Imperial College London

Digital health in primary health care: Current use and future opportunities in the Sub-Saharan African region

INSTITUTE OF GLOBAL HEALTH INNOVATION

Contents

Authors

Niki O'Brien, Nana Kwame Ayisi-Boateng, Olivia Lounsbury, Melanie Leis, Saira Ghafur, Ara Darzi, Shabir Moosa & Ana Luisa Neves

Suggested citation:

O'Brien N, Ayisi-Boateng NK, Lounsbury O, Leis M, Ghafur S, Darzi, A, Moosa S, Neves AL.
Digital health in primary health care: Current use and future opportunities in the Sub-Saharan African region.
Imperial College London (2023).

Acknowledgements

The report was developed in collaboration with the Global Digital Health Unit, School of Public Health, Imperial College London.

We would like to thank the following individuals who have contributed to this report by attending an interview, roundtable, or speaking with us informally / working closely with us on other outputs in this area and have agreed to be acknowledged. Their insights have been invaluable to the development of the report; however, the report outlines a synthesis of range of insights, and opinions and as such, responsibilities for the findings and content of the report rests solely with the authors.

Priscillah Balirwa, Living Goods

Mohini Bhavsar, Living Goods

Shivon Byamukama, Babyl

Cynthia N. Chaibva, Department of Nursing and Midwifery Sciences, National University of Science and Technology (NUST), Zimbabwe

Angela de Poli, PharmAccess Foundation

Barbara Franken, Witkoppen Clinic

Raquel Gomez Bravo, Centre Hospitalier Neuro-Psychiatrique (CHNP) and Department of Behavioural and Cognitive Sciences, University of Luxembourg, Luxembourg

Riona Govender, South African National Department of Health

Jean Kagubare, Bill & Melinda Gates Foundation

Shalmali Radha Karnad, HealthX Africa

Lana Kovacevic, Institute of Global Health Innovation, Imperial College London, UK

Ephraim Kumi Senkyire, GA West Municipal Hospital

Edmond Li, Institute of Global Health Innovation, Imperial College London, UK

Gugu Newman, Ribbon Protocol

Francoise Ngnedjou Nwabufo Foute, Africa Forum for Primary Health Care (AfroPHC) and Adventist University Cosendai, Cameroon

Olusola Oladeji, UNICEF Belize

Prince Onebieni Ana, Harm Reduction International (HRI) Global and Cross River State University, Nigeria

Tijani Oseni, Department of Family Medicine, Ambrose Alli University, Nigeria

Unben Pillay, Alliance of South African Independent Practitioners Associations (ASAIPA) and Independent Practitioners Association Foundation (IPAF)

Alice Serafini, Department of Primary Care, Azienda Unità Sanitaria Locale (AUSL) Modena, Italy

Eleleta Surafel Abay, The University of Edinburgh, UK

Mercy Nafula Wanjala, Africa Forum for Primary Health Care (AfroPHC)

Marie-Claire Wangari, Africa Forum for Primary Health Care (AfroPHC)

Kenneth Yakubu, The George Institute for Global Health

We would like to specifically thank Jonty Roland for reviewing the report.

This work was funded by the UK Research and Innovation (UKRI) Policy Support Fund. The views expressed are those of the authors and not necessarily those of UKRI or other funders associated with individual authors.

Foreword

Digital technology is well placed to become a powerful tool supporting primary health care delivery in health systems across Sub-Saharan Africa. As this paper shows, digital technologies are widely being used across the continent to deliver health services and address long-standing health system challenges. A diverse range of stakeholders – including governments, healthcare providers, non governmental organisations, and industry partners – are coming together to develop innovative digital solutions and broaden their application.

As the use of digital technology is scaled up, it is essential to maximise patient benefit, with the provision of equitable, safe and high quality care as a beacon for future development and best practice. Stakeholders must work collaboratively, alongside patients, families, caregivers, and communities, to sustainably achieve this.

The report sets out where digital technologies are being used to drive primary health care innovation across Sub-Saharan Africa, underpinned by examples and lessons learned from experts across the region. We have presented the current use of digital health across health systems and stakeholder groups to better understand future opportunities for maximum impact, and the challenges and threats that must be addressed.

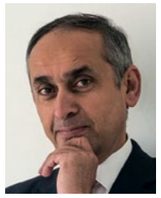
While this piece aims to provide a synthesis of current evidence and thought leadership in one place, we acknowledge that there are many questions that need further research and inquiry, particularly in the lowest income countries, and at local and grassroots levels in across the continent.

Our main message is that digitally-enabled primary care has a huge potential to drive improvement, if developed and implemented strategically and equitably. Early innovators have set the course for technologies to benefit patients, providers, and health systems, which must now be developed at scale.

We hope this paper sparks conversations on how to create national and regional collaborations, as well as a shared strategy across Africa to maximise impact and define best practice standards. The proposed recommendations can provide an evidence base for Sub-Saharan African countries to develop programmes and innovations that maximise the benefits of digital health for their citizens.

We hope that this work will not only resonate in Sub-Saharan Africa, but also help governments and health systems in low-, middle-, and high-income countries to consider the future of digital primary health care in their contexts to drive innovation and impact.

We would like to thank the many outstanding contributors who generously gave their time and energy to this work.



Lord Ara Darzi
Co-Director
Institute of Global Health Innovation
Imperial College London

Dr Ana Luisa Neves
Director
Global Digital Health Unit
School of Public Health
Imperial College London

Executive summary

Digital health promises to revolutionise healthcare delivery and address longstanding health system challenges, if developed and implemented across systems successfully. As national governments in low- and middle income countries (LMICs) work towards achieving universal health coverage, digital technology may be a powerful tool to support Primary Health Care (PHC) delivery as one of its main pillars, enabling services to reach remote or previously marginalised populations, reducing costs for patients, providers, and payers, and improving the quality and safety of services. Sub-Saharan Africa (SSA) has an opportunity to drive digital service delivery to benefit patients and communities across the continent and beyond.

Digital technology is being widely used to enable PHC across SSA. Most countries face significant challenges in providing health services to growing populations. Electronic health records and ePrescribing/eAppointments, including mHealth applications, are being used to develop safer, more efficient, and effective PHC systems. Telemedicine is improving access and efficiency of care and assisted living technologies are beginning to tackle the long-term challenge of caring for aging populations. Further, these technologies are being used across the continent with examples available across public and private PHC facilities, direct-to-consumer services, diagnostics centres, and laboratory services.

Use of digital technology is also extensive at the health system level for the wider functioning of health services at district, regional, and national levels. Technologies have been deployed to map health services and population-level needs, manage drugs and supplies, and facilitate digital systems for integration and central reporting. These efforts combine to enable an ecosystem in SSA that promotes the development of digital solutions and technologies for PHC. In order to be pro-active and sustainable, such an ecosystem requires close collaboration between governments, healthcare, academia, and the technology industry involved in development and implementation of digital health technologies.

Taking advantage of digital technology to drive improvement, early innovators and adopters have developed best practice examples and set the course for technologies to benefit patients, providers, and health systems. Digital technologies are benefitting patients and providers across SSA by improving continuity of care, enhancing decision-support, and expanding treatment models to enable innovative and more affordable pricing models and patient-centred services. Health systems are optimising quality and safety using digital health. Specific benefits are seen in equity (by reaching historically underserved populations), efficiency (through improved planning and delivery with time and cost savings), and effectiveness (by addressing gaps such as human resource shortages).

Several governments across SSA have taken ownership in the development and roll-out of digital technologies, enabling greater digital technology penetration across the continent than when driven by commercial organisations alone. The next step will be to create regional collaboration and shared strategy across Africa to maximise the impact of digital health in PHC. The utilisation of digital technologies both from the system/provider and patient perspective has the potential to mitigate longstanding health financing challenges, including service pricing and reimbursement models, and reduce the severe financial hardship suffered by individuals seeking care. Providing mobile and Internet access is a prerequisite for sustained progress and will be critical to success in this area.

It is important, however, to be realistic about the challenges that remain. Patients stand to reap the most benefits from digitally-enabled healthcare; yet ensuring patient buy-in and widespread support for digital health is a challenge, particularly in regard to disparities in patients' socioeconomic status and literacy rates across SSA. These have implications for equal access to digital health, as lower socio-economic groups and/or less literate may struggle with its acceptance. Furthermore, clinical buy-in at the provider level remains variable, particularly where training on digital systems is not prioritised and where literacy rates among healthcare workers (HCWs) are low. These challenges can sometimes lead to digital technology applications having unintended consequences on the service or wider system.

Challenges also remain with partial and fragmented digitalisation and poorly integrated systems. These challenges are confounded by limited best practice implementation examples and a lack of resources available to support service transformation, leading to inefficiencies and frustration. Many institutions work with what is available, which is often out of date technologies and legacy systems, leading to challenges in quality of care and data security. Proving that digital technologies, and the health data generated, are safe is critical to retaining trust in the role of digital technologies in delivering PHC.

High implementation and operational costs, coupled with unsustainable project funding and short-term donor investment, create financing challenges that undermine digital transformation at the provider and health system levels. Such challenges may be addressed by novel approaches to revenue generation and funding models.

Led by the evidence review and research findings, we developed recommendations for practice and policy. While the following recommendations are intended to be applicable across regional and national contexts, many of the actions discussed in this report require stakeholders to collaborate with each other, as well as with patients, their families, caregivers, and communities, at a greater scale than they are currently doing.

All stakeholders involved in digital transformation have an obligation and interest in co-developing digital solutions.

Gaining insights from patients and patient groups will enable the development of programmes and innovations based on patient needs that can provide greater efficiency, effectiveness, equity, patient-centredness, safety, and timeliness.

Government leaders and policymakers

1. **Ensure basic infrastructure is in place to support digital health innovation in PHC.** Healthcare leaders and policymakers must take responsibility in advocating for investment in infrastructure with relevant government bodies, stressing the urgency of this as the foundation for the adoption of digital health in PHC.
2. **Establish minimum regulations, including standards for data protection, digital innovation, and evaluation**. Healthcare leaders and policymakers must focus on developing and introducing regulations and standards across a continuum or maturity roadmap; first developing data protection regulations, legislation to advance interoperability, digital innovation standards, and standards for evaluation of technologies.

Health providers

1. **Develop a digital health strategy for the sustainable use of technologies by HCWs over time.** Health providers must ensure digital technologies are appropriate and functioning in their intended PHC context. Staff training on the technology and its correct application should be included within strategies to enable HCW buy-in and a clearer understanding of their role in its successful implementation.

Non-governmental organisations (NGOs)

1. **Seek meaningful, collaborative partnerships with local stakeholders to maximise programme impact.** NGOs must develop short- and long-term partnership strategies which outline the business case for collaboration and with whom. They must also be clear in what they can offer local stakeholders and ensure this is articulated across the organisation.
2. **Explore long-term and sustainable funding models for digital-focused PHC programmes and innovations.** NGOs must challenge traditional funding models and consider novel approaches to sustainable funding that focus on the entire health care context or ecosystem. A focus on blended finance opportunities, for example, offers alternative avenues to build sustainable programmes and innovations in PHC.

Researchers and research funders

1. **Increase funding for research into digitally-enabled primary care .** Research funding bodies must consider digitally-enabled care as modality for primary health service delivery and increase funding available for researchers to explore the safety and quality of digital technologies on services and outcomes. Grant challenges, for example, can focus the research agenda on digitally-enabled care to capture the breadth of potential priority research areas on this topic.
2. **Investigate the role of digital technologies in improving continuity of care across the health system and the importance of interoperability.** As digital technologies are increasingly used across healthcare service provision, researchers must explore the impact of digital technologies across the continuum of care, the potential threat of fragmentation and equity challenges, as well as the role of interoperability.

Industry

1. **Develop innovations that have the overt goal of addressing health inequities in PHC.** Industry stakeholders must evaluate the business case for developing innovations which address health inequalities in PHC services and outcomes. Where there is not a clear business case, industry must consider investing in not-for-profit programmes that tackle inequity to deliver good corporate citizenship and provide non-financial returns to the company.
2. **Adopt user-centred design methodologies in the development of digital technologies for health care.** Industry stakeholders must embrace user-centred design to ensure that HCWs (or patients, if they are the users) are involved in research and development (R&D) from the beginning, leading to the development of more useful technologies and increased uptake.

Introduction

In 2021,14.9% of the world's population was located in Sub-Saharan Africa (SSA),[1] and this is predicted to increase to 35% by 2100.[2] Given its large population, the SSA region represents the largest opportunity to develop and innovate in healthcare, with the potential to improve the lives of billions of individuals.

Digital health can emerge as a powerful tool to improve health and healthcare across the continent. While the World Health Organization (WHO) describes digital health as *"the field of knowledge and practice associated with the development and use of digital technologies to improve health"* there is no one definition used in academic literature or policymaking.[3,4] Across the globe, digital health interventions have played an increasingly important role in health and healthcare delivery. During the COVID-19 pandemic, digital solutions have supported the management of its direct and indirect effects on population health, as well as its broader, wide-ranging impacts.[5,6]

Digital technologies to achieve Universal Health Coverage (UHC)

The Sustainable Development Goals (SDGs), ratified by United Nations members in 2015, outline the achievement of universal health coverage (UHC) by 2030 as one of the key targets.[7] UHC describes the availability of a full range of essential safe and affordable health services for all. The WHO outlines three dimensions of UHC **(Figure 1)** to be considered in moving towards UHC: the total population covered by healthcare, the total amount of quality services available, and the proportion of healthcare costs covered **(Figure 1)**.[8] While some progress has been made towards certain aspects of UHC globally, there has been a range of challenges including the recent COVID-19 pandemic which stretched health systems and forced the reallocation of precious resources.[9]

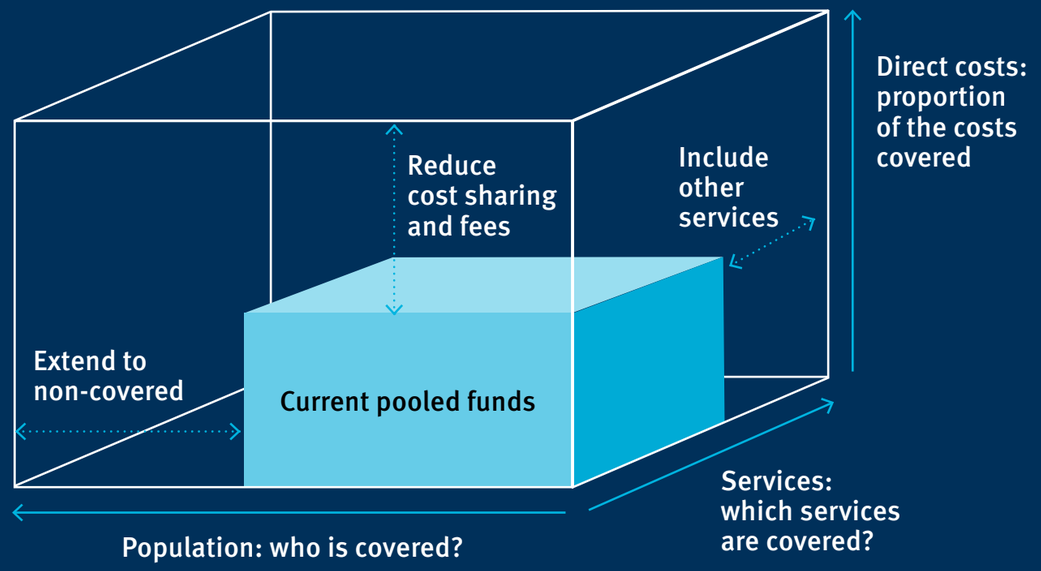


Figure 1: The three dimensions of UHC.[8] Republished with permission from WHO.

As national governments in low- and middle income countries (LMICs) work towards achieving UHC, there is a greater need to deliver healthcare solutions for their populations, with a focus on quality and safety, for an affordable price. Digital technologies, if implemented thoughtfully, may be a powerful tool to achieve UHC, enabling services to reach remote or previously marginalised populations, reducing costs for patients, providers, and payers, and improving the quality and safety of services.[10] As health systems around the world approach the midway point between the setting of the SDGs and the deadline to realise its goals, there have been huge strides in improving several of the SDG3 (Ensure healthy lives and promote wellbeing of all at all ages) indicators and across healthcare services, with reproductive, maternal, newborn, and child health services and core outcomes often cited as a particular success (e.g., under 5 mortality rates fell 14 percent from 2015-2020).[11] Despite these efforts, it is widely recognised that progress towards meeting the SDG targets has been compromised as a consequence of the COVID-19 pandemic, with health indicators particularly impacted.[12] A recent study also noted that 28 countries, 26 in Sub-Saharan Africa (SSA), are unlikely to attain several of the SDGs, including good health and wellbeing.[13]

Connecting underserved populations to quality health services

In the SSA region, the adoption of digital technologies in health care can offer important opportunities to improve access to care for vulnerable, underserved, and geographically remote patients,[14] across a vast range of services – from maternal, newborn and child health programmes, to vaccination programmes, to disease surveillance. In the last three years, the COVID-19 pandemic has massively increased the utilisation of digital technologies across the health sector, speeding up decades of innovation.[15] As health systems globally look to advance their use of digital technologies in health care, it is important that the quality of health services is at least maintained, but ideally, improved. This challenge of quality is further exacerbated by the fact that health systems have become increasingly overburdened through the pandemic.[15,16]

Driving innovation and policy in Sub-Saharan Africa and beyond

While a range of research exists on digital technology use in healthcare in SSA, there are limited publications which present the breadth of its use, and even fewer that present digital technology use in primary health care (PHC). Greater understanding of the current scope of digital technology use in the health sector is urgently required for the design, development, and implementation of high-quality, safe, and equitable service delivery. To this end, it is critical to listen to the perspectives of key stakeholders within primary health care in SSA to understand which digital solutions are currently used, which are their current strengths and weaknesses – as well as future opportunities and threats. Only by acknowledging and incorporating these perspectives will the true potential of digitalisation in the health sector be fully realised.

This report focuses on digital technology use in PHC in Sub-Saharan Africa, revisited through the lens of a diverse group of stakeholders, but we hope it acts as a catalyst for greater exploration of technology use more widely in healthcare, and in a broader range of LMICs. It provides evidence on this topic for a range of professionals, particularly policymakers, healthcare management professionals, clinicians, and most importantly, patients. For the latter, improved awareness of the current role and potential for digital technologies in healthcare is an important step in empowering them to advocate for quality digital healthcare.

Digital health: Terminology and use in health policy and research

Overall definition of digital health

As there is no one definition of "digital health",[3] it is important to be clear on the meaning and scope from the outset of this report. The Organisation for Economic Co-operation and Development (OECD) presents the below image to outline the scope and relationship between key aspects of digital health, which the OECD also refers to as "eHealth".

This report focuses on the use of digital technologies in health care, across the areas outlined in **Figure 2**, and so we use the following definition to act as a clear explanation of the term but also define the scope of its use within this report:

Digital technologies can include a range of solutions used to support the delivery of health care. These can include telephone, video, websites, chats applications, mobile applications (apps), short message system (SMS) messaging, electronic payments, and chatbots, among others.

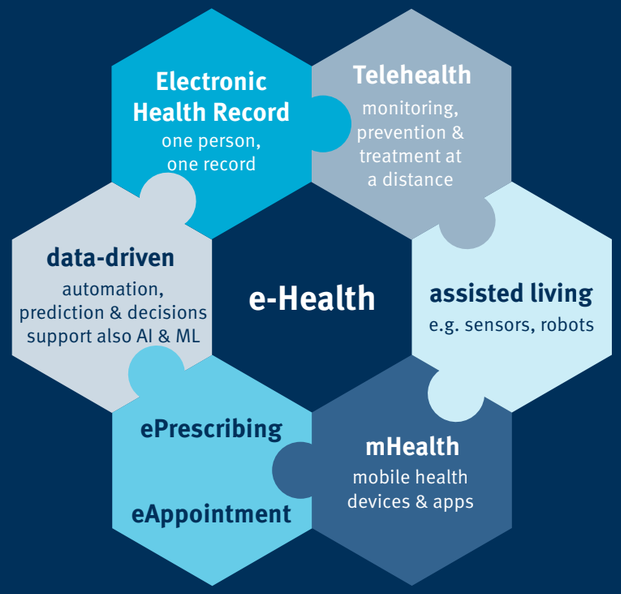


Figure 2: Defining digital health (eHealth), OECD. [17]
Republished with permission conveyed through Copyright Clearance Centre, Inc.

Specific areas of digital health

The different areas outlined above also vary in their uses and definitions across the research and policy landscape. For example, while the World Health Organisation presents a definition of "telemedicine" in the Global strategy on digital health 2020-2025, the word "telehealth" does not appear.[4] National guidelines tend to use the term "telemedicine" in setting out rules and regulations.[18] Instead, the OECD and various policy documents produced by governments and professional associations select to use the term "telehealth" as opposed to "telemedicine".[18,19] On this matter, the Health Professions Council of South Africa explained their position in the updated guidelines published in December 2021:

> "Previously, the HPCSA's referred to these guidelines as "Telemedicine". However, it has been resolved that a more inclusive term to accommodate all relevant professions, namely, Telehealth, be used going forward."[19]

In this report we will use the term **"telehealth"** to be as encompassing as possible when referring broadly to electronic and telecommunication technologies used to deliver care and services remotely.[20] For example, an online platform offering access to a registered medical professional who can provide advice by video. Instead **"telemedicine"** is used to describe the practice of medicine using technology to deliver care.[20] For example, a primary care physician may use a telecommunications infrastructure, such as telephone, SMS messaging, or video, to deliver care to a patient remotely.

The distinction between **Electronic Medical Records (EMR)** and **Electronic Health Records (EHR)** will also be made. In this report we use the term Electronic Health Record (EHR) to refer to the longitudinal electronic record of patients that contains or virtually links records together from multiple EMRs, computerised medical records created in an organisation that delivers care for patients of that organisation.[21,22] However, as these terms are often used interchangeably, where discussing findings from a paper or report, we use the terminology used by the authors of the publication.

Assisted living describes the use of digital health apps and other software (e.g., sensors, robots) that aid elderly people, people living with disabilities, or patients in homebased therapies in mobility, and in achieving independence more widely.[17]

Mobile health (mHealth) describes the use of mobile telephones and mobile-based solutions, from SMS to complex smartphone apps, to access health information and services related to health and healthcare provision.[23] mHealth facilitates the exchange of health-related information such as text, images, audio, and video using mobile devices, and can connect patients and healthcare workers to offer more affordable and efficient services.

"ePrescribing" describes the generation of a prescription electronically between the prescribers (e.g., the physician) and dispensing pharmacies (e.g., an external pharmacy or a pharmacy within a health facility) **"eAppointment"** describes the booking of health consultations electronically online. EHRs often also include systems allowing prescriptions to be generated and appointments to be booked electronically.[17]

Like other digital technologies used in health care, data-driven tools (also known as **data-driven technologies**) have the potential to reduce health systems gaps globally, particularly in LMICs.[10] The scope of data driven technologies include data-driven automation, prediction and decision support which employ technologies such as artificial intelligence (AI), a machine-based system that can make predictions and recommendations based on a given set of data and operator-defined objectives.[17]

Health systems development

While there is a range of newer and more comprehensive frameworks which conceptualise health systems,[24] the WHO Six Building Blocks of a Health System framework (2010) **(Figure 3)** remains widely used across research and policy as it aims to simplify highly complex systems into building blocks and overall goals / outcomes.[25]

Throughout this report, we build our discussion on the system building blocks presented in the framework. In doing so, we present the role of digital health technologies in each of these building blocks at the PHC level. As we will outline in the later sections of this report, leadership and governance and financing, alongside infrastructure, perform an essential function in both developing digital health technology use in PHC and improving health systems performance more widely.

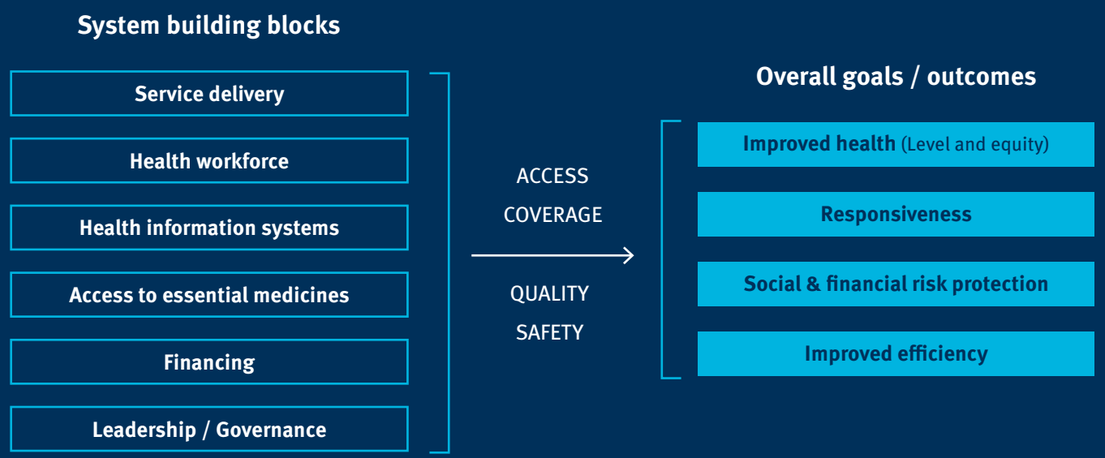


Figure 3: The six building blocks of a health system: aims and desirable attributes.[25] Republished with permission from WHO.

BACK TO CONTENTS

Methods

To facilitate safe, sustainable adoption of digital technologies in primary health care in the sub-Saharan African region, and wider low- and middle-income contexts, this report aims to explore the digital solutions currently used in healthcare in SSA, current strengths and weaknesses, and opportunities and threats to their further development in adoption in the future.

A mixed-methods research approach was used to derive the findings presented, including:

- a **review of the evidence across Sub-Saharan Africa**, including peer reviewed research papers, reports and publications from multilateral health-focused organisations, and health policy papers;
- expert involvement using **one-to-one interviews** and a **policy roundtable** discussion;
- **ethnographic approaches** including observations of digital health care technology use in practice at selected case study sites.

The evidence review was conducted in January 2022. The **13 one-to-one interviews** were held over an eight-week period in February and March 2022. Interviewees were recruited based on their experience and expertise on the topics of digital health and primary health care. These stakeholders represented a variety of roles, including PHC health care workers, PHC organisational leadership, other non-clinical healthcare professionals, industry professionals, international non-governmental organisations (INGOs) professionals, and academics. The spread of stakeholder expertise across job functions ensured that a wide range of challenges and opportunities were covered, in what concerns the use of digital technology in health care across policy and practice. Interviewees were from eight countries (Ethiopia, Kenya, South Africa, Nigeria, DRC, Rwanda, Nigeria and Uganda) across SSA or worked for INGOs outside of SSA.

Case study observations took place in **three primary healthcare sites** in the Johannesburg area, South Africa, in March 2022. There included one public primary healthcare clinic in Chiawelo, Soweto Johannesburg, one non-governmental organisation primary healthcare clinic in Fourways Johannesburg, and one private clinic in Midrand Johannesburg.

The observations included a short tour of the facilities and meetings with key personnel.

In April 2022, a **roundtable workshop** was held bringing together the individual interviewees for a group discussion. The roundtable discussion focused on key questions on future opportunities in embracing digital health in SSA. Workshop participants were from six countries (South Africa, Uganda/Kenya, Rwanda, Ethiopia, Nigeria) across SSA.

Based on the analysis we summarise the landscape of digital technologies use across healthcare delivery and the wider system in the SSA region context. The following chapters present a synthesis of the evidence review and interview and roundtable analysis.

Led by the evidence review and research findings, we present opportunities to develop digital technology across the health system (including for patients, providers, and health systems), but also the potential health system performance drivers to further advance the development of digital technologies for health care. Our findings further informed the development of recommendations for practice and policy, which are presented in the final chapter of this report.

Applications of digital health in the context of Sub-Saharan Africa

Summary of our research findings

- Digital health technologies are widely used in Sub-Saharan Africa to deliver healthcare and at the systems level to map health services and population-level needs, manage drugs and supplies, and facilitate digital systems for integration and central reporting
- Electronic Health Records are increasingly being used as a vehicle to develop more efficient and effective systems though widespread application in SSA remains limited
- Telemedicine use has increased across SSA, particular in response to the COVID-19 pandemic and related updates in legislation, regulation, and policy seen in some countries
- Infrastructure advancements, including the expansion of Internet access, has driven the development and use of mHealth applications which are used to deliver a range of services including the facilitation of eAppointments
- At the systems level digital technologies are being used to map health services, manage drugs and supplies, and enable integration and central reporting as part of digital transformation

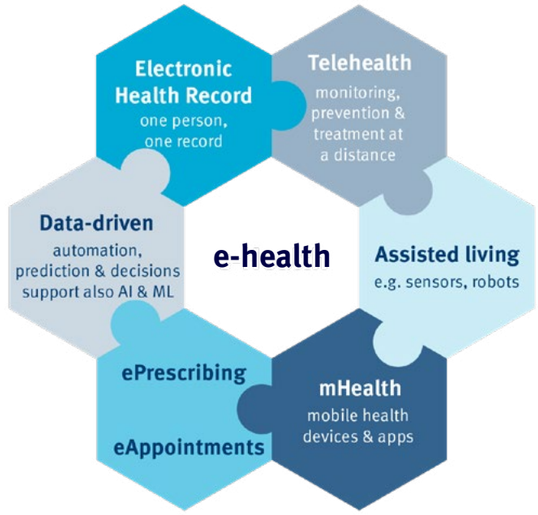


Figure 2: Defining digital health (eHealth)[17]

To understand the scale and reach of digital technology use in health in SSA, it is useful to first consider the extent to which technologies can be used across the health sector. The OECD definition of eHealth highlights six inter-connected areas that span PHC, secondary and tertiary care, as well as home care **(Figure 2)**.

Defining Primary Health Care in the SSA context

As health systems are structured differently from country to county in the SSA context, it is challenging to propose a single definition of primary health care, as well as its key stakeholders.

Healthcare workers (HCWs)

The main professional group providing primary care varies greatly between countries. Across the continent, PHC services may be provided by general practitioners (GPs), pharmacists, and traditional healers. Across LMICs, and particularly in SSA, community health worker (CHW) programmes are being scaled up and promoted as a key building block to improve equity in access to health care, particularly in remote areas and villages.[26] However, the involvement and remit of CHWs and the terminology used to name this group of healthcare workers varies.[27] For example, while CHWs primarily provide PHC in South Africa, in Malawi, medical assistants provide this function.[28] In Ghana, the Community-Based Health Planning and Services (CHPS) compounds are the basic units of PHC and are manned by nurses.[29]

Healthcare facilities

At PHC level, care is also provided by a range of institutions which differ between countries. These may include institutions within the public health sector, the private sector, public-private partnerships, non-governmental organisations (including local and international organisations), and faith-based organisations. Individual patients may move between these organisations in accessing care. PHC may occur at the district, primary, secondary, or tertiary level, depending on the context.

It has been noted that PHC can be considered "a set of values and principles that guide the health system in its policy, leadership and governance, commitment to universal health coverage and primary care".[28] To this end, the report is based on a systems approach, focusing on research and findings across sectors and professional groups.

Applications in healthcare delivery

The applications presented below are the six inter-connected areas: electronic health records, telemedicine, assisted living, mHealth, ePrescribing and eAppointments, and data driven technologies.

1. Electronic Health Records (EHRs)

An EHR is a real-time patient record created in the health care environment by healthcare providers, that allows immediate data access by authorised users.[30] EHRs can include clinical data, progress notes, medications and treatment plans, vital signs, past medical history, immunisations, laboratory data, radiology reports, and administrative and demographic data – and much more.[31] These records may be shared among healthcare providers within the same healthcare organisation or across different healthcare settings, including across primary, secondary, and acute care.

EHRs in sub-Saharan Africa

There are a multitude of current examples of EHR use in sub-Saharan Africa,[32-35] including in PHC, highlighting opportunities in advancing health care innovation. While efforts to evaluate EHR systems are useful in unpicking the strengths and weaknesses of their use in SSA,[33] the wider health care context should not be overlooked. For example, EHR systems are often developed as part of vertical programmes[34,35] programmes with a single focus area such as HIV/AIDS programmes focused solely on HIV/AIDS care and treatment, with implications for facilitating integration with other parts of the health system. The technical components of EHR systems, including their interoperability and cybersecurity, are essential considerations in the development of EHR in healthcare organisations.

The experts interviewed confirmed that use of electronic health records varies substantially between and across countries; in many cases, it remains a relatively new technological development and is largely used alongside paper records. Participants in the research often highlighted a greater use of EHRs in the private sector and within non-governmental organisation (NGO) programmes. There was little mention of EHRs being used widely in any public health care context.

EHRs as a vehicle to develop more efficient and effective systems

In several high-income countries, EHR systems have often struggled to iteratively adapt - and move from - older ('legacy') systems.[36] This approach has been financially costly and generated unprecedented computer work and burnout among staff. An entrenched, and sometimes outdated, EHR infrastructure can therefore represent a barrier to an effective scaling up of digital innovation.

In the context of SSA, the burden on legacy systems might be less relevant. The concept of "leapfrogging"[37] has been recently used in the context of LMIC countries, in which accelerated developments may occur by skipping inferior, less advanced digital solutions, including EHRs – and moving directly to more advanced ones. In Uganda, for example, pilots are being undertaken within the public health system to develop EMR in clinics.

> "(...) there is a new system that was internally developed within the country that is now being deployed at certain facilities. So (...) the country is also moving towards digitising the facility level systems as well."
> (NGO professional, East Africa)

Experts noted that where EHR are in the early stages of development, providers use a range of different tools to facilitate this, including Microsoft Excel, Google Docs, or specific technologies designed to facilitate EHR as a standalone solution - or offer this function as part of other business functions (e.g., billing). The current use of disjointed, non-interoperable systems and applications to digitise patient records involve risks of creating duplicate records and lack of longitudinal, standardised patient records across the system. The benefit of utilising more flexible and open source EHR systems, is the ability to tailor systems and use to the health care providers' context and develop digital systems at a comparably lower cost than larger EHR systems, such as Epic or Cerner, used in high-income countries.

2. Telemedicine

Telemedicine is a major area of digital health activity and innovation in primary care in the SSA region.

The scope of telemedicine use

Current telemedicine use in SSA includes a range of services, covering screening and diagnostics, treatment, long-term management, and follow-up. While telehealth technologies have been set up to offer direct-to-consumer primary care teleconsultations, specific areas of care are also being offered (e.g., non-communicable diseases (NCDs), such as cardiovascular diseases[38] and diabetes,[39] and maternal and neonatal health[40]). Other examples of the scope of use of telemedicine in other LMIC countries include provision of care for mental health patients[41] and for those having suffered a stroke.[42]

Modes of telemedicine use

In the literature, the most commonly used technologies to deliver care that does not require internet access are voice calls and short message services (SMS).[43] Technologies reliant on internet access to deliver health services include phone-based apps (such as those that facilitate video calls, or purpose-built apps developed by telehealth companies), and social media platforms (such as WhatsApp and Facebook Messenger). Participants included in this research explained that telemedicine services were largely provided through phone calls and WhatsApp calls.

> "Telemedicine is the other big piece that we're seeing [...] But that could be video calls, that could be voice calls, that could be chat functions (...) - there's a lot of either chatbots or actual WhatsApp or other formats that people are using (...) [to connect] to telemedicine providers or doctors (...)."
> (HCW and industry professional, East Africa)

According to many experts, the use of video functionality was not widely used unless the consultation was specifically focused on a health care need that requires a visual diagnosis (e.g., a patient may want to show specific lesions). However, considering diverse global use of telephone and video to deliver telemedicine, it is likely that use varies across contexts in SSA.[44,45]

Telemedicine to facilitate diagnostics and clinical management

Beyond direct patient care, the experts interviewed explained that health providers are increasingly employing digital systems to manage several aspects of business operations. Digital technologies are also being used to facilitate diagnostics at the point of care in a range of country settings and PHC facilities, with providers integrating systems to facilitate this application.

> "My doctors were all using little sheets of paper to scribble things about me and my kids, until very recently. And now we've seen them purchasing electronic booking systems, online booking systems, electronic medical records so that my records are in one place."
> (HCW and industry professional, East Africa)

Telemedicine's expansion during the COVID-19 pandemic

While the development of digital telemedicine solutions across SSA was already advancing prior to the pandemic[38,43] the COVID-19 pandemic led to an expansion of telemedicine services in PHC. The use of telemedicine expanded globally at a rapid pace,[46,47] with telemedicine offered as entirely digital (e.g., remote services only) or hybrid option (e.g., remote services as part of a wider offering also including face-to-face services).[43] The participants highlighted that policy and legislative changes took place almost immediately after the pandemic began in several countries, including South Africa and Kenya **(see Case Study 1)**.

There were conflicting views among participants in the research about the sustainability of telemedicine expansion, as the COVID-19 pandemic becomes more manageable. Several participants felt that telemedicine would continue to be used in primary care, but pointed towards a new trend of hybrid medicine, where patients could use a combination of telemedicine and face-to-face consultations.

> "We are seeing backward integration and forward integration [where] a digital company is opening a telehealth [service] and then going opening brick and mortar [face-to-face facilities]" (Industry professional, East Africa)

Case Study 1: The expansion in telehealth: policy and regulatory changes post-COVID-19

The onset of the COVID-19 pandemic and subsequent lockdowns in South Africa led to major changes in how primary health care was delivered, particularly in population groups with access to private clinics offering telemedicine services. At the Activecare Clinic of Dr Unben Pillay (Midrand, Johannesburg) patients became increasingly interested in telemedicine services during the pandemic, including consultations via specific platforms, WhatsApp, or simply phone calls.

The increasing trend towards telehealth during the pandemic led to the development of new guidelines by the Health Professions Council of South Africa, a statutory body established to provide standards, education, training, and registration for practicing of health professions registered under the Health Professions Act. Their latest guidelines for good practice in telehealth, published in December 2021, provide information on the ethical and legal issues that PHC providers offering telehealth must conside including guidance around consent, confidentiality, data protection, quality, and safety. They also outlir actions to avoid, such as the use of social media to deliver telehealth, and the exclusive offering of telehealth services by providers.

The development of guidelines for healthcare professionals, updated regularly based on the changing COVID-19 and legal and regulatory landscape, has given additional confidence to PHC providers, by clarifying the scope of what is allowed under the law, and which are the fundamentals of good practice in the context of telehealth provision.

While telehealth is not widely offered as part of the South African public health service and is used more commonly by private PHC providers in Johannesburg, the development of good governance and guidelines forms a strong basis to expand telehealth services in the future. Notably, there is a range of infrastructure, technical, financial, and operational challenges to overcome before telehealth can be a mainstream service offer in the public health service. These include the relatively high costs of calls and mobile data, and widespread and persistent outages on landlines. Many users do not have their own mobile phones, and some struggle to charge them, particularly those living in informal settlements and certain rural areas where there is costly access or limited/no access to electricity points.

3. Assisted living

The scope of digital technologies used for assisted living is varied and includes apps and other software, sensors, and robots which aid mobility and independence of older people, people with disabilities, or home care patients.[17] These technologies are grouped under technologies for assisted living and their primary aim is to enable patients to be in their own homes, return to their homes faster following hospital treatment, or live independently longer.

Digitally-enabled assisted living for aging populations

There are over 46 million older people (aged 65 years and older) in SSA, a figure expected to more than triple to 165 million by 2050.[48] Approaches to care vary from country to country across the region, developing alongside societal changes and health trends. Currently, care is often provided to older people primarily by their families and members of their communities, with institutional homes still considered a relatively new concept.[49] Given the projected increase in the elderly population, the current approach to care in SSA has been described as unsustainable, and results in inconsistent care quality, placing a heavy burden of care onto women and girls with implications for gender equality and economic development.[48]

As life expectancy increases, digital technologies designed for assisted living have a growing role in the delivery of essential health services. Increasing efforts are being made by national health systems to develop policy and to plan services, and to encourage private sector investment and service innovations, such as integrated care systems to bring together home care, nursing home care, treatment, and palliative care.[50,51]

Assisted living technologies in sub-Saharan Africa

In sub-Saharan Africa, there are examples of assisted living technology being developed and used to improve the quality of life and health of older people.

In Mauritius, the government launched its first national aging strategy in 2016, which has in-part led to the development of a market for age-related technology products.[50] In response to the decline in intergenerational family living and the growing need for paid caregivers offering nightly house calls, technology company Serenity[52] developed a monitoring and alert system which connects older people to 24/7 remote assistance, who calls family, neighbours, or emergency health services if required. Additionally, Serenity offers Serenity Mobile, which provides older people with a mobile phone where they can receive appointment and medication reminders and automatically record data from medical devices (e.g., glucose or blood pressure monitors).

4. mHealth

In sub-Saharan Africa, the growth of mHealth in SSA has coincided with the rapid scale up of internet connectivity. At the end of 2020, 81% of the sub-Saharan African population were living in an area covered by a mobile broadband network, rising from 53% five years earlier.[53,54] Operators in several countries, including Nigeria, Mali, and Tanzania, have increased coverage through 3G and 4G rollouts. In most countries, internet-enabled mobile phones are becoming more affordable due to the emergence of "smart feature phones".[54] Smart feature phones do not offer the full capabilities of a smartphone but allow for installation of a range of applications and provide a faster, better browsing experience than traditional mobile phones.

The scope of mHealth use

According to the experts we interviewed, mHealth in SSA includes the use of apps on a smartphone as well as the use of telephone services, SMS, and Unstructured Supplementary Service Data (USSD). A USSD communication protocol allows sending of USSD text between a mobile phone and programs running on the network, thus allowing an easy integration of SMS services/functionalities[55] on smart feature phones or basic handsets.

According to the literature, mHealth interventions in LMIC have been most commonly implemented for the management of communicable diseases (e.g., HIV and tuberculosis), vaccination, and maternal and neonatal services,[56-58] though the scope of their application is widening.[59] mHealth technologies were highlighted by the experts we interviewed as able to provide a range of services to patients: from self-care, to purchasing insurance, to mobile money.[60]

The broad scope of mHealth lends itself to use by multiple stakeholder groups. Firstly, healthcare providers are making use of mHealth to aid the healthcare delivery and clinical practice. The main use of mHealth by providers reported by participants was for clinical decision support and access to longitudinal compressive data by a range of different primary healthcare workers including physicians, nurses, and community healthcare workers (CHWs).

> "We are trying to support medical doctors and people that work as clinical officers (...) in their decision making, making sure that [through] digital tools they can [better] understand symptoms and a little bit of a medical history of the patient."
> (Industry professional, East Africa)

Secondly, mHealth, specifically apps, are also used for data collection and reporting at the provider and regional/national level within primary care, and at system level.

> "The community health workers (...) literally live in the community, they live close by, they visit households, and to have a tool in their hands that can (...) have more functionalities would be great, because it's just punching the numbers and reporting back (...) they can actually know things right there,

Innovative tools aiding mHealth

Innovative tools are increasingly designed and used to help deliver mHealth, including the use of drones to deliver health technologies and facilitate services. In 2019, the Ghanaian Ministry of Health introduced unmanned aerial vehicles, referred to as drones, to deliver blood and essential medicines to areas that are inaccessible by road.[61] At the height of the COVID-19 pandemic in 2020, the drones were also employed in the delivery of COVID-19 samples to testing sites in Accra and Kumasi. This facilitated the process of testing suspected cases and processing of samples to enable prompt clinical decision-making on patient management, contributing to efforts to contain the spread of the infection and mitigate its impact in Ghana.

they can inform, they can relate to the patients or communicate with, let's say, the nurses at the health centre"
(NGO professional, SSA-wide)

The WHO has previously noted the challenges of scaling the vast number of pilot projects undertaken, including the lack of integration between mHealth apps and national eHealth strategies and information and communications technology (ICT) architectures; the absence of regulation, standards, and best-practice guidelines; and the lack of multisectoral approach between government agencies and health and development donors.[23] More fundamental challenges exist in developing internet connectivity and access to mobile phones where major inequity exists. For example, in 2021, women in SSA were 37% less likely than men to use mobile internet and people living in rural areas were 54% less likely to use mobile internet than those living in urban areas.[62] Inequities also exist across the content where average download speeds in SSA remain below 10 Mbps, while the average in high-income countries is 50 Mbps.[62]

Digital payments for health care

The use of mobile banking has increased in SSA in the past years, with applications now beginning to focus on the health sector. mHealth is increasingly used as a means of enabling health care digital payments across health systems. In Kenya, for example, the national health insurance scheme (via Kenya's National Health Insurance Fund (NHIF)) is being rolled out with multi-sided digital platforms connecting patients, providers, payers, and suppliers.[63] For example, M-TIBA, developed by PharmAccess, Safaricom, and CarePay, connects patients, providers, and payers to enable payments to be made more easily using mobile phones.

5. ePrescribing and eAppointments

Participants in the research mentioned the importance and use of these eAppointment apps which are increasingly being developed and implemented across the continent **(see Case Study 2)**. One interviewee specifically highlighted the development of eAppointment systems in relation to antenatal care (ANC) and their use by large organisations to facilitate wider ANC planning.

"The customised system is called Family Connect. This was implemented by UNICEF. (...) Mothers are able to get reminders but the community healthcare workers are also able to register the mothers onto this system"
(NGO professional, East Africa)

ePrescribing to improve medication safety

Medication safety is an integral component of health systems, which requires good practice in prescribing, transcribing, dispensing, administration, and monitoring.[64] Medication safety requires patients to take their medication as prescribed, which, if improved, could save an estimated US$375 billion per year globally and improve health outcomes.[65]

Car J. and colleagues describe the "medicines management journey" where the patient spends considerable time gaining access to a healthcare provider, deciding on the prescription during consultation with the provider, attending a pharmacy to obtain the drugs at a pharmacy, and finally, integrating medication taking into their daily routine.[65] While digital technologies such as telemedicine can improve the beginning of the patient's medicines management journey, ePrescribing can aid the time-consuming aspects of the journey and improve medication safety.

For example, EHRs, computerised prescription order entry (CPOE) and computerised decision support systems (CDSS) all contribute to efficiency and patient safety [X].[65] CDSS can reduce prescribing by facilitating checks for drug allergies with EHRs and perform automatic checks on drug interactions. Transcribing errors can be reduced by CPOE and the direct transmission of prescriptions from the provider to a pharmacy electronically. ePrescribing technologies can also assist the patient by supporting remote monitoring of adherence through refill tracking, and issuing of automatic refill alerts, increasing medication adherence towards better health outcomes.

ePrescribing in sub-Saharan Africa

According to the experts we interviewed, the use of ePrescribing varies across countries in SSA. In Rwanda, ePrescribing was more readily available to patients as part of the national health insurance scheme, specifically when using Babyl services which are reimbursed under the scheme. In some cases, ePrescribing was widely used in the private sector but not in public facilities (e.g., in Nigeria and South Africa):

"I know some private hospitals that have actually implemented fully-fledged systems, where you have the entire workflow digitised from triage to consultation to the lab to pharmacy to radiology. Yes, that happens a lot in the private sector. But for government-owned facilities, it is something that is yet to happen"
(NGO professional, East Africa)

Instead, in Kenya, while there is increasing interest in ePrescribing, HCWs in primary care are reluctant to offer this service to patients for fear of the system being abused through fraudulent activity. Current innovators are seeking to resolve this challenge by setting up ePrescribing systems with inbuilt security checks to ensure drugs are dispensed safely.

Legal barriers to ePrescribing

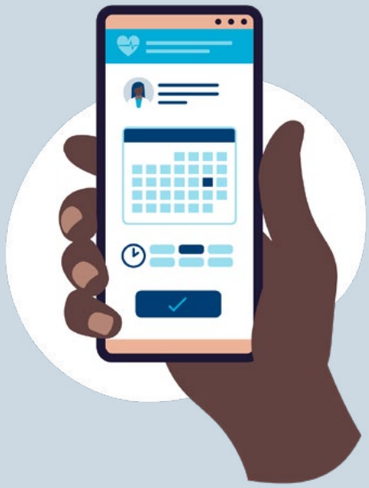
Legal frameworks in countries across SSA pose challenges for the development of ePrescribing technologies. However, there has been substantial innovation in prescribing across the continent in recent years, with the first e-pharmacy business registered in Kenya in 2013.[66] The COVID-19 pandemic has also encouraged some to embrace novel approaches to prescribing. In South Africa during the pandemic, vulnerable patients would have been put at risk if they were forced to gather in crowded locations to receive medication. This safety concern led the Cape Town Metropolitan Health Services to offer home delivery of medication, linking the chronic dispensing unit system with an emerging approach to community-orientated primary care.[67] Other than reducing the risk of contracting COVID-19, this approach offered additional benefits for patients, such as less time away from work and the subsequent loss of earnings.

Case Study 2: Developing an eAppointment system at Chiawelo Community Practice

Chiawelo Community Practice is part of Chiawelo Community Health Centre in Soweto, Johannesburg. The practice is developing community-oriented primary care, as a model for GP-led teams contracted to the National Health Insurance (NHI). The practice cares for more than 30,000 patients from the local community.

A first-of-its-kind electronic appointment system was set up at the practice in October 2021, to improve efficiency and clinical workflow. The online appointment system was developed by joinaQ Pty Ltd, a cloud-based queuing solution, pro-bono and is used to book appointments, manage registrations, and store clinical data (i.e., vitals).

In the early days, the workflow was optimised to improve the efficiency of vitals, ensuring patients were checked in at reception and scheduled for obtaining vital signs. The system now ensures a smooth workflow at the reception desk, and appointments are automatically announced on a screen in the waiting area, once patients are checked in.



Contrasting with the previous 'first-come, first-served' system, the current prebooked appointment system required some adaptation from users, but staff report that the transition was overall well-received. Community healthcare workers (CHW) have assisted in raising awareness and garnering support among patients by interacting and sharing information at the community level. However, some CHWs have also struggled with the change as it has negatively impacted their work schedules, requiring them to work longer hours in the afternoon.

As in other facilities owned by the public health service in South Africa, at Chiawelo Community Practice and the wider Community Health Centre, suboptimal infrastructure and resources can be a barrier to digital health innovation. This case study exemplifies how staff at the practice have learned from previous failed initiatives and made conscious decisions to develop digital interventions tailored to overcome the challenges previously identified.

As previous initiatives failed due to inconsistent internet connectivity, fibre Wi-Fi has been installed at reception to allow the eAppointment system to function throughout the day, and mobile phone data can be used when there are issues with the Wi-Fi connection. As previous initiatives were jeopardised by the loss and occasional theft of ICT equipment, the eAppointment system now selected is hardware light and only requires one computer and monitor. Providers can access it via an app on their personal mobile phones.

BACK TO CONTENTS

6. Data-driven technologies

Commonly cited benefits of data-driven technologies in LMICs include connecting hard to reach populations with health services, addressing workforce challenges, and reducing costs.[10]

Data-driven technologies in sub-Saharan Africa

Data-driven technologies and AI are not widely used in health care in SSA, as there are several barriers to their use. The primary challenge is the large amount of high-quality data required to inform appropriate automated algorithms in the technologies; such data is currently not available and difficult to collect.[10] Additionally, representative data is required to ensure an algorithm is trained well to facilitate the AI technology to make accurate predictions that do not exacerbate existing health inequities, a challenge that has been written about extensively in the context of healthcare delivery around the world.[71]

There are several examples of smaller-scale AI development in the SSA region reported in the literature. For example, Bogou, an AI platform, has been developed by the Senegalese Ministry of Health, WHO, and International Telecommunication Union (ITU) to facilitate the timely detection and management of diabetic retinopathy, connecting peripheral health centres to specialists.[72]

These findings echo information from the experts we interviewed that AI is sometimes used to facilitate clinical decision support, with built-in checks and balances to ensure HCWs had the autonomy to override any decision advised by the algorithm.

> "[We] were able to hire doctors and nurses, train them, and also using an app with artificial intelligence, which would help the nurses and doctors with prompt questions and different diagnosis and different treatment protocols."
> (NGO professional, SSA-wide)

Initiatives, such as H3Africa, which aims to facilitate research on genomics and environmental determinants of common diseases in African populations,[73] have attracted investments from global technology companies, such as Google investments in Ghana, and IBM in South Africa.[74] As many SSA countries are in the process of developing AI strategies, laws, and regulations, data-driven technologies and AI development are likely to become increasingly prominent across the region.[74]

What are data-driven technologies and artificial intelligence?

Data-driven technologies describe technologies that work by collecting, using, and analysing patient data to support the health care, public health, or medical research and innovation[68]. Artificial intelligence is one example.

IBM describes artificial intelligence (AI) as a field which combines computer science and large datasets to enable problem solving [69]. In the context of health, AI can assist healthcare professionals to make better clinical decisions and optimise health service delivery. AI systems do this using 'algorithms', a process or set of rules to be followed in calculations or problem-solving operations, to compute features from large datasets and obtain insights to assist clinical practice[70].

Applications at the systems level

While digital technologies are increasingly being used for health service delivery in PHC at individual facilities and among a range of HCWs, their use is also extensive at the health system level to address the wider functioning of health services at district, regional, and national levels. A range of stakeholders are involved in the implementation of digital technologies at the systems level, with important implications for policy and practice as the use of digital technologies expand across SSA.

1. Mapping of health services

Digital technologies are being deployed to map health services and population-level needs. One expert we interviewed noted that the use of the World Health Organization software (i.e., AccessMod[75]) and others facilitated health services mapping. Local initiatives are also taking place to adapt open-source software to specific geographies and contexts.

> "we're working with the government to video map, [and] do what we call geographical accessibility to [assess] travel time to another facility and find out the population that are covered by health facilities in terms of geographical conference."
> (NGO professional, East Africa)

Mapping for public health campaigns

Mapping of health services was highlighted as useful in undertaking public health campaigns (e.g., vaccination campaigns) as there are examples of mapping being used to locate underserved population groups and plan vaccination services to reach them. In this regard, digital microplanning has been undertaken to better facilitate mapping and outreach.

2. Management of drugs and supplies

Two experts we interviewed noted the use of novel digital technology to manage the provision of drugs and supplies. For example, in South Africa, distributed ledger technology (DLT), an asset database that can be shared across a network of multiple sites, geographies or institutions,[76] is being used to manage drug stocks and dispensing. Across the continent, NGOs are utilising digital technologies to manage their supply chains to provide vaccines, drugs, and other health products. In Ethiopia, UNICEF monitors supplies to facilitate delivery of services through an electronic supply management system.

> "In order to improve our supply management, we introduced monitoring of supplies. The checklist was also uploaded on ODK [Open Data Kit][77] and they were able to track where we need to deploy our monitors to the field."
> (NGO professional, East Africa)

The system enables healthcare facilities to provide real-time information on the availability of supplies to ensure supplies are available and dispensed to facilities in a timely manner, reducing the risk of stock outages.

3. Digital systems for integration / central reporting

Digital systems are increasingly used at the national level for central healthcare reporting and to connect and underpin different services across the system. Health management information systems (HMIS) (e.g., systems whereby health data is recorded, stored, retrieved, and processed to improve decision-making[78]) were mentioned as underpinning reporting from PHC facilities to national systems.

> "We have something called HMIS data where we are supposed to report to the Ministry of Health. The health centre will report theirs. We will report ours." (Healthcare organisation leadership, East Africa)

In SSA, the District Health Information Software (DHIS), an open-source software platform for reporting, analysis, and dissemination of data for all health programmes, is used across the continent. In Rwanda, the national health HMIS has used DHIS2 since January 2012 to collect routine data.[79]

The use of digital technology for central reporting in SSA is also undertaken across specific vertical programmes, as well as reporting to NGOs and other donors. Health facilities are responsible for reporting on health indicators and outcomes related to specific diseases like HIV/AIDS. In South Africa, for example, there has been longstanding reporting on tuberculosis that has been more recently combined to include HIV/AIDs reporting in the same system. However, the reporting systems have always relied, at least in part, on paper records.

> "There was an electronic tuberculosis register, a sort of surveillance-driven application locus at sub-district level. So, patients were principally being managed in a paper[-based] tuberculosis register (...) someone would then digitise that data into the electronic TB register." (Other health professional, Southern Africa)

One expert highlighted the value of undertaking a phased approach to developing central reporting systems that responds to the needs of the context, for example offering a non-network solution (e.g., a solution that enables data to be input without internet access and is uploaded when connectivity returns), to ensure reporting can be undertaken across the system.

4. COVID-19 and the digital transformation

The COVID-19 pandemic has increased the use of digital technologies globally, particularly for service delivery.[80] The OECD Africa's Development Dynamics 2021 report notes that the pandemic strengthened digitalisation, contributing to the African Union's vision for the continent's development.[81] The 2022 report cites Safaricom's mobile money product, M-PESA, used by patients to pay for health services, as contributing to the reduction of the physical exchange of money during COVID-19.[82]

The pandemic has also established telemedicine as part of future health care delivery systems.[47] Telemedicine contributed significantly to healthcare delivery during the pandemic.[83] In Nigeria, for example, family physicians working in PHC have utilised telemedicine to reduce the number of patients visiting clinics as part of a wider shift in practices.[84]

It is also notable that COVID-19 has created an ever more challenging environment for the financing of digital transformation. The OECD highlights that public financial resources are largely unavailable, particularly in the short term, as countries face increased spending on health needs related to the pandemic at the same time as a drop in revenue from tourism, trade, and remittances.[81] The true role COVID-19 will play in digital transformation in SSA.

Leveraging digital health in PHC to benefit patients, providers, and health systems

Summary of our research findings

- Digital technologies are benefitting patients across sub-Saharan Africa by expanding treatment models towards enabling innovative and more affordable pricing models and patient-centred services
- Providers across the continent are finding benefits in utilising digital technologies to enable training and capacity building, particularly remote training, and used technologies to aid decision-making
- Technologies are facilitating continuity of care by enabling interoperable systems which improve continuity of care across health systems and the longitudinal patient's journey
- Health systems are optimising quality and safety through the use of digital health, with specific benefits seen in equity, by reaching historically underserved populations, efficiency, through improved planning and delivery with time and cost savings, and effectiveness, by addressing gaps such as human resource shortages

Considering the health systems building blocks presented in the WHO framework **(see Figure 3)**, digital technologies have the potential to drive improvements across service delivery, the health workforce, health information systems, and access to care, drugs, and supplies. Greater access to health services and improved quality and safety are the vehicles for enhancing the positive outcomes of a strong health system, including improved effectiveness, efficiency, equity, and patient centredness.[85]

As previously noted, the increased uptake of digital technologies supports a range of functions, which in turn, delivers benefits to stakeholders across the system. In this section, we will discuss opportunities to leverage digital health at the patient, provider, and health system level.

1. Patients

Harnessing technology to increase accessible, patient-centred PHC

Patient-centred care describes health care that is respectful and responsive to individual patient preferences, needs, and values.[85] Several of the experts we interviewed highlighted the use of digital technologies in PHC as an enabler for more patient-centred care. It was noted that providing good quality, digitally enhanced services offers the opportunity to build patient satisfaction and trust. While these findings echo previous research highlighting the connection between digital services, quality of care, patient satisfaction and trust,[86-88] this research topic has been underexplored in the SSA context.[89]

> "If I tell [the patient] (...) I've got to check whether there's [an] adverse drug reaction here. Or (...) I've got to be sure what your risk is, and they are seeing me take my time to do due diligence, it conveys to them that [I am] (...) taking time to ensure good quality care, so [that] does inspire trust."
> (HCW, West Africa)

Interviewees further noted that digitally enhanced care can improve access to services with minimal delays and reduce the burden of travelling long distances, an important challenge across the continent. This highlights the value of digital technologies, particularly telemedicine, on provision of care to traditionally underserved populations. Until now, the lack of access to care for large populations in sub-Saharan Africa has been one of the main barriers to true user-driven services.

One participant noted that UNICEF has used global positioning system (GPS) tracking technology to deploy mobile health services to pastoralists in East Africa, whose movements are impacted by factors such as water resources and drought, enabling them to access care without walking up to five hours to the nearest health facilities.

Also, particularly following large-scale changes to consultations during the COVID-19 pandemic, experts interviewed highlighted that people are now more used to reaching their doctors in virtual modalities, and that this has been revolutionary. One expert noted the potential for digital technologies, delivered at scale across SSA to address the access challenge and considered digital health the primary vehicle of universal health coverage (UHC) delivery. As presented in the introductory section, digital health technologies have the potential to increase the total

population covered by health care, the total amount of quality services available, and the proportion of health care costs covered.

Expanding treatment models and more affordable pricing models

The drive towards digital PHC services, particularly telemedicine, offers the opportunity to disrupt traditional healthcare financing, for example, direct-to-consumer telemedicine companies in Kenya directly offer patients several payment models, from various subscription packages based on services required, to fee-for-services, or have linked with insurance companies to provide services through patients' insurance premiums. Experts interviewed broadly agreed that patients would be the ultimate beneficiary of expanded pricing models as they will have more options available to finance their health care, whether it be lower private health insurance premiums based on greater choice in the market, or an increasing number of services available to them under national health benefits packages (HBPs).

> "we're going to see in the next year maybe, couple of years is, which models seem to work for what demographic of patients, what costing seems to work [...], what modalities of telemedicine, for example, or digital health applications are most interesting or what patients want to use the most."
> (HCW and industry professional, East Africa)

Alongside accessibility and increased utilisation, participants in the research highlighted affordability of digital technologies as an important benefit for patients. For many patients globally, out-of-pocket (OOP) payments, and the high relative cost of health services discourage health care seeking and result in delays of care.[90,91] Digital technologies in PHC address this challenge on multiple levels. For example, the cost of healthcare services can be reduced. In Kenya, for example, the boom in telemedicine providers has led to a drop in prices, subsequently reducing OOP costs and increasing the affordability of telemedicine for Kenyan patients. These cost savings from the use of digital technologies to deliver health services also trickle down reducing the cost of health insurance premiums in some contexts in Kenya.

Increasing patient empowerment through data access

Academic institutions and industry organisations have long used patient data to drive innovation in health care globally. Several interviewees highlighted how digital technologies can facilitate data access for greater ownership, empowering patients to engage more fully with the health system and potentially drive innovation.

Should adequate enabling mechanisms be put in place to provide patients with access to their data and the ability to be active stakeholders in quality improvement (e.g., by correcting simple data input errors), the growing datasets generated from digital health applications, particularly EMRs, may be used as a tool to increase access, drive innovation, and optimise user-centred health care. **Figure 4** outlines the value of empowering patients through data access and ownership as a means of developing and continually improving user-centred digital care.

Mechanisms to enable access must be developed at the national level, adhering to relevant legislation on data protection and confidentiality, and provide clear guidance to providers on how to prepare themselves and how to assist patients. In the UK, for example, general practitioner (GP) systems were updated in November 2022 to give people with online accounts access to see new entries in their primary care health record automatically.[92] The process was led by NHS England, as part of national digital transformation policy, and supported by NHS Digital, to ensure digital platforms enabled functional and secure data access, with PHC providers offered guidance and training prior to roll-out.

Increasing patient incentivisation to improve outcomes

Another aspect discussed was the potential for incentivised health behaviour. Private providers such as Discovery, a company offering a range of medical insurance products in South Africa, offer incentives for customers changing their lifestyle choices towards healthier living. For example, the Vitality behaviour change programme offers customers cashback on healthy food purchases and reduced gym memberships as it will save them medical costs in the long term.[93]

Some of the experts interviewed discussed the future potential of incentivised health improvement, on a larger scale than what is currently offered by Discovery's Vitality programme. For example, patients could be offered incentives for every interaction they have with the health system throughout their life-course, such as testing, initiating treatment, adhering to clinical guidance or a medication regimen, as well as actions outside of the health system, such as joining a gym or healthy eating. This incentivisation could be a route for shared responsibility towards a healthier life. One expert highlighted the role of incentivisation in encouraging greater utilisation of key services and long-term adherence to treatment, particularly for long-term conditions such as HIV/AIDS.

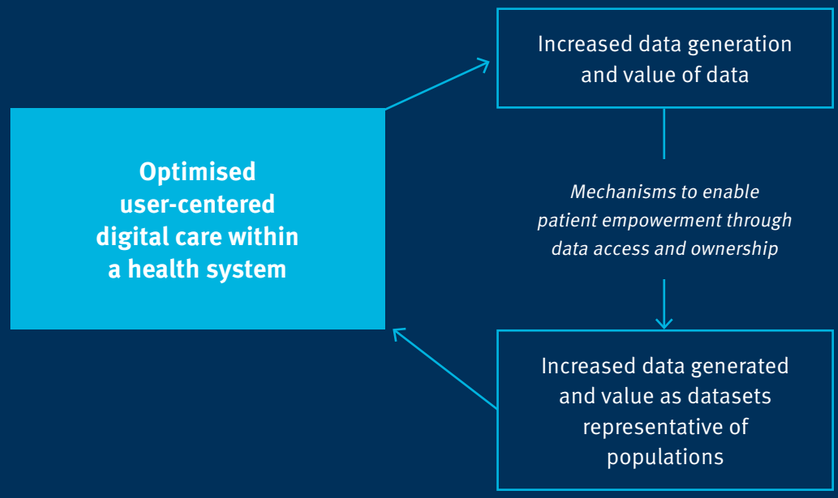


Figure 4: Utilisation of personal health data to empower patients, and develop and continually improve user-centred digital care

2. Providers

Utilising digital technologies for decision support

Digital technologies are being used across SSA to provide clinical support for a range of HCWs providing PHC. Given the extreme workforce shortages in PHC across the continent, the ability of electronic decision support tools to aid HCWs to deliver evidence-based care has huge potential in reducing workloads and improving the quality of care provided.

Several of the experts we interviewed discussed the future value of digital decision support, with one noting the potential value of artificial intelligence (AI) in supporting HCWs on diagnosis and prescribing. Another interviewee considered decision-support AI particularly useful for HCWs who have not been trained recently or based in settings where care is mostly provided by untrained staff. Decision-support tools that can be optimised for low-literacy HCWs, such as Dimagi's CommCare data collection app, were highlighted as an important enabler of

accessible digital technology across SSA.[94] Experts interviewed identified untapped potential in utilising remote connection, either via telephone or video, to connect HCWs in remote locations to other providers who can advise or guide on the management of specific clinical cases.

> "If a patient has a skin lesion [and] I'm not too sure what it is, I can send the video to a dermatologist or an expert in that particular area in South Africa, in America, in London, and then you'll be able to look at it and immediately get back to me and say - most likely, this lesion is this."
> (HCW, West Africa)

To aid decision support beyond clinical support, healthcare providers across SSA are using digital technologies to aid non-clinical planning and decision making. For example, experts interviewed mentioned that they used various online monitoring and evaluation systems to monitor quality outcomes at the facility level, track business functions, and monitor staff activities and stock availability. In the future, these non-clinical decision supports have the potential to make healthcare providers more profitable and enable their growth, as they can inform evidence-based service improvements, and subsequently optimise provision of care.

Training and capacity building enabled by digital technologies

Experts interviewed as part of this project highlighted that digital technologies, particularly mHealth technologies, are being used to deliver education and refresher training to a range of HCWs and information and education to patients.

A range of specific technologies are being used to achieve this, including mobile apps. They noted that other technologies are also being employed to deliver training including systems to provide simulation, online classes, and eLearning platforms.

> "We have other solutions, like an eLearning platform, where we support [CHWs] with remote education where they're able to learn more and get up to date with current technology in their field."
> (NGO professional, East Africa)

Participants highlighted the value of utilising digital technologies for training and capacity building, to reduce the need for HCWs to rely on expertise outside of their facility or district. In this regard, the unique value of capacity building and training delivered via digital technologies is the ability to engage with HCWs living in remote locations who would otherwise be unlikely to gain access to information, collaborate with other HCWs, or access regular training for continuous learning (e.g., via remote conferencing software). Through training and capacity building, digital technologies can, ultimately, build confidence in clinical decision making and practice. Positive examples of this in action were cited by several interviewees.

> "Having training for health workers over and over, refresher training for them over and over is sometimes practically impossible...This digital [solution], the Safe Delivery Hub [mobile education app] actually helps the health workers (...) to continuously educate themselves, mentor themselves, train themselves."
> (NGO professional, East Africa)

One interviewee suggested that existing educational apps and services can be developed easily to provide training across subject areas (e.g., infectious disease, obstetrics, mental health) or for different types of HCWs (e.g., physicians, nurses, CHWs) without beginning again to set up educational delivery mechanisms.

3. Health systems

Facilitating continuity of care through interoperable systems

At the health systems level, a greater use of digital technologies can facilitate improved continuity of care across PHC and the longitudinal patient's journey. The primary vehicle for improved continuity of care discussed by the experts interviewed was interoperability between systems which, to date, is

not widely implemented in PHC in SSA.

> "In some centres, they are able to link [data] on to other centres (...). But here, we still do not do that [...] that's [a] practice I would wish we will be able to do with time. It will require connecting to these special centres, and then it will [improve] consultations."
> (HCW, West Africa)

Interviewees highlighted the potential benefits of integration and interoperability, which would produce benefits across the health ecosystem and streamline continuity of care.

Optimising quality and safety

Quality of care is defined as the degree to which health services increase the likelihood of desired health outcomes and are consistent with evidence-based professional knowledge.[95] In what concerns quality of care, one of the most influential frameworks was proposed by the Institute of Medicine (IOM), which includes the following six dimensions for high-quality healthcare systems: safety, effectiveness, patient-centredness, timeliness, efficiency, and equity.[85] Safety is an important component of quality of care, described as the avoidance of harm to patients from the care that is intended to help them.

The provision of quality care is central to the achievement of UHC by 2030, however, it has been highlighted that even in contexts with UHC some patients will have access to only low-quality care that may harm them.[96] Technology itself has a potential impact on quality and safety of care; as such, participants, expressed the need to consider best practice in the development of digital technologies.

Most importantly, the relationship between digital technologies and patient safety can be approached from two complementary angles: the need to ensure digital technologies are safe and, equally, proactively use them as a tool to solve contemporary safety challenges.[97] Participants noted a range of ways in which current digital technology used in PHC improves the quality and safety of care (e.g., enabling patients to choose better quality providers) and enables providers to provide better quality care through decision support. There was consensus among interviewees that it was critical to lay strong foundations into the development of digital service delivery models, specifically hybrid telemedicine, grounded on the core values of quality and safety, to catalyse change and sustainably strengthen demand. Two interviewees also highlighted the importance of developing standardisation across various technologies.

While there are opportunities to develop each of the six domains of quality healthcare, experts interviewed focused on four which were particularly important to develop at the system level: **equity, efficiency, effectiveness and safety.**

i. Equity

Digital health has the potential to improve equity by bridging geographic provision gaps and reducing cost but may challenge equity based on the availability and costs of digital technology and given that its use demands complex skills that may vary among populations, such as low literacy or digital skills.[98]

Equity in health care describes care that should not vary in quality because of personal characteristics such as gender, religion, geographic location, and socioeconomic status.[85] Interviewees envision the use of digital technologies in PHC as contributing to equity as a solution available for all population groups, not just those groups who have previously benefited from greater access to quality health care. In particular, the use of digital technologies by CHWs was considered by participants in the research as an important lever in advancing equity in access to care in remote and rural areas.

> "Having the community health workers is in some ways an equity equalizer. If you go [to] Burkina Faso or Bali, where they have thousands of community health workers in countries, in rural places, they are using these very basic digital tools. In some ways, they are basically working on the equity side, making sure they are closer to the clients and closer to the communities."
> (NGO professional, SSA-wide)

Experts interviewed also noted the potential role of AI in improving the accessibility and affordability of health insurance through automated claims, and identifying tailor-made preventative solutions to improve individual patient outcomes.

Increasing equity through access to health care is only possible if all population groups have access; as such, the development of equitable digital services in primary care must occur at the systems level to ensure population groups are not left behind. Several actions and initiatives have been proposed globally. For example, in India, hub-and-spoke models (e.g., the concept of a central hub with geographically distributed networks) of service delivery with telemedicine at their core have been developed to connect patients to services.[99,100] During the COVID-19 pandemic, global sharing of intellectual property and facilitation of technology transfer to enable greater access, improved pharmaceutical pricing and subsequently more affordable drugs.[101]

As data will underpin the development of new digital diagnostics and systems, there is an urgent need to ensure datasets are truly representative and inclusive of data from underrepresented groups. The Data Poverty Index measures the "digital divide", a term used to describe disparities with respect to access to computing and information resources, such as the internet, and the opportunities derived from this access.[102] When applied to the health sector, disparities in technology access and usage can result in "data poverty" becoming a social determinant of health.[71] As fewer datapoints are held on individuals who do not access or engage with technology, digital technologies, including AI, are developed without crucial information. This has downstream implications for ensuring quality care is provided to individuals or whole health systems who are underrepresented in the data. One interviewee also highlighted the role of data in enabling equity:

> "Improving the data sources, data collection, data quality - and making sure that it's conclusive and not just (...) representing a small segment of the population."
> (NGO professional, SSA-wide)

All stakeholders, including government, academia, and commercial organisations must act now to ensure health technologies are equitably developed; in the particular case of algorithms and decision-support tools, these need to be trained on representative datasets to ensure they do not further exacerbate existing inequalities.

ii. Efficiency

Digital health may drive efficiencies through the potential to reduce personnel, equipment, travel costs, and supplies.[98] Efficiency is defined as avoiding waste, including waste of equipment, supplies, ideas, and energy, and is an important part of high-quality care.[85] Most participants believed digital technologies can improve efficiency in SSA through improved planning and delivery, but also enhanced standardisation.

> "On the efficiency side, digitising allows you (...) to build decision support, build standard operating procedures through the technology itself so that you're standardising patients' care - it's not up to the provider alone to be constantly making these decisions."
> (HCW and industry professional, East Africa)

There is a range of recent examples of advances in mHealth and use of technology for improving efficiencies across the system presented in the literature. For example, in Ghana, district hospitals utilise the District Health Information Management System (DHIMS), an essential software used in clinical care and data gathering. In research, mobile phone-based tools have been employed in surveillance of morbidities in care of patients with chronic diseases like heart disease.[103,104] Experts interviewed also highlighted the potential use of real time performance monitoring in SSA, citing examples from use in other countries globally, specifically for monitoring and optimising daily staffing numbers and improving adherence to quality and safety interventions.

Specific types of technology were cited by expert interviewees as particularly valuable in developing efficiencies, including telemedicine, EMR, and digital data collection more widely.

> "Even if you've seen the same GP over and over again, they don't have access to your record [...] it's incredibly inefficient."
> (HCW and industry professional, East Africa)

Experts interviewed were optimistic that digital data collection would be developed further in the future to build upon existing programmes and systems. For example, digital micro-planning was proposed by one interviewee as a means of further streamlining operational planning for health service delivery in the NGO sector. With digital data collection, NGOs can get accurate data that enables better monitoring and evaluation with downstream positive impacts on efficiency.

iii. Effectiveness

Digital health can enable greater effectiveness through the provision of more person-centred care based on the ability to tailor services more easily to individual patient preferences and needs.[98] Effectiveness describes the ability to "provide services based on scientific knowledge to all who could benefit and refraining from providing services to those not likely to benefit".[85] The tangible benefits of digital technologies to address systems' gaps and facilitate planning in SSA were highlighted extensively by the experts interviewed who offered a range of examples.

The ability to improve health and patient outcomes through expanded health coverage facilitated by digital technologies in SSA is an important consideration. Digital technologies enable stakeholders across the health sector to improve service delivery, by providing care to larger numbers of patients and fill existing workforce shortages. The experts interviewed explained that digital technologies are unique in aiding health systems to fill these gaps, by "decongesting health systems and facilities" on a scale that prior solutions, such as recruitment drives and task sharing/task shifting, have failed to do.

> "[Digital technologies] serve a purpose in filling gaps in the current health system that we just can't fill by building more hospitals or trying to hire more doctors – (...) we don't have the resources for those hospitals, [and] we are not producing enough doctors."
> (HCW and industry professional, East Africa)

Experts further highlighted the potential to improve service delivery in PHC, including AI and Bluetooth-enabled diagnostics, which will underpin remote consultation, decision-support tools, and provider training, and ultimately enable better quality, effective, timely and equitable care for patients (See Case Study 3).

> "We're talking to people who have Bluetooth-enabled machines, thermometers, blood pressure monitors, blood sugar machines, all of which will send readings directly to the patient and to the provider in real time, while they're in a virtual consultation. So suddenly, as a doctor, I have multiple things I can look at as I am trying to (...) make a clinical diagnosis"
> (HCW and industry professional, East Africa)

Advancements in healthcare data sharing between PHC services can also improve effectiveness. To reinforce the widespread use of interoperable EHRs that provide a longitudinal view of the patient's journey, three experts explained the need to develop and utilise unique patient identifiers (e.g., civil registration numbers which connect to health delivery systems). Such identifiers have the potential to tackle fraud, including identity theft and impersonation, across the system.

> "Rather than [going] to the record and looking for the case file, all you have to do is present your card, and they input your number into the system and your record is out. And once [its] done, you just come to the doctor, you open the system, your records are there."
> (HCW, West Africa)

Case Study 3: Combining Bluetooth-powered point of care medical devices with electronic health records to better manage chronic conditions in the private sector

Private clinics in Johannesburg have flexibility in choosing systems and ways of working with digital technologies. At the Activecare Clinic of Dr Unben Pillay (Midrand, Johannesburg), a suite of technology is used to integrate electronic health records (EHR) with Bluetooth-powered point-of-care (POC) medical devices used for the management of chronic conditions. Bluetooth-powered POC devices used at the clinic include electrocardiogram (ECG), blood pressure monitor, glucometer, and weighing scales.

Healthcare providers at the practice use KardioEHR, an EHR system designed to offer practitioners access to patient medical history, drug information, test results and home monitoring data, in one secure and centralised cloud-based system. Every patient profile is pre-loaded onto a KardioEHR iPad or tablet app prior to the appointment. Results are subsequently uploaded automatically via Bluetooth and synced to the cloud and to the desktop EHR.

During the consultation, providers at the practice facilitate shared decision-making with patients projecting the results, risk scores, and clinical data onto a TV screen for a better visualisation by the patient. The results are displayed in a user-friendly view, and a complete summary report is emailed to, or printed for, the patient.

According to the practitioners, patients have been particularly open to the use of smart medical devices for self-management and prevention. At Activecare, patients are encouraged to use health and fitness apps as a complement to usual care, as a strategy to enhance their empowerment and self-management.

From a service delivery perspective, the use of this integrated healthcare data system means that the clinical team have access to a unified source of healthcare data. For example, when assessing a person with diabetes, the dietician can then use the EHR results which are made available from the full body scan and point of care results. The podiatrist can perform an online diabetic foot assessment which is uploaded into the EHR. Patients can also use home monitoring devices (e.g., blood pressure or blood glucose monitoring devices) and sync these results into the EHR as well.

Rwanda may act as a regional model for others in developing a system based on the use of patient identifiers. However, the majority of SSA health systems are not doing this systematically yet.

Digital monitoring systems can also improve effectiveness by supporting the monitoring of supplies and stocking, including drugs, with positive benefits for patients and systems, including a better management of stock outages, and ultimately leading to better health management and outcomes.

> "[Digital monitoring systems] give more evidence, more realistic data as much as possible. So (...) it helps you to plan better. We have more realistic data for planning."
> (NGO professional, East Africa)

It was also suggested that in the future, digital technology could be harnessed to further digitise and improve the drug supply chain to increase transparency and tackle challenges such as counterfeit drugs and fraud at various points of the chain.

> "Counterfeit medicines [...] will not be able to be in the market anymore because you can actually track and check, maybe with QR [quick response] codes, [which are] things that you couldn't do before."
> (Industry professional, East Africa)

iv. Safety

Digital health should be planned and implemented alongside strategies to ensure patient safety.[85,98] Those we interviewed were eager to highlight advancements in data and database systems particularly, including EHR, and data-driven healthcare technologies, that are potentially beneficial to the safe of care delivery.

> "With digital, we're able to deal with issues around data integrity. You see, when a [CHW] is entering this data on the paper-based system, they're more likely to enter outrageous values, like maybe a very huge temperature value, but within the app we're able to implement validation checks, such that if someone is entering a wrong value, the system will automatically flag (...) [and] will not let you continue. So basically, we are able to improve issues around data quality."
> (NGO professional, East Africa)

BACK TO CONTENTS

Leveraging leadership and governance, financing, and infrastructure to enable digital health in PHC

Summary of our research findings

- There is increasing support for digital health care across Sub-Saharan Africa, as evidenced by examples where governments have taken ownership roles in the development and roll-out of digital technologies. Such leadership and buy-in can enable great digital technology penetration across the continent and creates a case for regional collaboration and shared strategy across Africa
- Legislation and regulation developed through multi-stakeholder involvement, and provided with clear guidance, enables stakeholders across public, private and NGO sectors to develop and adopt digital health innovations more easily
- The utilisation of digital technologies both from the system/provider and patient perspectives has the potential to innovate longstanding health financing challenges, including service pricing and reimbursement models and reducing the severe financial hardship suffered by individuals seeking care
- Advancements in digital health have been enabled by increasing mobile and Internet access. As research and innovation infrastructure advances across SSA, there is a greater opportunity for digital health innovations to be developed and deployed to improve health care quality

Digital technologies can act as a vehicle to advance health services and systems development, particularly where leadership and governance, infrastructure, and health financing act as enablers **(Figure 5)**. At the same time, health services and systems development through digital technology, can promote continuous improvement in leadership, governance, and infrastructure, while also creating greater fiscal space for health care.

1. Leadership and governance

Building government ownership and buy-in

Participants noted the increasing support for digital health across the SSA region. Increasing support was observed from a range of stakeholders, but particularly from governments who are increasingly 'buying-in to' digital health solutions and having a greater sense of ownership. These developments have implications for - and underpin - the development of legislation and regulation. Experts felt that stakeholder buy-in should be further encouraged in the future, by clearly presenting the level of adoption and health systems benefits, particularly in what concerns quality and cost improvement. For example, patient buy-in and support for digital technologies may act as a driver for government buy-in.

> "The more users you can get (...), [it will] encourage governments to participate - because they are looking for a way to communicate directly to patients." (Industry professional, East Africa)

Government buy-in is also critical to improve interoperability, and ensure digital systems can "speak to each other", both at local and national levels. One expert urged caution on national government ownership side-lining regional ownership, whether at the district or facility level, as engagement and ownership at all levels of the system will be critical in driving quality improvement.

Additionally, increasing policy engagement at governmental level will increase ownership and buy-in among this stakeholder group to enable the advancement of digital technology use in PHC. A greater understanding of the digital health ecosystem, including systems, policies, and processes, is a lever to enable more targeted objective setting and to further advance digital health priorities at the highest levels. One expert was concerned that digital health processes and policy in SSA are currently often driven by external stakeholders, such as NGOs and other funders, and suggested it would be important to ensure decision-making power sits primarily within ministries.

Regional collaboration and a shared digital health strategy

The value of regional collaboration cannot be underestimated as a means of enabling the development of digital health in PHC. In this regard, the sector can learn from a range of critical sectors and global geographic regions.[105]

There are already examples of collaboration in Southern Africa where the Southern African Development Community (SADC) Strategic Development Plan (2020-2030) is focused on "developing modern and well-resourced health systems that are accessible and responsive in addressing the burden of disease and emergencies".[106] While SADC has been limited in its impact due to development challenges and reliance on international donors, Penfold and Fourie (2015) highlight that there is potential to further broaden their impact by engaging with civil society, focusing on championing HCW training and retention, and training health diplomats in the region.[105]

Notably, regional collaboration and shared digital health strategy is lacking in SSA. In this regard, the European Union offers an example of what is possible. In 2018, the European Commission adopted an eHealth strategy to advance digital transformation in health and care across EU member states.[107] A commitment to the sharing of health data, which was laid out in the strategy, led to the publication of draft regulation for a European Health Data Space (EHDS) in May 2022, aiming to strengthen the links between national healthcare systems through secure, efficient access to and exchange of health data.[108]

As the EU Parliament and Council continue to develop legal frameworks and legislation associated with eHealth and specifically health data, the process provides key lessons in technical and legal challenges which can be considered by other regions and regional bodies as they seek to develop similar initiatives.

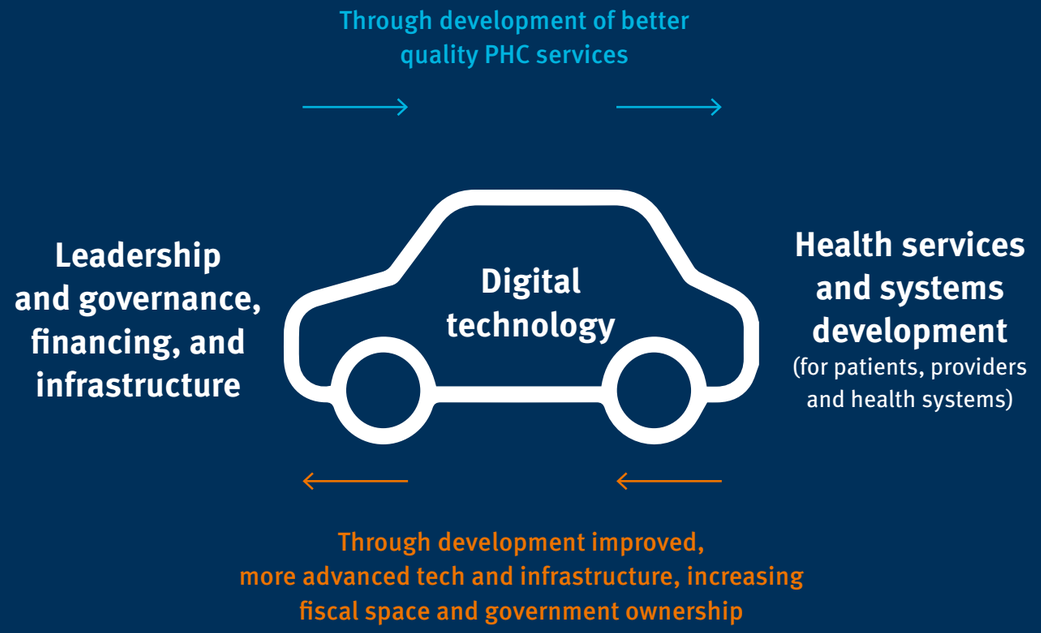


Figure 5: Digital technology as a vehicle for health services and systems development and advancement of leadership and governance, financing, and infrastructure

Wider stakeholder engagement

Beyond government engagement and buy-in, additional stakeholders are vital in influencing policy and processes - particularly as cross-sector involvement in health service delivery continues increasing. Two experts interviewed noted the value of also engaging young people to encourage the leaders of the future to develop skills relevant to digital health innovation.

New and updated legislation and regulation

Recent advances in the use of digital technologies in PHC has encouraged the development of legislation and regulation across areas related to digital technology and digital health, which has subsequently facilitated increased use. While many countries across SSA have some form of national policies or strategies on digital health, there has been some uncertainty on whether these extend to regulatory standards and guidance. Without clarity and implementable information which addresses key challenges affecting the use of digital technologies in health care, stakeholders may remain reluctant to embrace digital health.[109]

The recent advances highlighted by participants in the research can be separated into two aspects: **legislation, defined as a law or set of laws and regulation, defined as the implementation of the legislation.**[110]

Regulatory standards underpin and provide a framework and guidance, with clearly defined roles, for appropriate governance across different areas of digital health.[109]

i. Digital health legislation

While digital health legislation has existed across the SSA region for some time, there has been a recent renewed interest, in part encouraged by greater interest, investment, and development in the health sector. One interviewee used the eHealth Bill in Kenya, as an example of the development of a law designed to regulate digital health. In this regard, it is advisable to consult with as many stakeholders as possible and involve them in the law-making process as much as possible. An expert noted an example in which a working group developing a data protection law consulted with industry and government and sought best-practice guidance from other countries to ensure the legislation responded to the needs of stakeholders across the healthcare ecosystem.

The importance of developing legislation in line with future innovation and practice was also stressed by the experts interviewed.

> "'We also developed ways to legislate emerging technologies. So, we have proposed a (...) committee whose job is to look at emerging technologies and advise whether the technology can move to a sandbox,which we are also creating a provision for."
> (Industry professional, East Africa)

One expert highlighted the benefit of clear legislation aiding a more in-depth understanding of complex issues related to digital technology use in the health sector, such as the monetisation of health data for patient benefit, which remains a complex challenge both in SSA and globally.

ii. Regulation and regulatory frameworks

As with legislation, the increasing use of digital technologies in health care and through the COVID-19 pandemic has led to the development of regulations on various aspects of digital health across SSA. Rwanda was cited by the experts interviewed as a particularly positive example of a strong regulatory framework which was developed over the years and has been responsive to the digital health landscape in the country.

Telemedicine regulations were also described as a particular aspect of digital health regulation that has been improved through the COVID-19 pandemic, providing a regulatory framework and clearer guidance to providers across several countries in SSA. This regulatory push in part enabled the expansion of providers applying for, and receiving, licences to provide telemedicine. As health systems continue to develop and expand their telemedicine services, the importance of regularly updated regulations and guidance will enable providers to continue to follow best practice in the use of telemedicine, while maintaining quality and safety, and increasing confidence in protecting themselves from liability.

Participants in the research also considered data privacy as an area relevant to digital health where regulations have been updated and improved in recent years, enabling providers to be clearer and more confident in their obligations when it comes to patient data, data protection, and data privacy. It was noted that there is a growing awareness among patients on data protection, which has informed the development of regulations and policy in this area, and this effect is likely to further increase in the future.

2. Financing

Reducing the health financing gap using digital technology

The WHO explains that successful health systems financing must raise sufficient funds for the health system and provide financial risk protection to the population.[25] As part of the process of scaling up digital technology use in the PHC, participants in the research outlined the value of digital health innovation in reducing health system costs. Interviewees saw these cost savings as achieved through processes of streamlining and automation, as well as the scaling of technologies that are now being used in a piecemeal fashion.

> "[Manual processes] cost a lot of time and a lot of money. So, by automating you will cut away a lot of cost and waste (...) You'll save a lot of money - also by utilising health data as a resource."
> (Industry professional, East Africa)

Additionally, the utilisation of digital technologies from the patient perspective was also seen by experts as a potential means to reduce the severe financial hardship suffered by individuals seeking care, as some costs - particularly indirect costs - would be reduced. The use of telemedicine was most often cited as enabling this by reducing the requirement for patients to pay for transport to the healthcare facility, enabling them to take less time off work, and reducing potential childcare costs. While this positive impact was noted, patients would also perhaps be required to pay higher costs for internet access or call minutes to facilitate the teleconsultation. Overall, it was considered beneficial that the patient had the opportunity to decide between telemedicine and in-person care, based on what was most suitable for their individual circumstances.

Addressing the short-term nature of many digital innovation projects

It was noted by the experts interviewed that the testing of new financing models, which is currently happening across SSA, offers the opportunity to learn from what has worked and what has not. Within this, the value of engaging with local actors and bringing a range of actors together cannot be underestimated.

At present, the development and testing of digital health innovations are often funded by short-term projects set up by NGOs which struggle to sustain momentum and financial security once the project cycle is completed.

> "[We need] to skill-up these things as much as possible so that we can move it to other areas in the region. We are limited now because of resources to some areas. We feel we should skill it up to other areas as much as possible." (NGO professional, East Africa)

Experts emphasised that this challenge is only now starting to be considered among relevant stakeholders. Initial steps to address this include holding multi-stakeholder dialogues, building local capacity through training, planning resource management strategies, including people working on the project throughout its lifecycle, and further exploring local funding mechanisms to sustain pilot projects which show potential in improving health service delivery and/or patient outcomes.

3. Infrastructure

Recent advances in infrastructure across SSA have enabled and encouraged the development and use of digital technologies in health care. One individual we interviewed noted that continued digital health innovation in SSA can be fast-tracked as infrastructure, including telecommunication and research and innovation infrastructure, develops. This can provide an opportunity to leapfrog and develop health innovations in an agile way.

Digital health facilitated by increasing mobile phone and internet penetration

As presented in the context section, mobile phone ownership and use is increasing across SSA as African telecommunications companies compete to increase their customer base.[111,112] Participants confirmed that increasing mobile phone penetration is also now taking place within some previously difficult to reach population groups. As also noted, while mobile phone ownership is increasing, there is variable penetration of smartphones - and therefore smartphone-enabled health apps - across population groups, with implications for the accessibility of digital technologies developed for PHC in the future.

Until now, interviewees highlighted that technology innovators have focused on these trends in mobile phone penetration to ensure digital technologies for health care are developed in a way that most mobile phone users can use them, particularly utilising USSD functionality.

> "Only 15% of the population have smart phones, although there's 80% of the population with phones. So, one of the things that we have done is to adapt the service that we do to be suitable for the kind of phones that people have in their hands [...] we use USSD." (Healthcare organisational leadership, East Africa)

Increasing numbers of people across SSA have access to the internet, which has enabled the development of digital health innovations and the uptake of digital technologies for healthcare delivery. While SSA has made large strides to address the data poverty gap, in the majority of national contexts, data poverty remains a challenge, with incomplete datasets to analyse the data poverty gap in 35 African countries.[102]

Another important aspect highlighted by the participants was that internet access is not high for all population groups and may not be consistent for many. Digital health innovators have also developed technologies that can adapt to different settings with varying levels of internet availability and use.

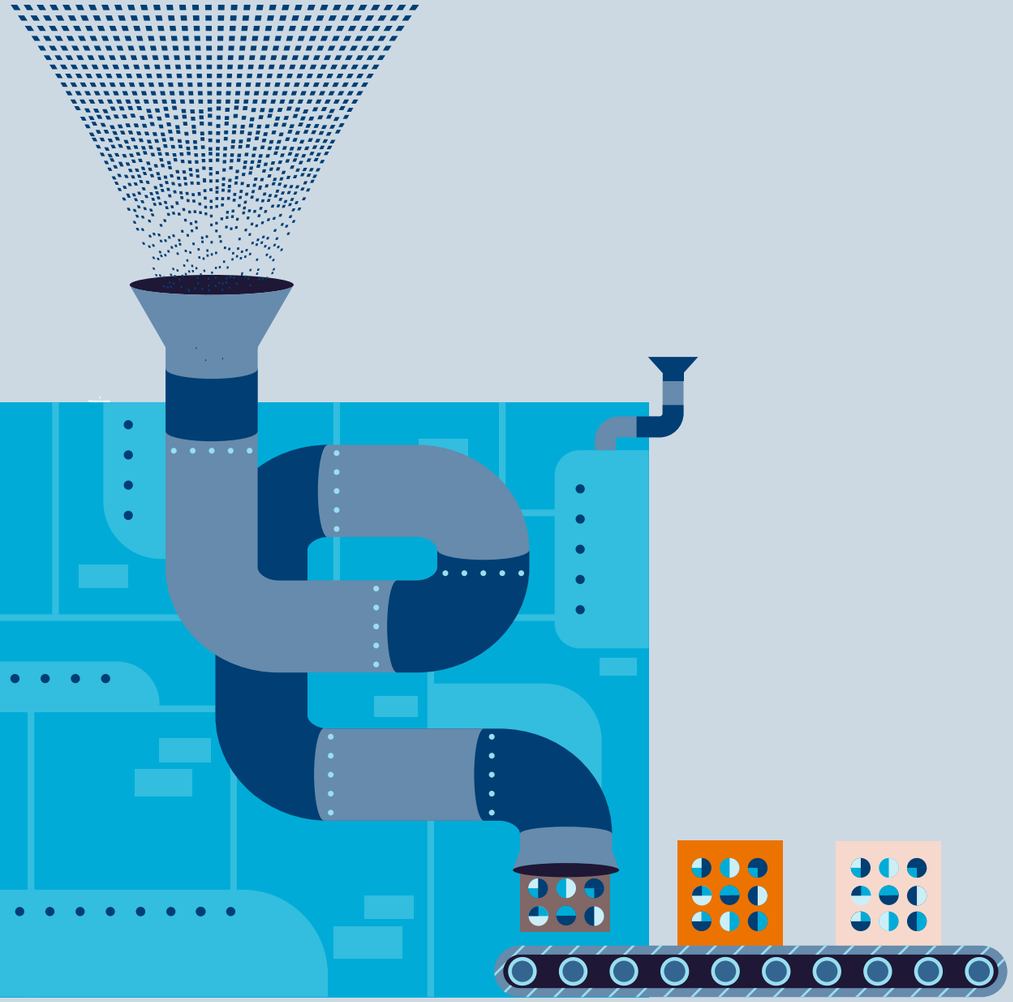
> "The beauty of the application is it works offline fast. Given the settings we are in right now, there is an issue with internet connectivity; the internet is unreliable [...] we have so many hours where there is no connectivity at all. So, during that time, they [CHWs] are actually able to work offline, and when they get to a place of connectivity, then the application automatically syncs the data to the service." (NGO professional, East Africa)

One participant highlighted that the value of internet connectivity for providing essential health services has in part encouraged the national government to invest in fibre broadband across the country. If digital technology use in PHC is to be scaled up to offer greater equity and access across the continent, the development of critical services must continue alongside. Several barriers have led to limited progress to date, including a funding gap estimated at more than US $100,000, and challenges in providing access to underserved populations and geographical areas.[113]

Research and innovation infrastructure in the context of PHC

There have undoubtedly been incredible advancements in the development of digital technologies in SSA, with only a fraction of the health-specific technologies noted in this report. The perception among those interviewed is that innovation to date is only the beginning of what can - and will - be achieved across the continent in the coming years, though several noted the importance of pursuing context-tailored technological innovation.

The justifications for context-driven innovation to inform digital health use in the health sector were two-fold. From a pragmatic perspective, different healthcare facilities within and across SSA countries have specific needs, budgets, patient preferences, and other factors that will influence which innovations they require - and how they need them to work. From a patient safety perspective, innovations and digital technologies designed for use in PHC must consider the user population and ensure they are developed to improve health services and outcomes for whole populations rather than developed with an specific user group in mind and helicoptered in with no safety testing. There are several cautionary tales where AI technologies have been applied to population groups in which they were not tested, and subsequently led to poorer outcomes.[115]



Case Study 4: An electronic donor management and reporting system for monitoring, evaluation, and reporting

In SSA, healthcare organisations are often required to report on various metrics related to service delivery and population health to NGO funders. Where funding is provided from multiple NGOs, this reporting burden is increased. While essential for continued investment, the time commitment for reporting can often be a challenge for healthcare providers.

In 2020, the Witkoppen Clinic in Fourways, South Africa made the decision to transition the organisation's monitoring and evaluation (M&E) data collection to the platform REDCap, which had been used for research previously. The transition aimed to improve efficiencies around M&E, feeding into donor reporting. REDCap is a secure web application for building and managing online surveys and databases.[114] It is a popular tool for research and other data-gathering work among the NGO community globally, as it's almost entirely customisable, free-of-charge for non-profit entities, and has a community-of-practice that enables information sharing and exchange of advice between users.

The system is now being used at Witkoppen, though the full transition is still ongoing. REDCap is the primary system of data collection, and those who work there longer term receive training on this system. A backup system is in place for sessional/locum clinicians who work at the clinic short-term who can fill in a paper register which is later manually inputted into the system.

The switch to REDCap has brought a range of benefits to Witkoppen Clinic. From a data quality perspective, the use of REDCap system provides data entry validation alerts and makes it easier to amend data collection parameters by adding, editing, or removing data fields almost immediately. The system also makes the process of data consolidation easier, faster and less error-prone, by consolidating all data in a single export from REDCap, as opposed to consolidating data from separate Excel sheets from various data capturers.

From an operational perspective, the use of REDCap facilitates greater efficiency, resulting in a faster turnaround time to generate available data. From the financial perspective, a reduction in printing costs could be achieved as no more paper registers were required.

For other organisations considering digitising their M&E, the team at Witkoppen emphasised the importance of understanding change management processes and allowing organisational leadership time to engage in these processes. The team also highlighted the need to ensure time to pilot the system, build user buy-in and understanding, finalise the account creation process, make upstream and downstream adjustments to processes, and create backup systems in case of system failure, power outage or computer malfunction.

Knowledge and practice gaps and key challenges

Summary of our research findings

- Ensuring patient buy-in and widespread support for digital health is a challenge, particularly in regard to disparities in patients' socioeconomic status and literacy rates across sub-Saharan Africa. These have implications for equal access to digital health, as lower socio-economic groups and/or less literate may struggle with its acceptance, in part as they prioritise the necessities above the consumption of technology
- Clinical buy-in at the provider level remains variable, particularly where training on digital systems is not prioritised and where literacy rates among HCWs are low. These challenges can sometimes lead to digital technology applications having unintended consequences on the service or wider system
- Partial and fragmented digitisation and poorly integrated systems are key challenges at the health system level as they lead to inefficiencies and frustration. These challenges are confounded by limited best practice implementation examples to draw from and a lack of resources available to support service transformation
- Even with strong governmental buy-in and effective leadership, developing clear legislation and regulation in a fast-moving field such as digital health can be challenging
- Many institutions work with what is available, which are often out of date technologies and legacy systems, leading to challenges in efficiency and quality of care, compounded by data security challenges that have been noted in the context of partial digitisation where paper records are collected, stored and later input into EHR systems
- High implementation and operational costs, coupled with unsustainable project funding and short-term donor investment, create financing challenges that undermine digital transformation at the provider and health system levels

1. Patient-Related Factors

Difficulties in patient buy-in, embracing change and novel technology

Whilst Europe and North America implemented electronic health records more than two decades ago, many countries in SSA are yet to employ fully operational technologies in healthcare delivery. It was noted by participants that the general population has been used to the traditional paper-based method of health service delivery.

Through the traditional paper process, patients can tangibly 'feel' and 'see' a process from beginning to end. In person, patients can see what is written and can draw attention to any errors or seek clarification when needed. Patients often consider this a more transparent process which they are accustomed to. The changing modality of the process poses a challenge for patients to embrace the paperless electronic health records system in which information is transmitted virtually. Experts interviewed noted that some patients tend to be suspicious of the process and question whether their data is accurately noted.

> "The challenge is, obviously, getting the buy-in from the consumers because it's very ingrained in the mind of everyone that the good thing is to see a doctor, physically engaging and eye-to-eye." (NGO professional, SSA-wide)

Interviewees noted that it is important to engage patients in the development and implementation of digital technologies in health care, particularly given increasing concerns on data security and where and how personal medical data is being stored and used.

Disparities and implications for access to digital technologies

Both across different SSA countries, and across different regions in the same country, there are wide disparities in levels of education, levels of development, availability of social amenities, degrees of exposure to technology, and access to digitalisation.[116,117] While it is easier for the higher echelons to support technological advancement, patients in lower socio-economic groups and/or less literate may struggle with its acceptance, in part as they prioritise the necessities above the consumption of technology, further widening the technological gap. In SSA, more literate populations are often concentrated in the urban areas, which in part explains why the use of digital health technology is more common in urban communities than rural settings.

> "That's where the issue of literacy comes in. The [literacy rate of] population here is about 50%. So, it's quite challenging. The educated ones, the literate ones embrace it, but for those who are not so literate, that is another challenge." (NGO professional, East Africa)

Experts interviewed expressed a cautious optimism on the ability for digital technologies to develop more equitable health services and wider systems. Digital technologies utilising speech-to-text functionality

An example patient's journal with traditional paper-based service delivery

Patients are more familiar with the process of reporting to the records unit of a hospital and being registered by a data officer who enters some demographic data into a notebook. As part of this process, a booklet, often referred to as 'folder' or 'Out-Patient Department (OPD) card', is handed to the provider as required. The provider collects the relevant medical information from the patient, does a physical examination and writes the findings in the folder. If some diagnostic tests need to be conducted, the doctor will fill out a request form and give it to the patient to present to the laboratory or imaging unit. When the results are ready, the patient is given a paper-based report to present to the doctor. The doctor makes a diagnosis, prescribes medications in the folder/OPD card, or writes the medications on a prescription form, and hands it to the patient to present to the pharmacy.

and video tutorials, for example, empower patients to engage with their health care. While some aspects of digital technologies, like the facilitation of remote care, enable previously underserved populations to access services, the challenge of literacy levels on accessibility of some digital technologies and their costs pose significant risks for exclusion of certain populations.

2. Provider-Related Factors

Lack of clinical buy-in

In most organisations, providers undergoing training are hardly exposed to digital technology during their patient encounters; therefore, they naturally develop more proficiency in the use of paper-based approaches. Additionally, the interviewed experts noted that due to the lack of electronic health records systems at most health facilities in SSA, health providers are not conversant with their use. Hence, institutions that attempt to introduce digital technology often receive complaints of delayed consultation processes and prolonged waiting time for patients. One clinically facing interviewee noted the impact of the learning curve; it takes time for providers to improve the speed of typing and become proficient at navigating their way through new software.

Context-specific, user-friendly guidelines, devoid of technical jargon and in languages that the local community can comprehend, would be hugely beneficial to improve clinical buy-in.

> "I've had to use a lot of digital technologies that are not context specific. It's not been built for the context I practice in, so I found myself struggling to adapt its use." (HCW, West Africa)

Experts also noted that health providers sometimes oppose the introduction of digital technology or do not document required information into an electronic data base, which invariably affects the quality and completeness of patient data. Furthermore, a resistance to change, particularly as some HCWs feel that digital health solutions take their important work away from them, was a key challenge noted by some interviewees.

Lack of digital literacy and training among HCWs

Several experts noted that a major gap in embracing digital health technology in Africa is the fact that healthcare facilities are manned by a cadre of staff who lack digital health literacy skills.[14,118] This is a challenge across primary, secondary, and tertiary levels. In some cases, staff may not have any level of formal education which challenges the ability to provide effective training.

> "You need to convince clinicians that maybe never saw a laptop or a tablet before, that maybe don't even have a proper internet connection, that it is actually possible to do all these things." (Industry professional, East Africa)

In community care, coupled with low level of education among CHWs, imparting digital systems literacy is a particular challenge. Convincing this cadre of HCWs that digital technology can be better or more efficient than the paper-based system often contradicts strongly held beliefs and can create negative feelings towards digitalisation.

It has been observed that for most health institutions, prior to the implementation of any digital health technology, there must be several training sessions to HCWs. Experts noted that there is rarely adequate training provided to staff when a new system or technology is implemented. Additionally, retraining of the staff during the implementation phase is scarce, which is further challenged by high attrition rates, new staff employment, or those resuming duties after long periods of leave.

Training sessions are not only essential to ensuring the safe use of digital technologies, but they also provide a platform for technology developers to get feedback on functionality, feasibility, and useability. Failing to provide training or providing inadequate training is a missed opportunity for HCWs to play an active role in developing the digital technologies designed for them.

> "So how much of training is going on, both for patients and doctors and nurses and health workers? You've had a number of people who have had their entire training on paper-based systems.

When they become specialists, you don't just expect them to know how to use digital systems overnight."
(HCW, West Africa)

The unintended consequences of digital technology use in practice

Experts noted several unintended consequences of digital technology use. One major concern raised by interviewees was the need for HCWs to pay for internet access personally to use digital technologies. Several noted that, in some health institutions, software or apps that are introduced require the use of personal mobile phones or tablets and internet data that the institutions do not pay for. HCWs are often paying out-of-pocket for access to the internet. Given the low salary levels among many HCWs in SSA, this is a disincentive for the use of such technologies.

Another consequence noted in the SSA context, but relevant to decision support tools globally, was the risk of technology incorrectly influencing clinical practice. Some digital health technologies that have in-built predictive diagnostic features; this makes it easier for clinicians to choose from a range of diagnoses, based on the data input by the clinician. Some of these features can incorrectly influence clinical decisions and practice. Some of the models of digital health technology are also quite restrictive and do not allow flexibility when entering clinical information. Beyond this, one expert also highlighted confusion that arose when validation options in a reporting system were felt to be telling HCWs how to be treating patients.

Given these challenges, it is important that those designing and implementing digital technologies in health care can access digital innovation standards which regulate how the technology can be used, as well as standards for evaluation of digital health solutions to timely identify and mitigate potential challenges to quality and safety of care.

3. Health Systems-Related Factors

Partial and fragmented digitisation

While it is pragmatic to implement digital health systems gradually, experts highlighted the challenges of partial and/or fragmented digitalisation. 'Phased approaches' to digitisation often do not progress in a timely and efficient manner, with the potential of creating frustrations and delayed acceptance among staff members.

"[Digitisation] has to be for the whole hospital to work properly. So, if the lab is not doing it and the pharmaceutical unit is not doing it then I can't see labs. I'll still have to rely on the paper-based records that the labs bring."
(HCW, West Africa)

Partial and fragmented digitalisation has implications for interoperability and potentially leads to greater inefficiencies. A national digital transformation plan might help to frame a clear pathway to transformation and reduce inefficiencies associated with fragmented digitisation.

Poor integration of ICT Systems

Amid the limited strides made in digital health technology implementation in SSA, experts explained the implications of the lack of integration of the electronic technologies at national, regional and facility levels. Innovations in EHR, for example, are usually either health organisation-specific (e.g., Ministry of Health), program-specific (e.g., Malaria Control Programme, Tuberculosis Programme) or Health facility-specific. Even within the same facility, one may find service-specific EHR systems across different departments (e.g., out-patient, in-patient, laboratory, or pharmacy). This lack of integration portends serious challenges for data aggregation, data integrity and can be frustrating for HCWs, policy makers, researchers, and patients.

"We were confronted with the practice of being vertical and not considering integrated care (...). All the infrastructure deficits around trying to negotiate that [digital integration] (...), capacity shortfalls around driving it at facility level, and how to square it with existing business processes, particularly around patient management."
(Other health professional, Southern Africa)

Due to the lack of integration, medical records and other data of patients cannot be retrieved from any other facility other than the primary source. Additionally, in facilities where isolated digital systems have been implemented, there is a lack of digital communication among the different service points.

"In primary health care, I have this EMR, and (...) a telemedicine solution. They do not talk to each other unless there's a one-to-one integration, which is very expensive. So, a big challenge is [having] quite a large number of specialised systems, which do not necessarily talk to each other."
(Industry professional, East Africa)

The potential of poor integration and interoperability to create greater system inefficiencies and poor data quality makes the case for systems to tackle these threats by addressing noninteroperable legacy systems used, while also ensuring new technologies are adopted with interoperability as a key criterion.

Lack of resources

Generally, SSA is a resource-limited region and provision of digital health technology is among the least prioritised resource within the health system.[119] This is often perceived as a luxury, hence essential drugs, salaries of staff, basic medical equipment and provision of physical infrastructure are given more attention and resource-allocation. Aside from the infrastructural resources, experts highlighted a lack of well-trained human resource to develop locally made innovative technologies at the system level and provide technical support for imported digital technologies implemented at the facility level.

As HCWs are in short supply, and with a lack of training and digital literacy, there is often the need to engage administrative staff to be responsible for entering data into systems. Data entry on digital infrastructure is often not a priority as compared to other core responsibilities. Additionally, administrative staff are in short supply and severely burdened, particularly in primary health care, often resulting in a missed opportunity for digital technologies to be implemented in this context.

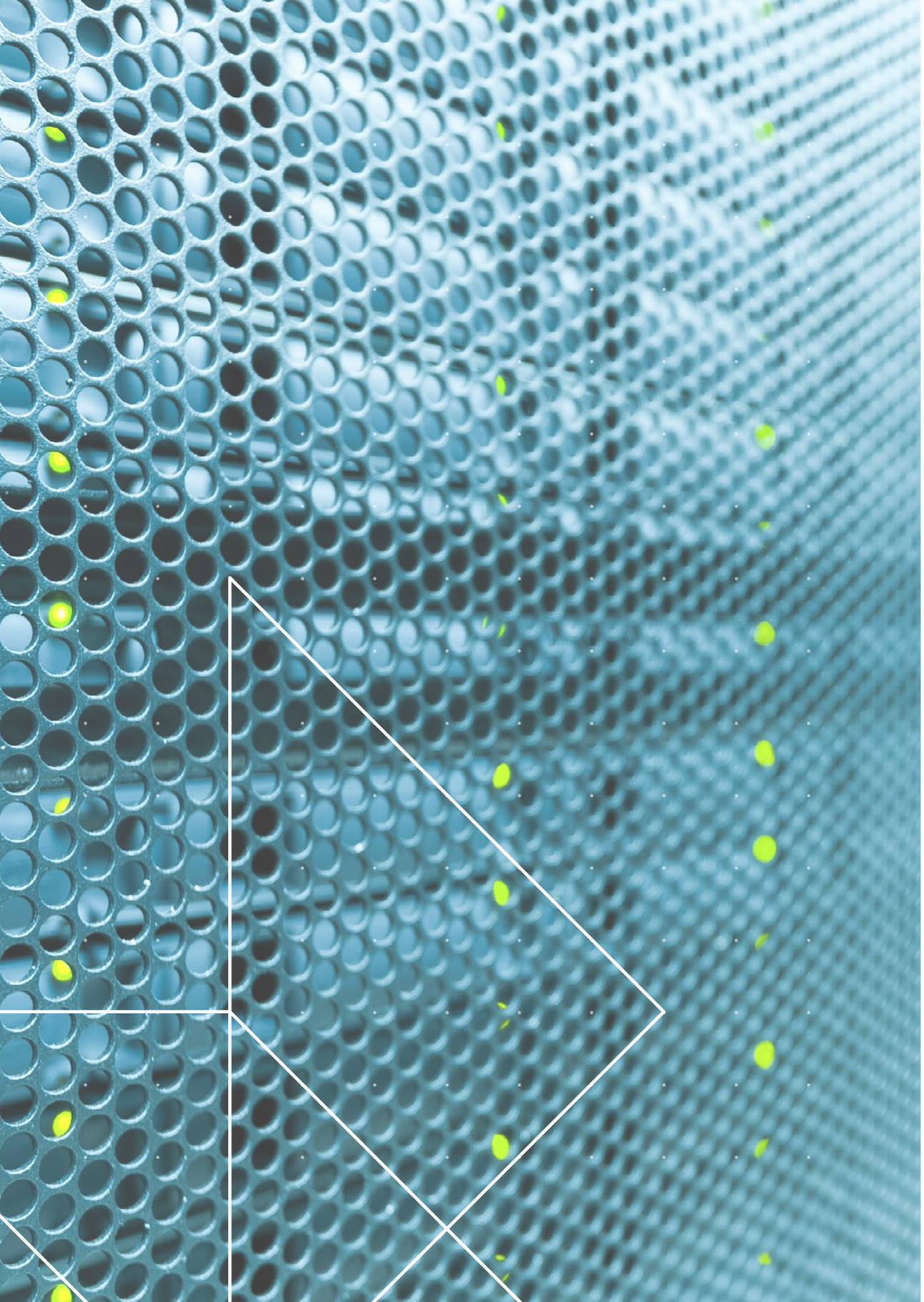
One expert noted, that due to a lack of human resources, support for digital technologies is sometimes outsourced to third parties with a reduced oversight of the systems and processes of the health facility, and a lack of health facility ownership with implications for a safe and appropriate use of technology.

"So, third parties were positioned in facilities to provide clinical support and data management support (...), but on the information digital health, information system side, that entire function was entirely led by third parties in our health facilities. So clinical managers and facility managers had a very removed [role]...."
(Other health professional, Southern Africa)

Implementation challenges

As the use of digital health is relatively new in SSA, its implementation poses great challenges since there are limited best practice examples to draw from and, as noted, a lack of resources available to support this service transformation. Considering the initiation and implementation of digital data systems, for example, basic challenges such as identifying a site for hosting servers, or finding space for servers and storage of data, can limit progress.

"Sometimes the implementation is the trickiest part, because (...) how do you know where the server is? Where do [you] want the server to be? And, if all



> the data goes onto that specific server, can it be processed in the Cloud? Are you allowed to share it to a Cloud?" (NGO professional, SSA-wide)

Beyond these challenges, experts noted that the complex nature of systems both at system and provider level, create operational challenges in implementation. These complexities often act as a barrier for leadership to fully understand the potential of digital technologies. Engagement across stakeholder groups is fundamental in creating a common understanding of digital technologies and how they can be implemented in health care.

Fraud and abuse of the health system

Though fraud reduction was highlighted as benefit of digital technology use in health care, experts also raised concerns about how the expansion of digital health systems may lead to high-level corruption practices. They further identified lower-level practices such as patient impersonation, unbridled access to patients' records once their ID is made available, as well as utilisation of user IDs and passwords of staff to access private patient data as areas of concern. One interviewee explained that fraud is particularly feared, as e-prescription services expand in SSA. There is also the concern that some patients can take undue advantage of the e-prescription system to abuse medications.

> "There's a big fear around fraud. There's a concern that patients will take one prescription and go to eight different clinics, eight different pharmacies and 20 packets of antibiotics, and maybe sell it on. There's a lot of concern about misuse." (HCW and industry professional, East Africa)

Notably, experts did not consider potential issues of fraud insurmountable and highlighted that most of the concern around potential fraud is based on fraudulent practices already happening in traditional systems (e.g., prescribing). Developing digital technology with built-in security checks to limit these abuses may reduce fraud in the system rather than increase it.

4. Leadership/Governance Factors

Legislation and regulation

In many jurisdictions, implementation of digital health technologies and systems require legislation and institution of appropriate regulation.[120] These processes can be sub-optimally slow, and complicated by competing priorities and political interests. The process can be further stalled, if not completely halted, when there is a change in leadership or a lack of appreciation of the value of digitisation.[119]

Experts noted that the development of relevant legislation and regulation depends on whether digitalisation is part of the vision of the leadership at the regional, national, or institutional level. However, even with strong governmental buy-in, developing clear regulation in a fast-moving field such as digital health can be challenging.

> "As we speak, Kenya, for example, has multiple e-health strategies, digital health strategies, and mHealth strategies, and mHealth policy – all of these things that set this beautiful vision of what digital health can be – and yet absolutely no regulation to say what is allowed, what is not."
> (HCW and industry professional, East Africa)

Experts highlighted the particular challenges of developing regulation on data privacy, data protection and procurement processes for digital infrastructure. They also noted a mismatch on standards and regulations where multiple stakeholders are involved, which can create additional misinterpretations and inefficiencies.

Beyond these challenges, experts also noted that regulations in SSA are often too slow to change and often regulators cannot keep pace with industry and other innovators.

5. Technology and Infrastructure Related Factors

Limited access to internet

While steadily improving, internet penetration in most countries in Africa is low. For the SSA countries where internet is available, challenges such as unreliability, network instability, slow speed and high cost prevail.[121] Challenges in the provision of a stable electricity power source are another fundamental facilitator of reliable internet access. Several of the experts interviewed noted that the countries where they are working grapple with unstable electricity, which creates severe limitations. While strong bandwidth can enable video calls for teaching and teleconsultation, poorer bandwidth may only enable telephone calls or complete inability to use certain digital technologies.

As noted, several experts explained that HCWs sometimes pay for internet access to use digital technologies clinically. There are obvious concerns and implications of HCWs paying out-of-pocket for access to the internet, specifically in terms of appropriateness, inequities, and data protection/cybersecurity. The inadequacy of mobile phones and internet data plans to enable the use of advanced technologies such as EHR was highlighted as another issue by one participant.

A reliance on individual HCWs to provide internet access for facilities creates challenges, including the limitations of personal internet access on mobile devices in enabling EHR and other systems and applications that run centrally at the provider, local, regional, or national levels. This reliance has further implications for equity across the system, as internet access is tied to the financial stability of individuals who should not be responsible for technology and infrastructure within their organisation.

Suboptimal access to ICT hardware

In SSA, most of the hardware currently used to set up digital health systems is imported from more developed countries.[121] As such, they are a scarce resource, in part due to high import costs and foreign exchange rates. Interviewees noted that institutions work with what is available, which are often legacy systems, which lead to challenges in efficiency and quality of care.

Another key challenge highlighted was that where ICT hardware is being used, issues with electricity outlets make consistent usability of technology challenging, both for static and mobile technology devices.

Fragmentation and poor-quality data

Due to a lack of integration of the digital health systems, data is confined to a geographical space as well as a defined population. Experts interviewed noted that the data is very much fragmented, with a large value-chain, and often duplicated which negatively impacts data quality, reliability, accessibility, and utilisation.

It was noted that industry and others are creating different EHR systems, for example, as the existing systems in SSA are in general, not efficient nor affordable. Most countries do not have a standard integrated EHR system that providers are encouraged to use. The implication of fragmentation and disintegration is poor-data quality, leading to unrepresentative or incomplete datasets, which was summed up by one expert:

One expert also highlighted that at the national level, data linkage has limited value if it does not also connect with clinical records at the facility level. The challenge of fragmentation and disintegration sits at the highest level of the system and requires, through stakeholder engagement across the ecosystem, greater mandates to address these challenges and their implications for data quality.

Data protection and security

One of the factors inimical to the successful implementation of health system digitisation is cybersecurity. Globally, cyber-attacks on healthcare organisations are increasing exponentially. In SSA, Life Healthcare in southern Africa was the victim of a cyber-attack in 2020, which impacted patient hospital admissions and business processing systems and resulted in administrative delays to patient services.[122] Experts interviewed expressed their concerns over security and cyber-attacks as the use of digital technology is scaled in SSA.

> "I've seen cyber-attacks where people can hack everything. So how do you really protect things, particularly in a country where there are not strong regulations - and how far should we go before we have strong regulations to protect both patients, but also the system as a whole?"
> (NGO professional, SSA-wide)

Within the field of cybersecurity, interviewees noted a particularly acute deficiency in the robustness of data protection systems in Africa.[123] This makes any digital technology vulnerable to invasion, theft, fraud, and manipulation. A lack of data protection has the potential to cause a loss of patient trust should personal patient health data be compromised.

Experts highlighted that data protection becomes even more precarious in circumstances where PHC facilities do not have enough computers, third parties are responsible for security systems and processes without complementary accountability within organisations, and health workers use their personal devices like computers and tablets to access electronic medical records.

> "In the clinic I worked in I didn't have an electronic health system; it was just paper-based. That meant that there were no computers specific for General Practice consultations, so everybody brought their own personal computers. Of course, you cannot host patient data on your own personal computer and if you did that, then there were ethical concerns that you had to make sure were addressed."
> (HCW, West Africa)

It was noted that international and national bodies are working through cybersecurity and data protection challenges, and that countries will need to customise guidance and proposed regulations for their contexts. In some country-contexts, the legacy of poor data security in the past, which led to data being scraped for commercial marketing purposes and individuals getting unsolicited messages, has had a lasting impression on public perceptions and trust when it comes to data security.

6. Financing

High implementation and operational costs

Among experts interviewed, there was a general perception that digitisation of health is expensive and requires substantial funding, making it challenging to advance at both system and provider level. Key areas perceived as expensive included hardware costs, as well as costs associated with implementation and ongoing operational costs. One participant highlighted that EMR systems in particular represent high cost for systems and organisations.

Coupled with a huge health financing deficit across SSA, which makes it more difficult for funds to be allocated for digital technologies, experts also noted that a financing gap has emerged for the development and implementation of digital health technologies.

> "The financing is not there. Countries are spending whatever they can, but they don't have enough revenue to devote to health."
> (NGO professional, SSA-wide)

Lack of sustainable project funding and long-term investment

The breakdown of spending on health care across SSA varies from country to country. In all cases, and regardless of the funding source, the need to expand the fiscal space is ever increasing. Stakeholders, including governments, are increasingly looking to economic evaluation to enable priority setting to tackle the financing gap.[124,125] Whether as part of government-funded universal health coverage-priority benefits packages or the donor programmes that make up on average 20% of spending on health in SSA, but up to 60% in some countries,[126] there is presently a limited wholesale investment in digital health as a modality of health service delivery.

One interviewee noted that in areas where digital health systems are initiated, a major challenge is the scarcity of funds to ensure maintenance and upgrade of systems and equipment as well as replacement of obsolete and legacy systems.

Finally, the experts interviewed highlighted that due to the reliance on external donor-funding for national, regional, and institutional programmes, projects can often be crippled when there is a cut in donor funds[121] or where donors fund only a pilot project rather than a long-term programme.

> "The other thing is around sustainability. Most of the time, we have funders coming in with our projects that have limited time, then once the funding ends, the project dies with the end of the funding period."
> (NGO professional, East Africa)

Next steps to embrace the potential of digital health

The following recommendations represent priority areas which emerged through the research rather than an exhaustive list of actions. We have categorised recommendations across stakeholder groups with the caveat that each of these recommendations will require shared knowledge, partnership, and meaningful collaboration across several groups. These recommendations should be underpinned by regional collaboration and the development of shared strategies for digital health across the SSA region.

Government leaders and policymakers

1. Ensure basic infrastructure is in place to support digital health innovation in PHC

What? Core challenges to developing digital health on a large scale in SSA exist at the critical infrastructure level, including stable electricity grids, internet access and mobile phones. Work to address these fundamental stumbling blocks is already ongoing in most countries, but sustained and accelerated progress must be prioritised.

Why? To enable the development of equitable digital health services for populations across the continent, all geographic areas and population groups must have ready access to electricity, internet, hardware (e.g., mobile phones, computers, tablets), and tools to develop both basic and digital literacy. Additionally, these are required to develop a truly digital ecosystem; where data is generated and stored securely at local, regional and population levels, where interoperable technologies seamlessly share information across the system, and where advanced data-driven technologies can be widely used to help deliver health care.

How? While development of critical infrastructure sits outside the remit of healthcare leaders and policymakers, they must take responsibility in advocating for investment in infrastructure with relevant government bodies, stressing the urgency of this as the foundation for the adoption of digital health in PHC. As part of this, these stakeholders must highlight the need for national regulations and policy that mandate the advancement of basic infrastructure to help ensure it is top of the agenda.

EXAMPLE:
Expanding mobile data access in Ghana

Ghana offers consumers several options for mobile data, enabling access for millions of people.[127] While challenges remain in connecting rural areas, Ghana has developed and grown its mobile internet market since 1992. Enablers of this growth include:

- National regulations and policy (e.g., Ghana Investment Fund for Electronic Communications continues to improve connectivity in rural areas)
- Competition within the market (e.g., there are nine telecommunications operators, four with appreciable market shares)
- Adoption of new technology (e.g., the first submarine fibre optic cables were installed in Ghana in 2012)

2. Establish minimum regulations, including standards for data protection, digital innovation, and evaluation

What? Government leaders should work to create an environment to foster digital health innovation. Precise details will vary between contexts, but must include government leadership to develop clear regulations, standards and guidelines related to health and healthcare data, digital technologies, and clinical practice. These regulations should be developed in consultation with other stakeholders, addressing the challenges of regulating within a fast-moving, innovation landscape, and ensuring regulations do not stifle future innovation.

Why? Standards, regulations, and guidelines are valuable on many levels. Firstly, ensuring the development of safe and appropriate digital health technologies and systems is essential to ensure patient safety. Secondly, innovators from across the public, private, and NGO sectors will be better informed to determine the feasibility of developing innovations and to enter markets with clear information about what is required.

How? As noted, precise actions to develop an enabling environment will vary, introducing regulations and standards across a continuum or maturity roadmap offers the benefit of developing at a sustainable pace. Focusing first on developing data protection regulations, legislation to advance interoperability, digital innovation standards, and standards for evaluation of technologies can enable government leaders to begin this process, without becoming overwhelmed by taking on too much. Existing guidance, such as WHO's The protection of personal data in health information systems – principles and processes for public health,[128] and learnings from efforts towards greater interoperability among G7 countries,[129] can offer a starting point to begin planning.

Decisions must also be made on the roles and responsibilities of government agencies and external stakeholders in enforcing regulations, limiting opportunities for fraud or abuse within the system, and ensuring clear communication about these to stakeholders across the health sector and beyond. Answering questions such as, "Where should my organisation store its data?", "How does my organisation get licensed?", will enable clearer pathways to innovation as innovators can clearly understand actions that must be taken to comply.

EXAMPLE:
Working towards interoperability by incorporating SNOMED CT into national eHealth strategy in Germany

SNOMED CT is a terminology which converts diverse medical information and specialist terms, into language-independent, unambiguous, and international numerical codes.[130] As part of efforts to incorporate SNOMED CT into the health sector in Germany the clinical terminology was introduced as a pilot. Following its completion, SNOMED CT has been incorporated into Germany's e-health strategy and free licences are now available for any organisation in Germany in accordance with the national Patient Data Protection Act.[131]

The use of SNOMED CT, underpinned by legislation and policy, has enabled the health sector in Germany to improve interoperability using this shared language and has optimised the secondary use of healthcare data. While the provision of SNOMED CT licences does not enable interoperability on its own, the national commitment to a shared language provides an important emphasis to drive standardisation for the exchange of data, intelligent data analysis, and the improvement of care and health outcomes.[130]

Health providers

1. Develop a digital health strategy for the sustainable use of technologies by HCWs over time

What? As the adoption of digital technologies in health care in the SSA context is sporadic across and within countries and health systems, leaders and providers should develop strategies to enable the long-term adoption of digital health within their systems.

Why? Without a clear plan to sustain long-term adoption of digital technologies across systems, there is the potential for dual systems of service to develop, where digital innovation is fostered in parts that are resource-rich, leaving behind the parts with resourcing challenges. Given the novel nature of digital technology use in clinical practice, it is also unsurprising that HCWs may have challenges and questions related to implementation. Addressing these early and developing buy-in will be critical to sustainability.

How? Ensuring digital technologies are appropriate and functioning in their intended PHC context (e.g., able to run offline in areas with limited or patchy internet connection) is a first step in ensuring long-term adoption. Offering staff training on the technology itself and its correct application enables HCW buy-in, as they can better understand the use of the technology and their role in contributing to its successful implementation. Providing technology configured to the native language(s) of HCWs will further enable this buy-in and improve the accuracy and appropriateness of its use. Finally, enabling users to see the impact of their work (e.g., data dashboards or other outcomes) in a feedback loop can act as a key motivator to continued use.

EXAMPLE:
Using data-driven technologies to incentivise the health workforce in Uganda and Kenya

In Uganda and Kenya, international non-profit organisation, Living Goods, supports government community health workers to deliver care in communities. To ensure their motivation and effective delivery of services, CHWs receive financial and non-financial incentives based on their work performance, which is measured through data-driven technologies. CHWs receive a mobile phone with an app with decision-support functionality, enabling them to provide supervisors with accurate data of their activities, which aids their professional development, as well as the delivery and improvement of services across the region.[132]

Non-governmental organisations

1. Seek meaningful, collaborative partnerships with local stakeholders to maximise programme impact

What? As governments are responsible for improving national health systems, a duty often enshrined in national constitutions, they are the gatekeepers of health service innovation. While health services are provided by the range of actors outlined in this report, including public and private providers, and NGOs and faith-based organisations, they must be aligned with national legislation, policies, and guidelines.

Why? Engaging local stakeholders in the development and implementation of digital technologies will enable NGOs to connect with country and regional insights into population health and services and local levers to develop digital health in this context. Meaningful engagement in work undertaken by NGOs increases local ownership in the work and can improve sustainability and reach to develop better, more responsive services.

How? Depending on the nature of the organisation and its existing and aspirational engagement in the health system, NGOs must develop short- and long-term partnership strategies which outline the business case for collaboration and with whom. NGOs must also be clear in what they can offer local stakeholders and ensure this is articulated across the organisation. In the case of INGOs, ensuring presence within the country and system in which the organisation seeks to work will often enable a more substantial partnership, provide greater credibility for the organisation and justify its involvement in healthcare-focused activities.

EXAMPLE: Development of mHero to connect health care workers during the Ebola outbreak in West Africa

mHero was created to support health sector communication during the Ebola outbreak in Liberia in 2014.[133] The Ministry of Health and Social Welfare in Liberia has since integrated the platform into its health information system to meet communication needs for a variety of health services.

The mobile phone-based communication system, interoperable with key systems such as RapidPro, iHRIS, and DHIS2, was developed in partnership between the Libyan Ministry of Health, IntraHealth International and UNICEF. The organisations developing mHero utilised the 9 Principles for Digital Development[134] as part of its development and deployment, including designing the innovation with the user. mHero provides infrastructure which is adaptable to the needs of the Ministry of Health and leverages information already being managed, as it was designed specifically for their needs and systems.[135] Since the initial mHero was developed, other countries in West Africa, including Sierra Leone and Senegal, have implemented the system to aid healthcare delivery in their contexts.

2. Explore long-term and sustainable funding models for digital-focused PHC programmes and innovations

What? As the use of digital technologies in the health sector increases across SSA, so too will digital-focused programmes within NGOs in this geographical area. However, digital health programmes and innovations face high implementation and operations costs that jeopardise their sustainability and their potential impact on the health systems.

Why? Where funding has been invested in digital-focused programmes and innovations it has often been short term in nature, which has led to activity reduction or full closure of the project or programme once the funding is withdrawn. To realise the potential of digital technologies in health care, the development of sustainable funding models that manage the donor transition out of the project is essential.

How? Beyond the traditional approaches to gaining programme funding from a range of sources and a balance of restricted and unrestricted funding,136 international NGOs must consider novel approaches to sustainable funding that look at the entire ecosystem **(see Figure 6)**.[137,138] While NGOs may focus on multi-source funding and donations, working with private organisations to develop blended finance opportunities, for example, offers alternative avenues in which to build programmes and innovations in PHC. Again, government stakeholder support and financing are integral to the sustainability of programmes, and as such, NGOs must open discussions early to maximise opportunities for shared learning and a roadmap for action.

EXAMPLE: Gates Foundation and the development of Babyl in Rwanda

In 2016, the Rwandan Ministry of Health partnered with the Gates Foundation and Babylon Health to launch the Babyl Rwanda app to provide phone or video-based remote consultations, resulting in over two million users and one million consultations.[139] The Gates Foundation was focused on the sustainability of the initiative from the outset, providing support to test it, but clear that if successful, the Rwandan government would support it long term.

Following the initiative's initial success, Babyl signed a 10-year deal with the Rwandan government in 2020 giving every person over the age of 12 access to digital health consultations, paid for through the government's Mutuelle de Santé community-based health insurance scheme, as Babyl was set up as a provider.

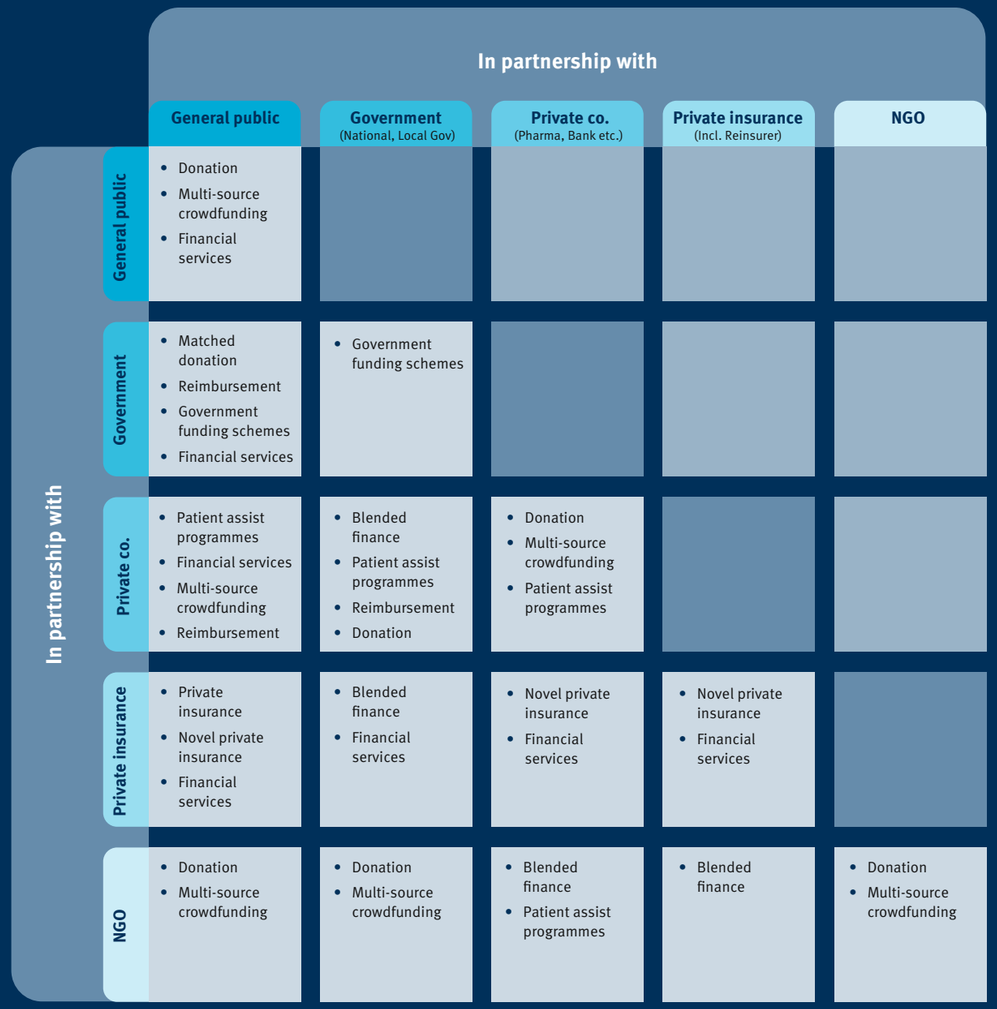


Figure 6: Assessing the global funding and financing landscape[137]
Republished with permission from IQVIA

Researchers and research funders

1. Increase funding for research into digitally-enabled primary care

What? Given the limited but increasing evidence on the value of digital technology in health and health care, research funding bodies should prioritise research into digitally-enabled primary care to provide the evidence basis to inform stakeholders' decisions.

Why? Research funding bodies should increase the funding available to researchers interested in exploring the safety and quality of digital technologies in health care. Considering digitally-enabled care as a modality of primary care delivery reframes prior discourse around "digital health" as a sub-specialty area of healthcare research. Developing a funding ecosystem for researchers to investigate the role of digital technologies in improving continuity of care across the health system and the importance of interoperability also enables multidisciplinary teams (e.g., data science, implementation science, and other disciplines) to address important areas of research that may otherwise struggle to find a foothold within the existing funding landscape.

How? Research funding bodies can develop grant challenges which focus on digitally-enabled care as a modality for primary care delivery to capture the breadth of potential priority research area on this topic. While this is currently in-part challenged by the pervasiveness of vertical funding programmes among some research funders, an increasing acceptance that greater impact will be realised by taking a horizontal view of health systems and services must continue in the post-COVID-19 environment.

EXAMPLE: The Global Fund's Digital Health Impact Accelerator, a US$50 million catalytic fund

The Global Fund, in partnership with private sector partners, has begun to prioritise research on digital care as a modality of healthcare delivery.[140] The Digital Health Impact Accelerator (DHIA) announced in December 2022 is designed to accelerate countries' digital health transformation in sub-Saharan Africa. The DHIA will also seek to build local capacity on data- and technology-enabled innovations that strengthen African health systems. The accelerator builds upon foundational investments and key learnings of the Data Science Catalytic Fund, supported by The Rockefeller Foundation, which focused on community health data in Burkina Faso, Ethiopia, Rwanda, and Uganda.

Ringfenced accelerators, funds, and donor challenges (e.g., The Gates Foundation Strengthening Data Science Capacity and the Ecosystem Grants Challenge[141]) are important in developing digital health research and research capacity in SSA and beyond. Funders must consider a wider scope of potential projects to enable innovation that goes beyond the targeting of select countries and focus on vertical programming or aspects of the system to enable whole systems thinking and maximise potential impact.

2. Investigate the role of digital technologies in improving continuity of care across the health system and the importance of interoperability

What? To enable stakeholders to provide quality and safe health care using digital modalities and technologies, researchers should seek to push the boundaries of existing research to explore the role of digital technologies and interoperability in improving continuity of care across the system.

Why? As digital technologies are increasingly used across healthcare service provision, there is a pressing need to ensure policy and practice is based on evidence-based best practice. While academics and research groups are increasingly exploring the impacts of digital technology on health and healthcare outcomes, and novel methods are being explored to best evaluate digital health technologies,[142] further research is required to explore impact of digital technologies across the continuum of care, the potential threat of fragmentation and equity challenges, as well as the role of interoperability.

How? As noted above, a greater commitment from research funders to increase the opportunity for researchers to develop work is a prerequisite for meaningful advancement in this area. Academics and research groups may also find opportunities to explore digital modalities and technologies for health care as part of wider research projects. In such instances, it will be important to take a systems approach to ensure continuity of care is a focus of future research.

EXAMPLE:
Research funding from the UK Department for Digital, Culture, Media and Sport (DCMS) to test 5G-supported health technologies to help people manage long-term conditions

The Liverpool 5G Health and Social care testbed was the first 5G supported health trial of its kind in Europe. The £4.9 million project explored if 5G technology provides measurable health and social care benefits in a digitally deprived neighbourhood.[143] Following the creation of a 5G mesh network, university researchers identified volunteers through the small to medium-sized enterprise (SME)-led eHealth Cluster and Liverpool City Council (home care providers and care homes) to trial the technology.

Running from 2018-2020, the project showed that 5G can support new and existing technologies and enable their cost-effective use, improve health outcomes and quality of life for service users, increase the capacity of health and social care services by decreasing the need for primary and social care services and hospital services as a go-to first option. The research also showed that 5G provides an estimated potential cost saving to health and social care services of over £200,000 GBP per 100 users per year.

DCMS awarded £28 million GBP of industry matched funding for 15 new projects as part of the 5G Create competition in late 2020.[144]

Industry

1. Develop innovations that have the express goal of addressing health inequities in PHC

What? While the development of digital technology innovations for the health sector has increased exponentially in recent years, a fraction of these were developed with equity as a key consideration. Equity is an essential element of functioning health systems and must be strived for across systems as an integral aspect of digital transformation.

Why? There is a strong business case for developing digital technologies to address health inequity as the reduction of health disparities adds value for patients (e.g., through access), providers and wider society, and this value can be tracked and measured.[145]

How? Depending on the type of industry and company, the scope to develop innovations addressing health inequity will vary. In some cases, there may be a strong business case for such research and development, which can be determined through an evaluation. In other cases, there may not be a business case, but investing in not-for-profit programmes that tackle inequities in PHC services and outcomes can deliver good corporate citizenship[146] and benefit the image of the company.

EXAMPLE:
GSK tiered pricing for affordable and sustainable access to vaccines in SSA

GSK was one of the first vaccine companies to seek to address vaccine inequalities by adopting a public sector tiered pricing approach linked to a country's ability to pay, making vaccines available in a sustainable and affordable manner. In partnership with Gavi, the Vaccine Alliance, GSK provides countries supported by Gavi access to the lowest prices and has committed to providing more than 850 million vaccine doses (15 million annually) at reduced prices to help protect 300 million children in developing countries by 2024[147], as well as 10 million doses for use in pilot projects in Malawi, Kenya, and Ghana.[148]

Once countries 'graduate' out of Gavi support, GSK has also committed to providing access to GSK's lowest price for 10 years from the time of graduation.[149]

2. Adopt user-centred design methodologies in the development of digital technologies for health care

What? As digital health technologies are increasingly used in health service delivery, it will be important to ensure they are designed with users in mind. Planning must consider the unique range of HCWs and allied professionals in each context and their specific needs. Where patients are users, they must also be engaged in the development and deployment of the technology.

Why? User-centred design ensures that HCWs (or patients if they are the users) are involved from the beginning, leading to the development of more useful technologies and increased uptake. As noted, HCWs may have challenges and questions about technologies being implemented given their novelty in many settings. User-centred design and the engagement of HCWs from the conception of digital technologies, address this challenge and builds support and buy-in.

How? A wealth of examples of user-centred design methodologies exists in the academic literature[150] that can help guide industry in developing methodologies. The International Organization for Standardization (ISO) standard ISO 9241-210:2019 "Human-centred design for interactive systems" defines six key principles to judge whether design work is genuinely user-centred, including,

1. The design is based upon an explicit understanding of users, tasks, and environments;
2. Users are involved throughout design and development;
3. The design is driven and refined by user-centred evaluation;
4. The process is iterative;
5. The design addresses the whole user experience; and
6. The design team includes multidisciplinary skills and perspectives.[151] Beyond this, ensuring engagement with a range of HCWs as potential end users and seeking appropriate representativeness among participants is essential.

EXAMPLE: Human-centred design methodology to guide intervention planning for non-communicable diseases in Kenya

While there are some good examples of human-centred design in digital health specifically,[152] an example of methods used by researchers offers an example of using a human-centred design (HCD) framework consisting of four steps (Discover, Design, Test, and Refine), with an emphasis on community and end-user engagement at each stage, to develop health intervention planning in Kenya.[153]

The researchers set up a Design Team of health professionals, patients, microfinance officers, community health workers, and village leaders.[153] This team then undertook a four-step approach of synthesis, idea generation, prototyping, and creation, as per the HCD framework, to develop an integrated microfinance-group medical visit model for non-communicable diseases, which was then tested in a six-month pilot.

At the same time, a feasibility evaluation based on focus group discussions with pilot participants and community members was undertaken. At the end of the process, the user-centred design approach facilitated the development of a contextually relevant intervention.

All stakeholders involved in digital transformation have an obligation and interest in co-developing digital solutions

There is increasing international recognition that patients need to be involved in their health and health care, both in terms of having ownership of health and wellbeing outcomes and an active voice in shaping the development of health services. The roles of patients, carers, families, and communities, as well as the patient groups that bring them together are equally important in digital transformation of the health sector.

Gaining insights from patients and patient groups will enable the development of programmes and innovations based on patient needs that can provide greater efficiency, effectiveness, equity, patient-centredness, safety, and timeliness. All stakeholders involved in digital transformation have an obligation and interest in co-developing digital solutions.

While SSA-led examples of patient engagement are in their infancy, we present here two examples that showcase ongoing work and the empowering of patients.

EXAMPLE: Sharecare, a non-profit patient group for persons with disabilities and their families and caregivers in Ghana

Sharecare Ghana is an organisation of persons with autoimmune and neurological conditions, as well as their families and caregivers, formed in 2007.[154] The aim of the patient group is to advocate for and support persons with autoimmune and neurological conditions and promote research in these areas. As part of their activities, the group advocates for the National Health Insurance Scheme (NHIS) to cover diagnosis and drugs for persons living with autoimmune and neurological conditions, which are not currently accessible to many Sharecare members, and provides community level support to individuals, families, and caregivers.[155]

EXAMPLE: Patient perceptions of participation in clinical research on COVID-19 in The Gambia

Local research on digital health care transformation in SSA is essential to its success and patient participation is integral. To encourage greater involvement, research on patient perceptions on clinical research participation in SSA is an important starting point to enable stakeholders in academia and thinktanks to take necessary actions.

In recent work in The Gambia, authors of the study found that patients were more likely to participate in research if it is viewed as beneficial and being undertaken by an expert and trusted institution.[156] Research which includes socio-economically diverse individuals, has gained government approval, and was designed with medical professionals was also considered by some as important. The recruitment process must respond to local cultural practices and changing norms.

Reference list

1. The World Bank. Data: Population, total. 2021; https://data.worldbank.org/indicator/SP.POP.TOTL.
2. Ezeh A, Kissling F, Singer P. Why sub-Saharan Africa might exceed its projected population size by 2100. Lancet. 2020;396(10258):1131-1133.
3. Fatehi F, Samadbeik M, Kazemi A. What is Digital Health? Review of Definitions. Stud Health Technol Inform. 2020;275:67-71.
4. WHO. Global strategy on digital health 2020-2025. 2021; https://www.who.int/docs/default-source/documents/gs4dhdaa2a9f352b0445bafbc79ca799dce4d.pdf.
5. The World Bank. Study Protocol : An Evidence Gap Map for Digital Health Interventions. 2020; https://documents.worldbank.org/en/publication/documents-reports/documentdetail/211341591931421760/study-protocol-an-evidence-gap-map-for-digital-health-interventions.
6. The World Bank. Harnessing digital technology to fight the pandemic. 2020; https://www.worldbank.org/en/news/feature/2020/09/19/harnessing-digital-technology-to-fight-the-pandemic.
7. WHO. Universal Health Coverage. 2021; https://www.who.int/news-room/fact-sheets/detail/universal-health-coverage-(uhc).
8. WHO. Health in 2015: from MDGs, Millennium Development Goals to SDGs, Sustainable Development Goals. 2015; https://apps.who.int/iris/bitstream/handle/10665/200009/9789241565110_eng.pdf?sequence=1.
9. WHO. Tracking universal health coverage: 2021 Global Monitoring Report. 2021; https://cdn.who.int/media/docs/default-source/world-health-data-platform/events/tracking-universal-health-coverage-2021-global-monitoring-report_uhc-day.pdf?sfvrsn=fd5c65c6_5&download=true.
10. Alami H, Rivard L, Lehoux P, et al. Artificial intelligence in health care: laying the Foundation for Responsible, sustainable, and inclusive innovation in low- and middle-income countries. Global Health. 2020;16(1):52.
11. UN. Goal 3: Ensure healthy lives and promote well-being for all at all ages. 2022.
12. Fenner R, Cernev T. The implications of the Covid-19 pandemic for delivering the Sustainable Development Goals. Futures. 2021;128:102726.
13. Moyer JD, Hedden S. Are we on the right path to achieve the sustainable development goals? World Development. 2020;127.
14. Holst C, Sukums F, Radovanovic D, Ngowi B, Noll J, Winkler AS. Sub-Saharan Africa-the new breeding ground for global digital health. Lancet Digit Health. 2020;2(4):e160-e162.
15. Budd J, Miller BS, Manning EM, et al. Digital technologies in the public-health response to COVID-19. Nat Med. 2020;26(8):1183-1192.
16. Nimako K, Kruk ME. Seizing the moment to rethink health systems. Lancet Glob Health. 2021;9(12):e1758-e1762.
17. OECD. Empowering the health workforce: Strategies to make the most of the digital revolution. 2021; https://www.oecd.org/els/health-systems/Empowering-Health-Workforce-Digital-Revolution.pdf.
18. Paheenthararajah K, Bodulovic G, de Morpurgo M. Telehealth around the world: A global guide. 2021; https://www.dlapiper.com/en-de/insights/publications/2020/11/telehealth-around-the-world-global-guide.
19. HPCSA. GENERAL ETHICAL GUIDELINES FOR GOOD PRACTICE IN TELEHEALTH Booklet No: 10. 2021; https://www.hpcsa-blogs.co.za/wp-content/uploads/2022/08/Booklet-10_Telehealth__Dec_2021_.pdf.
20. AAFP. Telehealth and Telemedicine. 2021; https://www.aafp.org/news/media-center/kits/telemedicine-and-telehealth.html.
21. OECD. Health at a Glance 2021: OECD Indicators. 2021; https://www.oecd-ilibrary.org/social-issues-migration-health/health-at-a-glance-2021_ae3016b9-en.
22. OECD. OECD Health Working Paper No. 99: READINESS OF ELECTRONIC HEALTH RECORD SYSTEMS TO CONTRIBUTE TO NATIONAL HEALTH INFORMATION AND RESEARCH. 2017; https://one.oecd.org/document/DELSA/HEA/WD/HWP(2017)9/En/pdf.
23. WHO. SEVENTY-FIRST WORLD HEALTH ASSEMBLY A71/20 Provisional agenda item 12.4. mHealth: Use of appropriate digital technologies for public health. 2018; https://apps.who.int/gb/ebwha/pdf_files/WHA71/A71_20-en.pdf.
24. Labrique AB, Vasudevan L, Kochi E, Fabricant R, Mehl G. mHealth innovations as health system strengthening tools: 12 common applications and a visual framework. Glob Health Sci Pract. 2013;1(2):160-171.
25. WHO. Monitoring the building blocks of health systems: a handbook of indicators and their measurement strategies. 2010; https://apps.who.int/iris/bitstream/handle/10665/258734/9789241564052-eng.pdf.
26. Schurer JM, Fowler K, Rafferty E, et al. Equity for health delivery: Opportunity costs and benefits among Community Health Workers in Rwanda. PLoS One. 2020;15(9):e0236255.
27. 1 Million Health Workers. CHW Program Profiles. 2023; http://1millionhealthworkers.org/resources/chw-program-profiles-2/.
28. Mash R, Howe A, Olayemi O, et al. Reflections on family medicine and primary healthcare in sub-Saharan Africa. BMJ Glob Health. 2018;3(Suppl 3):e000662.
29. Ministry of Health Ghana. National Community Health Planning and Services (CHPS) Policy. 2014; https://www.moh.gov.gh/wp-content/uploads/2016/02/CHPS-policy-final-working-draft-for-validation.pdf.
30. The Global Health Observatory. Country has national Electronic Health Record (EHR). 2015; https://www.who.int/data/gho/indicator-metadata-registry/imr-details/4791.
31. Cilliers L, Wright G. Electronic Health Records in the Cloud: Improving Primary Health Care Delivery in South Africa. Stud Health Technol Inform. 2017;245:35-39.
32. Odekunle FF, Odekunle RO, Shankar S. Why sub-Saharan Africa lags in electronic health record adoption and possible strategies to increase its adoption in this region. Int J Health Sci (Qassim). 2017;11(4):59-64.
33. Kavuma M. The Usability of Electronic Medical Record Systems Implemented in Sub-Saharan Africa: A Literature Review of the Evidence. JMIR Hum Factors. 2019;6(1):e9317.
34. Castelnuovo B, Kiragga A, Afayo V, et al. Implementation of provider-based electronic medical records and improvement of the quality of data in a large HIV program in Sub-Saharan Africa. PLoS One. 2012;7(12):e51631.
35. Chaplin B, Meloni S, Eisen G, et al. Scale-up of networked HIV treatment in Nigeria: creation of an integrated electronic medical records system. Int J Med Inform. 2015;84(1):58-68.
36. USAID. Leapfrog to Value. 2020; https://www.usaid.gov/cii/document/leapfrog-value-report.
37. World Economic Forum. Health Systems Leapfrogging in Emerging Economies. 2016; https://www3.weforum.org/docs/WEF_Health_Systems_Leapfrogging_Emerging_Economies_report.pdf.
38. Bediang G, Nganou-Gnindjio CN, Kamga Y, Goethe Doualla FC, Bagayoko CO, Nko'o S. Evaluation of the Effectiveness of Telemedicine in the Management of Cardiovascular Diseases in Primary Health Care in Cameroon: An Interventional Study. Stud Health Technol Inform. 2021;281:615-619.
39. Ngassa Piotie P, Wood P, Webb EM, Hugo JFM, Rheeder P. Designing an integrated, nurse-driven and home-based digital intervention to improve insulin management in under-resourced settings. Ther Adv Endocrinol Metab. 2021;12:20420188211054688.
40. Ouedraogo AM, Compaore R, Some A, et al. [Acceptability and satisfaction with pregnancy and newborn diagnostic assessment (PANDA) system providing prenatal care in Burkina Faso]. Pan Afr Med J. 2020;37:361.
41. Torrey WC, Cepeda M, Castro S, et al. Implementing Technology-Supported Care for Depression and Alcohol Use Disorder in Primary Care in Colombia: Preliminary Findings. Psychiatr Serv. 2020;71(7):678-683.
42. Shahid R, Al-Jehani HM, Zafar A, Saqqur M. The Emerging Role of Telestroke in the Middle East and North Africa Region in the Era of COVID-19.

Prim Care Companion CNS Disord. 2021;23(5).

43. Salient Advisory. Digital Counseling and Telemedicine in East Africa: Companies, Emerging Trends and Opportunities. 2022; https://www.salientadvisory.com/reports/telemedicine-in-east-africa-companies-trends-opportunities/.

44. OECD. The COVID-19 Pandemic and the Future of Telemedicine. 2023; https://www.oecd.org/publications/the-covid-19-pandemic-and-the-future-of-telemedicine-ac8b0a27-en.htm.

45. Fisher R, Sarkar U, Adler-Milstein J. Audio-Only Telemedicine In Primary Care: Embraced In The NHS, Second Rate In The US. Health Affairs. 2022.

46. Hoffer-Hawlik MA, Moran AE, Burka D, et al. Leveraging Telemedicine for Chronic Disease Management in Low- and Middle-Income Countries During Covid-19. Glob Heart. 2020;15(1):63.

47. Garg S, Gangadharan N, Bhatnagar N, Singh MM, Raina SK, Galwankar S. Telemedicine: Embracing virtual care during COVID-19 pandemic. J Family Med Prim Care. 2020;9(9):4516-4520.

48. WHO. Towards long-term care systems in sub-Saharan Africa. 2017; https://apps.who.int/iris/bitstream/handle/10665/340535/9789241513388-eng.pdf?sequence=1&isAllowed=y.

49. Dovie DA. The Status of Older Adult Care in Contemporary Ghana: A Profile of Some Emerging Issues. Front Sociol. 2019;4:25.

50. AARP. The 2018 Aging Readiness & Competitiveness Report: Small Innovative Economies. Mauritius. 2018; https://www.aarpinternational.org/file%20library/arc/countries/full%20reports/2018_mauritius.pdf.

51. WHO. Ageing gracefully in a digital world. 2021; https://www.who.int/china/news/feature-stories/detail/ageing-gracefully-in-a-digital-world.

52. Serenity Solutions. Serenity Solutions [homepage]. 2023; http://www.serenity-solutions.com/.

53. Delaporte A. The state of mobile internet connectivity in Sub-Saharan Africa: why addressing the barriers to mobile internet use matters now more than ever. 2021; https://www.gsma.com/mobilefordevelopment/blog/the-state-of-mobile-internet-connectivity-in-sub-saharan-africa/

54. Delaporte A, Bahia K. The State of Mobile Internet Connectivity 2021. 2021; https://www.gsma.com/r/wp-content/uploads/2021/09/The-State-of-Mobile-Internet-Connectivity-Report-2021.pdf.

55. Zhou M, Herselman M, Coleman A. USSD Technology a Low Cost Asset in Complementing Public Health Workers' Work Processes. Bioinformatics and Biomedical Engineering. 2015:55-64.

56. Amoakoh-Coleman M, Borgstein AB, Sondaal SF, et al. Effectiveness of mHealth Interventions Targeting Health Care Workers to Improve Pregnancy Outcomes in Low- and Middle-Income Countries: A Systematic Review. J Med Internet Res. 2016;18(8):e226.

57. Oliver-Williams C, Brown E, Devereux S, Fairhead C, Holeman I. Using Mobile Phones to Improve Vaccination Uptake in 21 Low- and Middle-Income Countries: Systematic Review. JMIR Mhealth Uhealth. 2017;5(10):e148.

58. Colaci D, Chaudhri S, Vasan A. mHealth Interventions in Low-Income Countries to Address Maternal Health: A Systematic Review. Ann Glob Health. 2016;82(5):922-935.

59. Sandstrom J, Swanepoel D, Laurent C, Umefjord G, Lundberg T. Accuracy and Reliability of Smartphone Self-Test Audiometry in Community Clinics in Low Income Settings: A Comparative Study. Ann Otol Rhinol Laryngol. 2020;129(6):578-584.

60. IMF. FAS: What is mobile money? How is it different from mobile banking? 2023; https://datahelp.imf.org/knowledgebase/articles/1906552-fas-what-is-mobile-money-how-is-it-different-fro.

61. Lamptey E, Serwaa D. The Use of Zipline Drones Technology for COVID-19 Samples Transportation in Ghana. HighTech and Innovation Journal. 2020;1(2).

62. Delaporte A, Bahia K. The State of Mobile Internet Connectivity 2022. 2022; https://www.gsma.com/r/wp-content/uploads/2022/12/The-State-of-Mobile-Internet-Connectivity-Report-2022.pdf

63. Morgan L. CASE BRIEF: M-TIBA DIGITAL HEALTH PLATFORM. 2020; http://www.impactinsurance.org/sites/default/files/CB24%20-%20EN_1.pdf.

64. WHO. Medication Without Harm. 2023; https://www.who.int/initiatives/medication-without-harm.

65. Car J, Tan WS, Huang Z, Sloot P, Franklin BD. eHealth in the future of medications management: personalisation, monitoring and adherence. BMC Med. 2017;15(1):73.

66. Musiega A, Ogira D, Wafula F. Designing fit-for-purpose regulation for evolving healthcare systems Country report: Kenya. 2018; https://www.lshtm.ac.uk/sites/default/files/2020-09/Country%20Report_Kenya_website.pdf.

67. Brey Z, Mash R, Goliath C, Roman D. Home delivery of medication during Coronavirus disease 2019, Cape Town, South Africa: Short report. Afr J Prim Health Care Fam Med. 2020;12(1):e1-e4.

68. The Academy of Medical Sciences. Our data-driven future in healthcare: People and partnerships at the heart of health related technologies. 2018; https://acmedsci.ac.uk/file-download/74634438.

69. IBM. Artificial Intelligence (AI). 2020; https://www.ibm.com/uk-en/cloud/learn/what-is-artificial-intelligence.

70. Jiang F, Jiang Y, Zhi H, et al. Artificial intelligence in healthcare: past, present and future. Stroke Vasc Neurol. 2017;2(4):230-243.

71. O'Brien N, Van Dael J, Clarke J, et al. Addressing racial and ethnic inequities in data-driven health technologies. 2022; https://spiral.imperial.ac.uk/handle/10044/1/94902. Accessed 03/03/2023.

72. Le Monde. Bogou, l'application africaine qui permet de désenclaver les déserts médicaux. 2018; https://www.lemonde.fr/afrique/article/2018/11/09/bogou-l-application-africaine-qui-permet-de-desenclaver-les-deserts-medicaux_5381270_3212.html.

73. h3Africa. Our History. 2023; https://h3africa.org/index.php/about/.

74. Ibeneme S, Okeibunor J, Muneene D, et al. Data revolution, health status transformation and the role of artificial intelligence for health and pandemic preparedness in the African context. BMC Proc. 2021;15(Suppl 15):22.

75. WHO. AccessMod: geographic access to health care. 2023; https://www.who.int/tools/accessmod-geographic-access-to-health-care.

76. UK Government Office for Life Science. Distributed Ledger Technology: beyond block chain. 2016; https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/492972/gs-16-1-distributed-ledger-technology.pdf.

77. ODK. ODK [Homepage]. 2023; https://getodk.org/.

78. Endriyas M, Alano A, Mekonnen E, et al. Understanding performance data: health management information system data accuracy in Southern Nations Nationalities and People's Region, Ethiopia. BMC Health Serv Res. 2019;19(1):175.

79. USAID. Updating Rwanda's Health Management Information System (HMIS): Measuring What Matters. 2019; https://pdf.usaid.gov/pdf_docs/PA00TX6Q.pdf.

80. Peek N, Sujan M, Scott P. Digital health and care in pandemic times: impact of COVID-19. BMJ Health Care Inform. 2020;27(1).

81. OECD. Africa's Development Dynamics 2021. 2021; https://www.oecd-ilibrary.org/docserver/0a5c9314-en.pdf?expires=1649346313&id=id&accname=guest&checksum=2D1A187A6E3B6E0ED793063E4C7915F0.

82. OECD. Africa's Development Dynamics 2022. 2022; https://www.oecd-ilibrary.org/development/africa-s-development-dynamics-2022_2e3b97fd-en.

83. David NJ, Brey Z, Ismail M. Telemedicine in the Western Cape Department of Health during the first peak of the COVID-19 pandemic: Leveraging data to save lives by activating a telemedicine response. African Journal of Primary Health Care & Family Medicine. 2021;13(1).

84. Oseni TI, Agbede RO, Fatusin BB, Odewale MA. The role of the family physician in the fight against Coronavirus disease 2019 in Nigeria.

African Journal of Primary Health Care & Family Medicine. 2020;12(1).

85. Institute of Medicine. In: Crossing the Quality Chasm: A New Health System for the 21st Century. Washington (DC)2001.

86. Antinyan A, Bassetti T, Corazzini L, Pavesi F. Trust in the Health System and COVID-19 Treatment. Front Psychol. 2021;12:643758.

87. Zanaboni P, Fagerlund AJ. Patients' use and experiences with e-consultation and other digital health services with their general practitioner in Norway: results from an online survey. BMJ Open. 2020;10(6):e034773.

88. Belfrage S, Helgesson G, Lynoe N. Trust and digital privacy in healthcare: a cross-sectional descriptive study of trust and attitudes towards uses of electronic health data among the general public in Sweden. BMC Med Ethics. 2022;23(1):19.

89. Edoh T, Pawar PA, Kora AD. Evaluation of Telemedicine Systems User Satisfaction in Developing Countries: The Case of Mali and Senegal. Research Anthology on Telemedicine Efficacy, Adoption, and Impact on Healthcare Delivery. 2021:180-198.

90. Murphy A, McGowan C, McKee M, Suhrcke M, Hanson K. Coping with healthcare costs for chronic illness in low-income and middle-income countries: a systematic literature review. BMJ Glob Health. 2019;4(4):e001475.

91. Onah MN, Govender V. Out-of-pocket payments, health care access and utilisation in south-eastern Nigeria: a gender perspective. PLoS One. 2014;9(4):e93887.

92. NHS England. Getting ready for patients to have access to their future information. 2023; https://www.events.england.nhs.uk/getting-ready-for-all-patients-to-have-access-to-their-future-data.

93. Discovery Ltd. Vitality [Homepage]. 2023; https://www.discovery.co.za/vitality/join-today/.

94. CommCare. CommCare for Low-Literate Users. 2023; https://confluence.dimagi.com/display/commcarepublic/CommCare+for+Low-Literate+Users. Accessed 06/03/2023.

95. WHO. Quality health services. 2023; https://www.who.int/news-room/fact-sheets/detail/quality-health-services.

96. National Academies of Sciences E, and Medicine,. In: Crossing the Global Quality Chasm: Improving Health Care Worldwide. Washington (DC)2018.

97. NHS England. Digital Clinical Safety Strategy. 2021; https://transform.england.nhs.uk/key-tools-and-info/digital-clinical-safety-strategy/. Accessed 06/03/2023.

98. Neves AL, Burgers J. Digital technologies in primary care: Implications for patient care and future research. Eur J Gen Pract. 2022;28(1):203-208.

99. Dash S, Aarthy R, Mohan V. Telemedicine during COVID-19 in India-a new policy and its challenges. J Public Health Policy. 2021;42(3):501-509.

100. Srivastava S, Datta V, Garde R, et al. Development of a hub and spoke model for quality improvement in rural and urban healthcare settings in India: a pilot study. BMJ Open Qual. 2020;9(3).

101. OECD. Access to COVID-19 vaccines: Global approaches in a global crisis. 2021; https://www.oecd.org/coronavirus/policy-responses/access-to-covid-19-vaccines-global-approaches-in-a-global-crisis-c6a18370/#sr-p-d1e119-1.

102. Leidig M, Teeuw RM, Gibson AD. Data poverty: A global evaluation for 2009 to 2013 - implications for sustainable development and disaster risk reduction. International Journal of Applied Earth Observation and Geoinformation. 2016;50:1-9.

103. Debrah LB, Mohammed A, Osei-Mensah J, et al. Morbidity management and surveillance of lymphatic filariasis disease and acute dermatolymphangioadenitis attacks using a mobile phone-based tool by community health volunteers in Ghana. PLoS Negl Trop Dis. 2020;14(11):e0008839.

104. Sarfo FS, Akpalu A, Bockarie A, et al. Phone-Based Intervention under Nurse Guidance after Stroke (PINGS II) Study: Protocol for a Phase III Randomized Clinical Trial. J Stroke Cerebrovasc Dis. 2021;30(8):105888.

105. Penfold ED, Fourie P. Regional health governance: A suggested agenda for Southern African health diplomacy. Glob Soc Policy. 2015;15(3):278-295.

106. Southern African Development Community. SADC Regional Indicative Strategic Development Plan (RISDP 2020-2030) 2020; https://www.sadc.int/pillars/regional-indicative-strategic-development-plan-2020-2030.

107. Digital Health Europe. DigitalHealthEurope recommendations on the European Health Data Space. 2021; https://digitalhealtheurope.eu/wp-content/uploads/DHE_recommendations_on_EHDS_July_2021.pdf.

108. Rammos T, Schwarz TJ. A European Health Data Space – EU Commission publishes draft Regulation. 2022; https://www.taylorwessing.com/en/insights-and-events/insights/2022/07/a-european-health-data-space.

109. Baker L. Regulatory standards and guidance for the use of health applications for self-management in Africa: scoping review protocol. 2022; https://healthcare-newsdesk.co.uk/regulatory-standards-and-guidance-for-the-use-of-health-applications-for-self-management-in-africa-scoping-review-protocol/.

110. Kosti N, Levi-Faur D, Mor G. Legislation and regulation: three analytical distinctions. The Theory and Practice of Legislation. 2020;7(3):169-178.

111. Orange. Orange and DabaDoc launch "Orange Santé" in Côte d'Ivoire, a platform dedicated to e-health. 2022; https://newsroom.orange.com/orange-and-dabadoc-launch-orange-sante-in-cote-divoire-a-platform-dedicated-to-e-health-9545/?lang=en.

112. Vodafone. How tech is connecting mothers with critical health services in Africa. 2023; https://www.vodafone.com/news/vodafone-foundation/how-technology-is-connecting-mothers-with-critical-health-services-in-africa.

113. Broadband Commission. 21st Century Financing Models for Bridging Broadband Connectivity Gaps. 2021; https://broadbandcommission.org/wp-content/uploads/dlm_uploads/2021/11/21st-Century-Financing-Models-Broadband-Commission.pdf.

114. REDCap. REDCap [Homepage]. 2023; https://www.project-redcap.org/

115. Ghafur S, Fontana G, Halligan J, O'Shaughnessy J, Darzi A. NHS data: Maximising its impact on the health and wealth of the United Kingdom. 2020; https://spiral.imperial.ac.uk/handle/10044/1/76409

116. Boutayeb A, Helmert U. Social inequalities, regional disparities and health inequity in North African countries. Int J Equity Health. 2011;10:23.

117. Musau Z. Africa Grapples with Huge Disparities in Education. International Journal of Strategic Research in Education, Technology and Humanities. 2022;10(1):91-94.

118. Wong BL, Khurana MP, Smith RD, et al. Harnessing the digital potential of the next generation of health professionals. Human Resources for Health volume. 2021;19(50).

119. Kante M, Ndayizigamiye P. Internet of medical things, policies and geriatrics: An analysis of the national digital health strategy for South Africa 2019–2024 from the policy triangle framework perspective. Scientific African. 2021;e00759.

120. Tambo E, Madjou G, Mbous Y, et al. DIGITAL HEALTH IMPLICATIONS IN HEALTH SYSTEMS IN AFRICA. European Journal of Pharmaceutical and Medical Research. 2016;3(1):91-93.

121. van Stam G. Conceptualization and practices in digital health: voices from Africa. Afr Health Sci. 2022;22(1):664-672.

122. O'Brien N, Ghafur S, Durkin M. Cybersecurity in health is an urgent patient safety concern: We can learn from existing patient safety improvement strategies to address it. Journal of Patient Safety and Risk Management. 2021;26(1).

123. Institute for Security Sciences. Keeping the humanitarian sector in Africa safe from digital threats. 2022; https://issafrica.org/iss-today/keeping-the-humanitarian-sector-in-africa-safe-from-digital-threats.

124. Turner HC, Archer RA, Downey LE, et al. An Introduction to the Main Types of Economic Evaluations Used for Informing Priority Setting and Resource Allocation in Healthcare: Key Features, Uses, and Limitations. Front Public

Health. 2021;9:722927.

125. Chi Y-L, Jeffery M. Health Priority Setting:A Practitioner's Handbook. 2019; https://www.jointlearningnetwork.org/wp-content/uploads/2020/02/Health-Priority-Setting-Pratitioners-Handbook-200221.pdf. Accessed 06/03/2023.

126. Asante A, Wasike WSK, Ataguba JE. Health Financing in Sub-Saharan Africa: From Analytical Frameworks to Empirical Evaluation. Appl Health Econ Health Policy. 2020;18(6):743-746.

127. Hatt T, James H, Lucini BA. Country overview: Ghana Driving mobile-enabled digital transformation. 2017; https://www.gsma.com/mobilefordevelopment/wp-content/uploads/2020/05/Ghana-Country-Overview.pdf.

128. WHO. The protection of personal data in health information systems – principles and processes for public health. 2021; https://apps.who.int/iris/bitstream/handle/10665/341374/WHO-EURO-2021-1994-41749-57154-eng.pdf?sequence=1&isAllowed=y.

129. UK Department of Health & Social Care. G7 Open standards and Interoperability: Final Report. 2021; https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/1045267/G7-open-standards-final-report.pdf.

130. Medical Informatics Initiative Germany. Finding a common language for healthcare data: key progress made towards interoperability in German medicine. 2021; https://www.medizininformatik-initiative.de/en/finding-common-language-healthcare-data-key-progress-made-towards-interoperability-german-medicine.

131. SNOMED International. A Collaborative Approach to Deliver Global Interoperability: 2021 Annual Report. 2021; https://900274fb-d080-447b-a566-8dd2ca035ffd.usrfiles.com/ugd/900274_96b2866bfc9e436494206a86d9ebf8e8.pdf.

132. Living Goods. The Living Goods Approach. 2023; https://livinggoods.org/what-we-do/the-living-goods-approach/#.

133. UNDP. mHero. 2023; https://www.undp.org/policy-centre/singapore/mhero.

134. Principles for Digital Development. Principles. 2016; https://digitalprinciples.org/principles/.

135. Principles for Digital Development. mHero and the Principles for Digital Development: Development Done Right. 2023; https://digitalprinciples.org/resource/mhero-and-the-principles-for-digital-development-development-done-right/.

136. Bowman W. The Uniqueness of Nonprofit Finance and the Decision to Borrow. Nonprofit Management and Leadership. 2002;12:293-311.

137. Morales P, Arnaiz F, Brown W, Burr R. Innovative Funding Models for High-Cost Non-Communicable Diseases (NCDs). 2021; https://www.iqvia.com/-/media/iqvia/pdfs/asia-pacific/white-papers/innovative-funding-models-for-high-cost-non-communicable-diseases.pdf.

138. Citigroup. InnovatIve FInancIng For Development: Scalable Business models that produce economic, Social, and environmental outcomes. 2014; https://www.citigroup.com/citi/foundation/pdf/innovative_financing_for_development.pdf.

139. Postelnicu L. Babylon inks 10-year partnership with Rwandan government. 2020; https://www.mobihealthnews.com/news/emea/babylon-inks-10-year-partnership-rwandan-government.

140. The Global Fund. Global Fund and Private Sector Partners Launch US$50 Million Catalytic Fund to Accelerate Digital Health Transformation in Africa. 2022; https://www.theglobalfund.org/en/news/2022/2022-12-14-global-fund-and-private-sector-partners-launch-us-50-million-catalytic-fund-to-accelerate-digital-health-transformation-in-africa/.

141. Global Grant Challenges. Strengthening Data Science Capacity and the Ecosystem: Enabling Data-Centered Public Health Interventions. 2022; https://gcgh.grandchallenges.org/challenge/strengthening-data-science-capacity-and-ecosystem-enable-data-centered-public-health.

142. Guo C, Ashrafian H, Ghafur S, Fontana G, Gardner C, Prime M. Challenges for the evaluation of digital health solutions-A call for innovative evidence generation approaches. NPJ Digit Med. 2020;3:110.

143. Liverpool5g. Our work 2020; https://liverpool5g.org.uk/health-social-care-testbed/.

144. GOV.UK. Guidance: 5G Testbeds and Trials Programme. 2023; https://www.gov.uk/guidance/5g-testbeds-and-trials-programme.

145. Aluko Y, Hall R. How digital technology can enable health equity and enterprise growth. 2021; https://www.ey.com/en_us/health/health-equity-services/how-digital-technology-can-enable-health-equity.

146. Rendtorff JD. The Concept of Business Legitimacy: Corporate Social Responsibility, Corporate Citizenship, Corporate Governance as Essential Elements of Ethical Business Legitimacy. Responsibility and Governance. 2018:45-60.

147. GSK. Responsible Business Supplement 2014. 2014; https://www.gsk.com/media/8090/gsk-responsible-business-supplement-2014.pdf.

148. GSK. ESG Performance Report 2021. 2021; https://www.gsk.com/media/7473/esg-performance-report-2021.pdf.

149. GSK. GSK Public policy positions. 2019; https://www.gsk.com/media/5683/tiered-pricing-and-vaccines-aug19.pdf.

150. De Vito Dabbs A, Myers BA, Mc Curry KR, et al. User-centered design and interactive health technologies for patients. Comput Inform Nurs. 2009;27(3):175-183.

151. ISO. ISO 9241-210:2019 Ergonomics of human-system interaction — Part 210: Human-centred design for interactive systems. 2019; https://www.iso.org/standard/77520.html.

152. Kumar M, Macharia P, Nyongesa V, et al. Human-centered design exploration with Kenyan health workers on proposed digital mental health screening and intervention training development: Thematic analysis of user preferences and needs. Digit Health. 2022;8:20552076221090035.

153. Leung CL, Naert M, Andama B, et al. Human-centered design as a guide to intervention planning for non-communicable diseases: the BIGPIC study from Western Kenya. BMC Health Serv Res. 2020;20(1):415.

154. Sharecare Ghana. About Sharecare Ghana. 2021; http://www.sharecare4u.org/about_us.html.

155. Chronicity Care Africa. Living with multiple sclerosis in Ghana. Nana Yaa Agyeman shares her 25-year journey. 2021; https://chronicitycareafrica.com/2021/12/03/living-with-multiple-sclerosis-in-ghana-nana-yaa-agyeman-shares-her-25-year-journey/.

156. Diallo BA, Usuf E, Ceesay O, D'Alessandro U, Roca A, Martinez-Alvarez M. Clinical research on COVID-19: perceptions and barriers to participation in The Gambia. BMJ Glob Health. 2022;7(2).

Imperial College London

INSTITUTE OF GLOBAL HEALTH INNOVATION