medical internet of things (MIoT), 3D printing, virtual clinics, digital mass media and social media, among others. This is phase one of the two data collection phases, and it is meant to help gain more in-depth insights before collecting quantitative data. We would like to discuss factors contributing to high under-five mortality in this district and which ones could possibly be addressed using emerging technologies, the most feasible emerging technologies that could potentially be adopted to reduce U5M in Makonde District, level of preparedness to adopt emerging technologies, factors that can potentially affect the adoption of emerging technologies and the potential role emerging technologies can play in reducing U5M in Makonde District's public healthcare institutions. Participation in this discussion is voluntary, and you may withdraw at any stage. I undertake to preserve the anonymity of all participants by using coded names rather than your actual names.

(b) Consent Process

I will ask all of you to fill in the consent form to be shared immediately so that I will ascertain if we are voluntarily participating in this focus group discussion.

(c) About the focus group

- Some of you might have participated in focus groups before. I am using this focus group to gain more and deeper insights about U5M in Makonde District to help me plan the next phase of data collection.
- You are the experts, and I wish to learn from you. I do not only wish to learn the positives but even the negatives too. As public healthcare professionals, you have vast information, experiences, needs and perspectives about U5M in Makonde District as you closely work with under-five children; and I wish to learn all those from you as experts.
- This discussion does not seek to achieve consensus but to gather information. It is okay to have divergent opinions from some members of this group because our experiences, knowledge and perspectives may not necessarily be the same. However, it is important to be respectful when expressing a point that disagrees with a group member's views.

2. Focus Group Ground Rules

- In this discussion, every participant is equal, and their views shall be treated with respect. No view is wrong, but you are allowed to have a different view, provided you express it respectfully.
- The discussion must remain within the confines of the questions asked. Your participation in this discussion is out of your own will, and you may withdraw at any stage of the discussion should you decide to.
- This discussion will be audio-recorded with your permission. The recording is only for the purposes of correctly capturing your views and will be destroyed shortly after transcribing your responses.
- Everyone is expected to participate, but only one person shall speak at a time.

If there are any questions, please feel free to ask.

Start recording the session

Focus Group Questions

Research Question 1

1. How prevalent is the problem of U5M in the Makonde District?
2. What factors could be contributing to that level of prevalence in U5M?
3. Which of these factors in 2 above do you think could be addressed by emerging technologies?
4. Which emerging technologies do you consider more feasible in reducing U5M in Makonde District and why?
5. Which emerging technologies in healthcare do you know?
6. If any emerging technology is to be introduced at your health facility to reduce U5M, would you accept and use it? Why?

Research Question 2

7. What factors (both negative and positive) could potentially affect the adoption of emerging technologies for reducing U5M in Makonde District by healthcare professionals?
8. What factors (both negative and positive) could potentially affect the adoption of emerging technologies for reducing U5M in Makonde District by pregnant women and mothers of under-five children?
9. Do you think your health facility is ready to introduce emerging technologies to reduce U5M? Why?

Research Question 3

10. If an emerging technology is to be introduced to reduce U5M in Makonde District's public healthcare institutions, do you think it would be successful? Why do you think so?
    a. What do you propose should be done to improve the likelihood of success of emerging technologies in Makonde District's public healthcare institutions?
11. What contribution do you think emerging technologies would make in reducing U5M in Makonde District?
12. Which of the following technologies do you think are feasible in Makonde District's public healthcare institutions and why?
    a. Telemedicine and telehealth
    b. Artificial intelligence

c. Electronic billboards
d. SMS-based solutions
e. Internet of things
f. mobile applications
g. virtual assistants / medical chatbots
h. big data analytics
i. cloud computing
j. mass media
k. social media
l. Other (specify)

13. What contribution could emerging technologies make towards disease prevention in Makonde District?
14. What contribution could emerging technologies make in improving disease management amongst under-five children in Makonde District?
15. What contribution could emerging technologies make in improving the quality of healthcare for under-five children in the Makonde District?

Thank you for your participation

ii. Shona version

Gwara renhaurirano reboka

<u>Chikamu 1: Kugamuchirwa, Kubvumira Maitiro uye Sumo</u>

<u>Chikamu 1: Kwaziso, Mvumo nemirairo</u>

<u>(a). Kwaziso</u>

Kwaziwai kwamuri mose. Ndinokuchingamidzai kuhurukuro yedu yanhasi.

Ndinokutendai nekuratidza chido chekupinda muhurukuro ino, iyo ine chinangwa chekutsvakurudza kuti hunyanzvi nemishina yechizvinozvino zvingagona kubatsira sei mukurwisa dambudziko rekufa kwevana vane makore mashanu zvichidzika muzvipatarat zvehurumende mudunhu reMakonde.

Zita rangu ndinonzi John Batani, mudzidzi arikuita zvidzidzo zve PhD in Information Systems and Technology pachikoro che University of KwaZulu Natal (UKZN). Chinangwa chehurukuro ino kutsvakurudza matambudziko amuri kusangana nawo mukurapa uye kuchengetedza vana vari pasi pemakore mashanu mudunhu reMakonde. Hunyanzvi nemishina yechizvinozvino mubandiko rezvehutano ndiyo iya ine mukana wekushandura marapirwo evarwere uye mashandiro avana mazvikokota vezvehutano. Hunyanzvi uhwu hunenge huchiri hutsva munyika yeZimbabwe.

Chikamu chino ndechekutanga mutsvakurudzo ino, uye chiri kugadzira hwaro hwechikamu chepiri chetsvakurudzo ino. Tinoda kukurukura kuti ngenyi vana vakawanda vari kufa mudunhu reMakonde vasati vasvika makore mashanu; kuti ndeapi matambudziko aya angagona kurwiswa tichishandisa mishina yechizvinozvino, ndeipi mishina nehunyanzvi hwechizvinozvino zvingagona kushandiswa kurwisa dambudziko iri, danho regadziriro yekushandisa mishina nehunyanzvi uhwu, uye zvimhingamupinyi mukushandiswa kwehunyanzvi uhwu mudunhu reMakonde. Hamumanikidzirwe kupinda mutsvakurudzo ino uye makasununguka kubuda chero pamadira. Ndinovimbisa kuti mazita enyu akachengetedzwa. Hapana achaziva kuti ndiani akataura kuti kudii mutsvakurudzo ino. Ndichakupai mamwe mazita achashandiswa mutsvakurudzo ino, kuti mazita enyu chaiwo asazivikanwa.

<u>(b) Mvumo</u>

Ndichakumbira mumwe nemumwe wenyu kuti aise runyoro rwake pagwaro rekubvuma kupinda mutsvakurudzo ino. Gwaro racho ndiri kukupai munguva pfupi inotevera. Izvi zvichandibatsira kuti ndizive kana muri kubvuma kupinda mutsvakurudzo ino.

(c) About the focus group

- Vamwe venyu munogona makambopinda mune dzimwewo hurukuro dzakada kufanana neino. Ini ndiri kuita hurukuro ino nemi kuti ndigowana ruzivo rwakadzama maringe nezviri kuitika mudunhu reMakonde padambudziko rekufa kwevana vasati vasvika makore mashanu okuberekwa. Zvichabuda muhurukuro ino zvichabatsira muchikamu chepiri chetsvakurudzo ino.
- Ndimi vana mazvikokota, saka ndinovimba ndichadzidza zvizhinji kubva kwamuri, zvinofadza nezvinosuwisa pamwechete. Sunungukai kutaura zvose, zvingava zvakanaka kana kushata, kufadza kana kusuwisa. Sevashandi vezve hutano, ndinoziva kuti mune ruzivo rwakadzama maringe nenyaya yatirir kuda kukurukura nezvaya nhasi.

- Hurukuro ino haisi pakutsvaga kuti tose tibvumirane kuva nemuono mumwe chete ba, asi kuti mumwe nemumwe ataure maonero ake, zvaanoziva nezvaakasangana nazvo sedungamunhu. Hazvina kushata kuti vanhu vaite maonero akasiyana, asi chakakosha kuti titaure tichiremekedzana pakusiyana kwemaonero edu iwayo.
- **2. Mitemo yenhaurirano ino**
  - Munhu mumwe nemumwe ari munhaurirano ino akaenzana nevamwe vose pakuonekwa kwake, naizvozvo ngatiremekedzanei kana tiine maonero akasiyana kana kufanana. Mafungiro nemaonero enyu ndichamaremekedza. Pfungwa dzose dzakakosha uye dzicharemekedzwa zvakakodzera.
  - Hurukuro yedu inotarisirwa kuramba iri pamubvunzo wabvunzwa panguva iyoyo. Zvatichakurukura muhurukuro ino hazvitarisirwe kuendwa nazvo panze, ngazviperere muno. Kupinda kwenyu muhurukuro ino hakumanikidzwe uye munogona kubuda chero pamadira.
  - Hurukuro ino icharekodwa nemvumo yenyu. Kurekodwa uku kuri kungoitirwa kuti ndisarakirwa nepfungwa dzenyu dzamunenge mapa. Kana ndapedza kutora pfungwa dzenyu, ndichaputsa humbowo uhwu.
  - Munhu mumwe nemumwe achapihwa mukana wekutaura, asi hatitenderwi kutaura kana mumwe achitaura.

Kune mune mibvunzo yamungava nayo, sunungukai kubvunza.

Mutsvakurudzi anotanga kurekodha

Mibvunzo yehurukuro

Mubvunzo wekutanga

1. Dambudziko rekufa kwevana vasati vasvika makore mashanu rakatekeshera zvakadii mudunhu reMakonde?
2. Zvii zvingava zviri kukonzeresa kuti dambudziko iri ritekeshere kusvika padanho ramataura?

3. Ndeapi matambudziko amabva kureva amunofunga kuti angagadziriswa nekushandisa hunyanzvi nemishina yechizvino zvino?
4. Ndeipi mishina nehunyanzvi hwechizvinozvino zvamunofunga kuti zvingabatsira kurwisa dambudziko re U5M mudunhu reMakonde? Nei muchifunga kudaro?
5. Which emerging technologies in healthcare do you know?
6. Kana dai pachipatara pamunoshandira paizounzwa hunyanzvi nemishina yechizvinozvino kuti zvibatsire kurwisa dambudziko re U5M maizoishandisa here? Sei madaro?

Mubvunzo wepiri

7. Zvii zvingaita kuti vashandi vezvehutano mudunhu reMakonde vatambire kushandisa mishina nehunyanzvi hwechizvinozvino mukurwisa dambudziko re U5M mudunhu iri? Zvii zvingaitawo kuti vasatambira kana kushandisa hunyanzvi uhwu?
8. Zvii zvingaita kuti madzimai akazvitakura uye vana mai vevana vane makore ari pasi pemashanu mudunhu reMakonde vatambire kushandisa mishina nehunyanzvi hwechizvinozvino mukurwisa dambudziko re U5M mudunhu iri? Zvii zvingaitawo kuti vasatambira kana kushandisa hunyanzvi uhwu?
9. Munofunga kuti chipatara/ kiriniki yenyu yakagadzirira here kushandisa hunyanzvi nemishina yechizvinozvino mukurwisa dambudzo re U5M? Sei muchidaro?

Mubvunzo wetatu

10. Kana hunyanzvi nemishina yechizvinozvino zvikaunzwa mudunhu reMakonde muzvipatara zeruzhinji, Munofunga kuti hunyanzvi uhwu hungabudirira here? Sei muchifunga kudaro?
    a. Zvii zvamunofunga kuti zvingada kuitwa kuti mukana wekubudirira kwehunyanzvi uhwu mudunhu reMakonde huwedzereke?
11. Munofunga kuti hunyanzvi uhwu kana hukaunzwa muMakonde hungagona kubatsira nenzira dzipi kurwisa dambudziko re U5M?
12. Munofunga kuti hunyanzvi uhwu kana hukaunzwa muMakonde hungagona kubatsira nenzira dzipi mukubatsira kudzivirirwa zvirwere kuvana vane makore ari pasi pemashanu?
13. Munofunga kuti hunyanzvi uhwu kana hukaunzwa muMakonde hungagona kubatsira nenzira dzipi mukusimudzira kumanejwa kwezvirwere kuvana vane makore ari pasi pemashanu?
14. Munofunga kuti hunyanzvi uhwu kana hukaunzwa muMakonde hungagona kubatsira nenzira dzipi mukusimudzira quality mukurapwa kwevana vane makore ari pasi pemashanu?
15. Mune zvimwewo zvamungada kutaura here pamusoro penyaya yatanga tichikurukura nezvayo?

Ndinokutendai nekupinda kwenyu muhurukuro ino

Appendix XIII: Interview Guide – Mashonaland West Provincial ICT Officer

I. English Version

Interview Schedule- Mashonaland West Provincial ICT Officer

Section A: General Information

1. For how long have you been in this position of Provincial ICT Officer- Mashonaland West Province?
2. (a) What e-health systems are you currently using in the province and what are they being used for?
   (b) Of these e-health systems, which ones are available in Makonde District?
   (c) Of these e-health systems in Makonde District, which ones are meant for monitoring and managing the health of under-five children?
   (d) Please state any emerging technologies that are being used in public healthcare in Zimbabwe.
   (e) Describe your role in the introduction of new ICTs in public health institutions in the province.
3. (a) Are you working on introducing any emerging technologies in the Makonde District? If yes, please state them.
   (b) If yes to 3(a) above, which ones are meant to enhance disease management, control and prevention among under-five children?

Section B: Factors affecting the adoption of emerging technologies

4. How does the current national ICT policy impact the potential introduction of emerging technologies in public healthcare institutions to enhance disease management, prevention and control among under-five children in Makonde District?
5. How do the policies of the Ministry of Health and Child Care impact the potential introduction of emerging technologies in public healthcare institutions to enhance disease management and control and improve the quality of healthcare to under-five children in Makonde District?
6. Please state the ICT infrastructure that you have to support the introduction of emerging technologies in the Makonde District.

7. What additional ICT infrastructure would you need for the successful deployment of emerging technologies in public healthcare institutions in Makonde District?
8. (a) What other factors would you say are impeding the adoption of emerging technologies in public healthcare institutions to improve disease management and service quality for under-five children in Makonde District?

   (b) How do you think these factors can be addressed?

9. What do you think should be done for the successful adoption of emerging technologies in public healthcare institutions to enhance service quality, disease management, prevention and control among under-five children in Makonde District?

********************Thank you for your participation*******************

II. Shona Version

Hurukuro na ICT Officer wedunhu reMashonaland West (Interview Schedule-Mashonaland West Provincial ICT Officer)

Chikamu A: Ruzivo rwakawanda (General Profile)

1. Mava neguva yakareba zvakadii muchiita basa iri ra Provincial ICT Officer wedunhu reMashonaland West?
   2. (a) Ndehupi hunyanzi nemishina yechizvinozvino mune zvehutano huri kushandiswa mudunhu reMashonaland West, uye hunyanzvi uhwu huri kushandswa pakudii chaizvo?
      (f) Pane hunyanzvi nemishina yechizvinozvino iri kushandiswa mudunhu re Mashonaland West iyi, ndeipi iri kushandiswa mudunhu re Makonde?
      (g) Pane hunyanzvi nemishina yechizvinozvino iri kushandiswa mudunhu reMakonde iyi, ndehupi hunyanzvi nemishina yechizvinozvino iri kushandiswa pakuongorora nekubata hutano hwevan vane makore ari pasi pemashanu?
      (h) Ndehupi humwe hunyanzvi nemishina yechizvinozvino iri kushandiswa mune zvehutano munyika yeZimbabwe?
   3. (a) Muri kugadzirira kuunza humwe hunyanzi nemishina yechizvinozvino here mudunhu re Makonde? Kana mhinduro yenyu iri hongu, ndehupi hunyanzi nemishina yechizvinozvino iyi?

(b) Kana mhinduro yako pamubvunzo 3(a) iri hongu, ndehupi hunyanzvi nemishina yechizvinozvino yamuri kugadzirira kuunza mudunhu reMakonde nechinangwa chekuvandudza uye kusimudzira kudzvivirirwa kwezvirwere, hutano nekurapwa kwevana vane makore ari pasi pemashanu okuberekwa?

Chikamu B: Zvinhu zvinokanganisa kugamuchirwa kwehunyanzvi nemishina yechizvinozvino mudunhu reMakonde

4. Gwaro riripo iko zvino re national ICT policy rinosimudzira kana kudzivisa kuunzwa kwehunyanzvi nemishina yechizvinozvino yekuvandudza kudzivirirwa kwezvirwere nekurapwa kwevana vane makore mashanu muzvipatara nemakiriniki ehurumende mudunhu reMakonde nenzira dzipi?
5. Mungati mitemo yemashandiro ebazi rezvehutano nekurerwa zvakanaka kwevana inosimudzira kana kudzivisa kuunzwa kwehunyanzvi nemishina yechizvinozvino yekuvandudza kudzivirirwa kwezvirwere nekurapwa kwevana vane makore mashanu muzvipatara nemakiriniki ehurumende mudunhu reMakonde nenzira dzipi?
6. Ndezvipi zvinodikanwa (ICT infrastructure muchirungu) kusimudzira kuunzwa kwehunyanzvi nemishina yechizvinozvino zvamunazvo mudunhu reMakonde?
7. Kuwedzera pane zvinodikanwa (ICT infrastructure) kusimudzira kuunzwa kwehunyanzvi nemishina yechizvinozvino zvamunazvo mudunhu reMakonde, ndezvipizve zvimwe zvamungada kuti mugokwanisa kubudirira kuunza hunyanzi nemishina yechizvinozvino mudunhu reMakonde?
8. (a) Ndezvipi zvimwe zvamungati zviri kudzivisa kushandiswa kwehunyanzvi nemishina yechizvinozvino muzvipatara nemakiriniki ehurumende mukuedza kuvandudza kurapwa uye kudzivirirwa kwezvirwere muvana vane makore asingadariki mashanu mudunhu reMakonde?

   (b) Munofunga kuti zvimhingaidzo nezvimhingamipinyi izvi zvingagadziriswa sei?

9. Munofunga kuti zvii zvinofanirwa kuitwa kuti kuunzwa nekushandiswa kwehunyanzvi nemishina yechizvinozvino kubudirire mukuvandudza nekusimudzira hutano hwevana vane makore asingapfuuri mashanu mudunhu reMakonde?

*******************Tinokutendai nemhinduro dzenyu*********************

Appendix XIV: Request for Permission to Conduct Research (PMD)

I. Supervisor's Letter

To Whom It May Concern:

RE: PERMISSION TO CONDUCT RESEARCH

John Batani (Student No. 218020009) is a PhD student in Information Systems and Technology at the University of KwaZulu Natal under my supervision. His thesis title is **"Reducing under-five mortality in Makonde District's public healthcare institutions: An exploratory investigation into the potential role of emerging technologies."**

The successful completion of his studies requires the collection of data through questionnaires, focus group discussions and interviews.

Your assistance in granting permission to access your organisation for the purposes of this research will be highly appreciated. Please be assured that all information obtained from the research will be treated with the utmost confidentiality. Data will be analysed in aggregate only, and no personal information will be exposed. Furthermore, should you wish any result/s or findings from the research "to be restricted" for an agreed period of time, this can be arranged. The confidentiality of information and anonymity of personnel will be strictly adhered to by the student and the University of KwaZulu-Natal.

Please contact me should you require any clarification or have any questions. Permission from your institution is required for the University ethical clearance process, which Mr Batani will have to apply for.

Sincerely

Prof. Maharaj

Appendix XV: Gatekeeper's Consent

I, ____in my capacity as ____

do hereby allow **John Batani (Student No. 218020009)** to conduct research in my organisation. The student MAY/MAY NOT (*delete whichever is inapplicable)* use the name of my organisation in his thesis.

Signature ____

Date _______/_____________/2020

Company Stamp

II. Researcher's Letter

University of KwaZulu Natal

Durban

South Africa

14th of June 2020

To Whom It May Concern

Ministry of Health and Child Care

Harare

Zimbabwe

Dear Sir/Madam

RE: PERMISSION TO CONDUCT RESEARCH IN MAKONDE DISTRICT AS PART OF A PHD QUALIFICATION

My name is **John Batani (Student No. 218020009)**, a Zimbabwean studying toward a PhD student in Information Systems and Technology at the University of KwaZulu Natal under the supervision of Prof Manoj Maharaj. My thesis title is **"Reducing under-five mortality in Makonde District's public healthcare institutions: An exploratory investigation into the potential role of emerging technologies."**

For the successful completion of my studies, I must collect data typically through questionnaires, focus group discussions and interviews. I am in the process of applying for ethical clearance from my university, but they need a letter from your organization confirming that you have allowed me to carry out this study.

Your assistance with permission to access your organisation for the purposes of this research will be highly appreciated. Please be assured that all information gained from the research will be treated with the utmost confidentiality. Furthermore, should you wish any result/s or findings from the research "to be restricted" for an agreed period of time, this can be arranged. I will strictly adhere to the confidentiality of information and anonymity of personnel, and the data gathered in this research will solely be used for research purposes.

I am available at any stage to answer any queries and/or to discuss any aspect of this research project. For more details, I am reachable on the following:

Email addresses: 218020009@stu.ukzn.ac.za or jonj188@gmail.com

Phone numbers: +266 63494922

Thank you for your assistance in this regard.

Yours sincerely

John Batani

Appendix XVI: Interview Guide – Makonde DHIO

English Version

Interview Schedule- Makonde District Health Information Officer (DHIO)

Section A: General Information

1. For how long have you been in this position of DHIO- Makonde District?
2. How many private, public, and mission health institutions are there in Makonde District?
3. How many beds are there in private, public and mission health institutions in Makonde District?
4. How many healthcare professionals are there in private, public and mission health institutions in Makonde District?
5. (a) How many under-5 children are there in Makonde District?
   (b) Of these, how many attend public health facilities?
6. What is the population of Makonde District women with under-five children?
7. (a) What e-health systems are you currently using in the district, and what are they being used for?
   (i) Of these e-health systems in Makonde District, which ones are meant for monitoring and managing the health of under-five children?
   (j) Please state any emerging digital technologies that are being used in public healthcare in Zimbabwe.
8. (a) Are you working on introducing any emerging technologies in Makonde District? If yes, please state them.
   (b) If yes to 3(a) above, which ones are meant to enhance disease management, control and prevention among under-five children?

Section B: Factors affecting the adoption of emerging technologies

9. How does the current national ICT policy impact the potential introduction of emerging technologies in public healthcare institutions to enhance disease management, prevention and control among under-five children in Makonde District?
10. How do the policies of the Ministry of Health and Child Care impact the potential introduction of emerging technologies in public healthcare institutions to enhance disease management and control and improve the quality of healthcare to under-five children in Makonde District?
11. Please state the ICT infrastructure that you have to support the introduction of emerging technologies in the Makonde District.
12. What additional ICT infrastructure would you need for the successful deployment of emerging digital technologies in public healthcare institutions in Makonde District?
13. (a) What other factors would you say are impeding the adoption of emerging technologies in public healthcare institutions to improve disease management and service quality for under-five children in Makonde District?
    (b) How do you think these factors can be addressed?

14. What do you think should be done for the successful adoption of emerging technologies in public healthcare institutions to enhance service quality, disease management, prevention and control among under-five children in Makonde District?

15. To what extent are you involved in the process of introducing new digital technologies in Makonde District?

*******************Thank you for your participation*********************

Appendix XVII : Healthcare Facilities in Makonde District

Public healthcare institutions	Private healthcare institutions	Mission healthcare institutions
Alaska Clinic, Chikonohono Clinic, Chimanimani Clinic, Chinhoyi Clinic, Chinhoyi Provincial Hospital, Chipfuwamiti Clinic, Doma Clinic, Gamanya Clinic, Godzi Clinic, Green Valley Clinic, Gudubu Rural Health Centre, Hombwe Clinic, Kamhonde Rural Health Centre (RHC), Kamuzingizi Clinic, Kanyaga Clinic, Kenzamba Clinic, Khosana Ranch Clinic, Long Valley Clinic, Makonde CBDS Clinic, Makonde ZNFPC Clinic, Manyamba RHC, Matoranjera Clinic, Mukohwe Clinic, Murereka RHC, Mutala Clinic, Muzari Polyclinic, Naison Dip Clinic, Nyamugomba Clinic, Obva Clinic, Portlet Clinic, River Ranch Clinic, Runene Clinic, Sadoma Clinic, Shackleton Clinic, Umboe Clinic and Zumbara RHC.	Presbyterian Private Clinic, PSZ Private Clinic, ZPS Chinhoyi Prison Clinic, Chinhoyi University of Technology Clinic, Dr Chitambo Surgery, Premier Medical Service Investments (PSMI) Clinic.	St Rupert's Mission Hospital, FACT New Start Centre Static

Appendix XVIII: List of Sub-Saharan African Countries

Angola, Benin, Botswana, Burkina Faso, Burundi, Cabo Verde, Cameroon, Central African Republic, Chad, Comoros, Congo, Côte d'Ivoire, Democratic Republic of the Congo, Djibouti, Equatorial Guinea, Eritrea, Eswatini (formerly Swaziland),, Ethiopia,, Gabon, Gambia, Ghana, Guinea, Guinea-Bissau, Kenya, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mauritius, Mozambique, Namibia, Niger, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Seychelles, Sierra Leone, Somalia, South Africa, South Sudan, Togo, Uganda, Tanzania, Zambia, Zimbabwe.

Source: (UN IGME, 2021)

Appendix XIX : UKZN Ethical Clearance Renewal

UNIVERSITY OF KWAZULU-NATAL
INYUVESI YAKWAZULU-NATALI

24 December 2021

John Batani (218020009)
School Of Man Info Tech & Gov
Westville Campus

Dear J Batani,

Protocol reference number: HSSREC/00002132/2020
Project title: Reducing under-five mortality in Makonde District s public healthcare institutions: An exploratory investigation into the potential role of emerging technologies

Approval Notification – Recertification Application

Your request for Recertification dated 20 December 2021 was received.

This letter confirms that you have been granted Recertification Approval for a period of one year from the date of this letter. This approval is based strictly on the research protocol submitted and approved in 2020.

Any alteration s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study must be reviewed and approved through the amendment /modification prior to its implementation. Please quote the above reference number for all queries relating to this study.

PLEASE NOTE: Research data should be securely stored in the school/department for a period of 5 years

All research conducted during the COVID-19 period must adhere to the national and UKZN guidelines.

HSSREC is registered with the South African National Research Ethics Council (REC-040414-040).

Yours sincerely,

[redacted]

Professor Dipane Hlalele (Chair)

/dd

Humanities & Social Sciences Research Ethics Committee
UKZN Research Ethics Office Westville Campus, Govan Mbeki Building
Postal Address: Private Bag X54001, Durban 4000
Tel: +27 31 260 8350 / 4557 / 3587
Website: http://research.ukzn.ac.za/Research-Ethics/

Founding Campuses: Edgewood Howard College Medical School Pietermaritzburg Westville

INSPIRING GREATNESS

Appendix XX : UKZN Ethical Clearance

UNIVERSITY OF KWAZULU-NATAL™
INYUVESI YAKWAZULU-NATALI

05 January 2021

Mr John Batani (218020009)
School of Management, IT & Governance
Westville Campus

Dear Mr Batani,

Protocol reference number: HSSREC/00002132/2020
Project title: Reducing under-five mortality in Makonde District s public healthcare institutions: An exploratory investigation into the potential role of emerging technologies
Degree: PhD

Approval Notification – Full Committee Reviewed Protocol

This letter serves to notify you that your response received on 17 December 2020 to our letter of 08 December 2020 in connection with the above, was reviewed by the Humanities and Social Sciences Research Ethics Committee (HSSREC) and the protocol has been granted **FULL APPROVAL**.

Any alteration/s to the approved research protocol i.e. Questionnaire/Interview Schedule, Informed Consent Form, Title of the Project, Location of the Study, Research Approach and Methods must be reviewed and approved through the amendment/modification prior to its implementation. In case you have further queries, please quote the above reference number. PLEASE NOTE: Research data should be securely stored in the discipline/department for a period of 5 years.

This approval is valid for one year until 07 January 2022
To ensure uninterrupted approval of this study beyond the approval expiry date, a progress report must be submitted to the Research Office on the appropriate form 2 - 3 months before the expiry date. A close-out report to be submitted when study is finished.

All research conducted during the COVID-19 period must adhere to the national and UKZN guidelines.

HSSREC is registered with the South African National Research Ethics Council (REC-040414-040).

Yours faithfully

[redacted]..........................

Professor Dipane Hlalele (Chair)

/ms

Humanities & Social Sciences Research Ethics Committee
UKZN Research Ethics Office Westville Campus, Govan Mbeki Building
Postal Address: Private Bag X54001, Durban 4000
Tel: +27 31 260 8350 / 4557 / 3587
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