Federal Ministry
for Economic Cooperation
and Development

Strategic Partnership
Digital Africa

Digital Health Ecosystem for African countries

A Guide for Public and Private Actors for establishing holistic Digital Health Ecosystems in Africa

bmz.de

LIST OF ABBREVIATIONS

ACBF	African Capacity Building Foundation
API	Application Programming Interface
BMZ	Federal Ministry for Economic Cooperation and Development
CDA	Clinical Document Architecture
CDA	Common Document Architecture
CDR	Clinical Data Repository
CDW	Clinical Data Warehouse
CODL	Centre for Open and Distance Learning
DATIM	Data for Accountability Transparency Impact Monitoring
EAIDSNet	East African Integrated Disease Surveillance Network
ECS	Emergency Care Summary
eHR	Electronic Health Record
eID	Electronic Identification
eIDSR	Electronic Integrated Disease Surveillance and Response
EMR	Electronic Medical Record System
ePS	Electronic Patient Summary
ESA	European Space Agency
ESB	Enterprise Service Bus
EWS	Early Warning Systems
FBO	Faith-based Organisation
GIZ	German Corporation for International Cooperation GmbH
HIS	Health Information System
HISM	Health Information Management System
HIV	Human Immunodeficiency Virus Infection
HL	Health Level
HPRS	Health Professionals Registration System (Kenya)
ICD	International Statisticall Classification of Diseases and Related Health Problems
ICT	Information and Communications Technology
IHE	Healthcare Enterprise
IVD	Ischemic Vascular Disease
KPI	Key Performance Indicators
mHealth	Mobile Health Applications
MPI	Master Patient Index
MRS	Medical Record System
NGO	Non-Governmental Organization
NHSSP II	National Heath Sector Strategic Plan II
openEHR	Open Electronic Health Record
PaaS	Platform as a Servcie
PEPFAR	President's Emergency Plan for AIDS Relief
PHCIS	Primary Health Care Information System
REC	Regional Economic Communities
RRI	eHealth Regulation Readiness Index
SaaS	Software as a Service
SACIDS	Southern Africa Centre for Infectious Disease Surveillance
SARA	Service Availability and Readiness Assessment
SDG	Sustainable Development Goals
SDI	Service Delivery Indicators
SMEs	Small- and Medium-sized Enterprises
SPA	The Service Provision Assessment
SPDA	Strategic Partnership Digital Africa
tMed	Telemedicine
USAID	United States Agency for International Development
WAHO	West African Health Organization
WHO	World Health Organisation

Content

The Strategic Partnership Digital Africa (SPDA) is a network of the German Federal Ministry for Economic Cooperation and Development (BMZ) and European companies, managed by the Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH. Its goal is to harness digitalisation opportunities to drive Africa's development—in partnership with European companies.
One of six thematic expert groups of the SPDA concerns digital health. Its experts from the private and public sector have identified integrated, interoperable Digital Health Ecosystems as an area of interest due to the widespread state of fragmentation in the digital health sector.

GRAPHS

TABLES

EXECUTIVE SUMMARY

Digital technologies will influence the future of well-being and economic growth worldwide. African economies are well-positioned to benefit from this accelerating technological change that will help to overcome limitations and the costs of physical infrastructure in important areas of economic life.

The health sector is benefitting from this trend, in particular in Africa. Substantial investment in digital solutions in recent years have already improved health services in Africa. African leaders who gathered at the African Ministerial Dialogue on digital health leadership at the May 2017 World Health Assembly affirmed their commitment to digital health and identified the pathway towards realising strong Digital Health Ecosystems in their countries. A Digital Health Ecosystem is the holistic application of Information and Communication Technologies (ICT) to support and improve health care delivery, its coordination and integration across providers.

In this study, framework conditions, requirements and options for the successful, sustainable implementation of Digital Health Ecosystems in Africa are analysed with the goal to create an action-oriented framework for digital infrastructure and services, based on a well-founded health policy context. Relevant partners include decision makers, health system operators and industry in African countries, development partners and companies with expertise in Digital Health Ecosystems and applications.

The study provides a basis for these actors to jointly develop Digital Health Ecosystems that address the respective needs and technical requirements of African countries.

Core results

The study results are summarised in seven key messages and recommendations:

Seven Key Messages

1. **Digital health supports the Sustainable Development Goals and Universal Health Coverage.**
   To meet the health targets of the Sustainable Development Goals by 2030, progress must be accelerated, in particular in regions with the highest burden of disease. When implemented appropriately, digital health is a great enabler towards better health care and health coverage.

2. **The establishment of a national Digital Health Ecosystem should be based on an integrated framework.**
   A sustained transformation of health systems requires a holistic vision, driven by priorities and a unifying approach that ensures that all eHealth applications are integrated through a national digital health infrastructure platform—a Digital Health Ecosystem.

3. **There is no one-size-fits-all solution for digital health.**
   Implementing and sustaining digital applications in the health sector is demanding, complicated and time-consuming. There is no one-size-fits-all platform solution. Instead, each solution has to be tailored to local needs, circumstances and resources.

4. **Instead of developing individual pilots, governments and development partners should focus on integration.**
   Stand-alone eHealth implementations and pilot projects that rarely reach scale or sustainability should be avoided. Focus on a few health care and/or public health priorities to guide nation-wide investments. Ensure coordination and integration of all stakeholders.

"A Digital Health Ecosystem is the holistic application of Information and Communication Technologies (ICT) to support and improve health care delivery, its coordination and integration across providers."

5. **There are four building blocks for successfully implementing a National Digital Health Ecosystem: a strategy, roadmap, implementation elements and evaluation.**
   Drafting an eHealth strategy will not do the job. Three additional building blocks are needed: An actionable, realistic roadmap on how to move from strategy to implementation and long-term sustainability, six implementation elements (national platform, core services, interoperability guidance, leveraging the "open" approach, change management, governance and legal framework) and measuring impact to guide further development.

6. **Fostering a Digital Health Ecosystem requires close coordination of all stakeholder, with strong leadership from governments.**
   Governments make decisions on health system structures, regulation and financing and determine the needs, priorities and investment procedures in Digital Health Ecosystems. To avoid the disparate development of siloed eHealth applications, a national framework must include close coordination between all stakeholders. Therefore, calls for tender specifications must fully align with the national digital health framework.

7. **Digital health investments should be based on a cooperative investment approach.**
   To translate opportunities into action, a cooperative investment approach is recommended. Customers, local Ministries of Health, health care providers and health professionals, national and international development partners and financiers, not-for-profit and commercial suppliers, providers of digital health software, hardware and services should come together and collaboratively pursue country or district-specific opportunities.

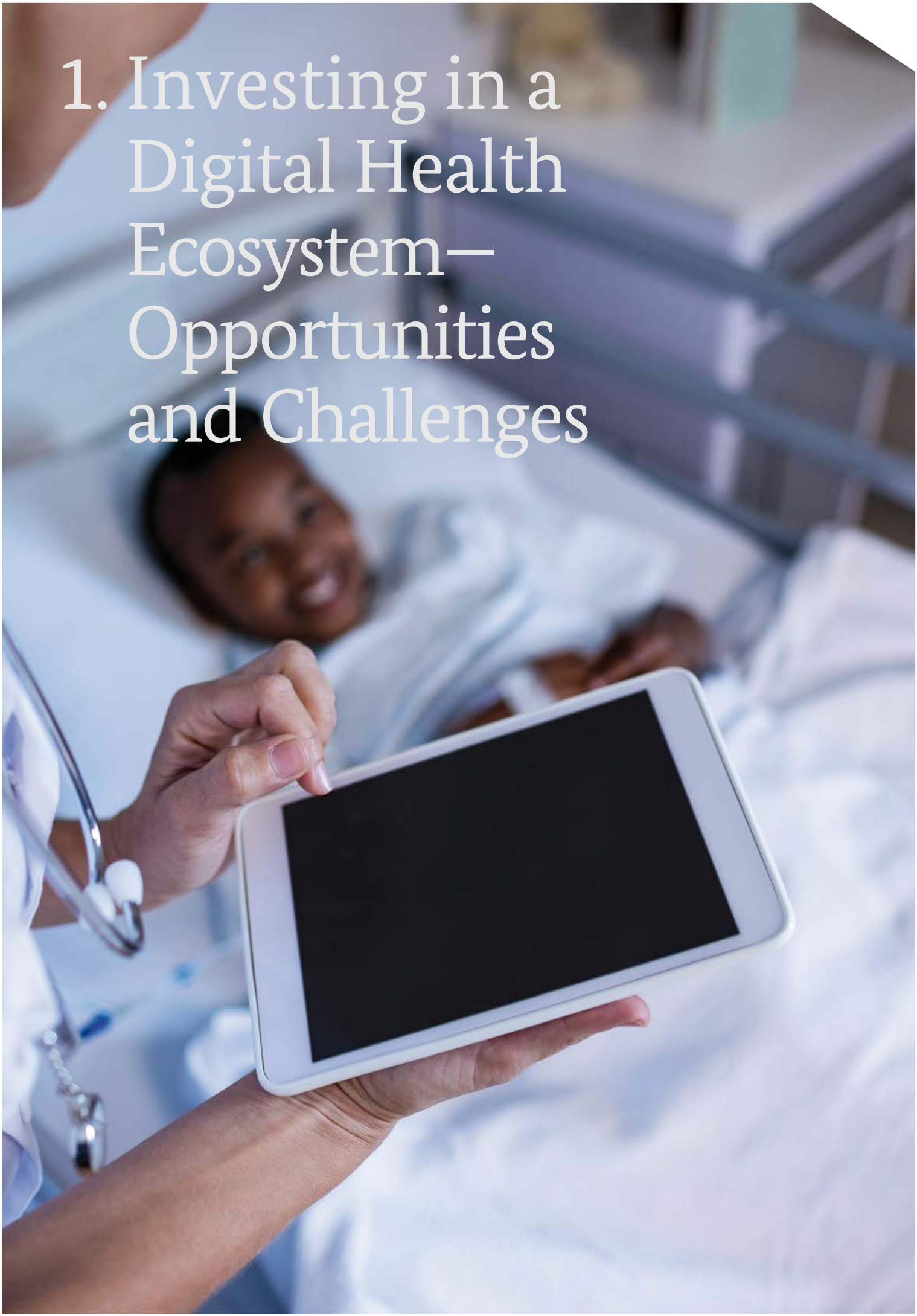
Key Recommendations

Governments that aim to foster a Digital Health Ecosystem may consider the following recommendations:

- Be mindful that drafting an eHealth strategy is only the first step towards a Digital Health Ecosystem which should be complemented by a detailed plan and resilient implementation.
- As implementing a national Digital Health Ecosystem is a multi-year endeavour, put in place careful planning processes, including risk and change management, from the beginning.
- Focus first on low-hanging fruit and early benefits for health care delivery, particularly health professionals and patients. Build on and integrate what is already there—do not start yet another isolated project.
- Ensure coordination, adequate infrastructure processes and organisation, e.g. through an eHealth Division in the Health Ministry or a competent eHealth Authority.
- Enforce mandatory coordination among all core stakeholders who invest in digital health applications, including open source data models, standards and coding systems.
- Be detailed and specific on interoperability: Agree on who needs which data when in which format for which decisions. Define and regulate standards, data formats and coding systems in line with these requirements in an open approach, control their implementation and certify the software.
- Be aware that a comprehensive governance and regulatory framework is a key success factor.
- Establish non-partisan monitoring & evaluation and use the results to improve the performance of the Digital Health Ecosystem.

Companies that engage in African Digital Health Ecosystems should consider that the market for digital health hardware, software and devices is changing, as governments aspire towards a more integrated, open and flexible infrastructure. The trend towards Digital Health Ecosystems, where individual applications must be fully interoperable, is changing the playing field. This might require companies to become familiar with open source and open data models in digital health and cooperate with other engaged stakeholders. One strategy for companies might be to search for (new) alliances and partners to flexibly respond to calls for tender for Digital Health Ecosystems, connected applications and services, thereby creating value for a wide range of stakeholders—including local partners in African countries. This may lead to an adapted or new business model, similar to other sectors where digitalisation changes the rules of the game. Digital Health Ecosystems do not represent short-term business opportunities but necessitate a long-term commitment.

1. Investing in a Digital Health Ecosystem—Opportunities and Challenges



Investment in health sector infrastructure and service delivery directly benefits the well-being of people and, thereby, improves productivity and national wealth. Digital Health Ecosystems and applications will deliver an additional dimension to support national health services. It will enable individual providers to offer better quality health care and, as a long-term vision, ensure innovation, safety and value in addition to quality in health care.

DIGITAL HEALTH ECOSYSTEM

A Digital Health Ecosystem is the holistic application of information and communication technologies to support and improve health care delivery, its coordination and integration across providers in a given domain (local, district, national, regional).

Why has it proven so difficult to establish sustainable Digital Health Ecosystems? Why do other service sectors such as banking, retail and insurance succeed in implementing powerful, globally connected electronic systems, while the health care sector does not?

A few observations can assist in explaining the present situation. They may also help to explore a more promising path into the future of digital health.

Why digital health is different

- **Data complexity:** Clinical and care data is unique, textual and not interoperable
  Clinical terminology is often ill-defined. The same word may have different meanings in different contexts and different terms may be used for the same fact, like a diagnosis. The level of detail in measurements depends on the clinical situation. A brain surgeon, for example, needs much more detail than a general practitioner. The wide use of abbreviations is another challenge. In summary, most medical information is textual and not well structured.

- **Cultural complexity:** Wide variety of actors involved
  In health systems, a wide variety of actors work together, including general practitioners, specialists, nurses, health workers, patients, administrators, managers, public health specialists and many others. They all have their own interests, language and behaviour. Even hospitals located in the same region may have different internal cultures, affecting language, workflows and decision-making.

- **Decision Complexity:** Fast decision processes with countless options and interactions
  In a health emergency, decisions have to be made fast, often based on incomplete information. In addition, in the treatment of multi-morbid patients, for example, decision options may not be well-defined or they may be countless. Little empirical evidence is available to support the treating professional.

- **Process Complexity:** No simple workflow rules of health care processes
  In spite of clinical guidelines, each patient's pathway may be different. It depends on the availability of primary, secondary and tertiary care facilities, access to diagnostic and treatment equipment, competition and cooperation patterns, financial incentives and many other factors.

  Regulatory Complexity: Information governance / personal data, safety, cybersecurity
  Patient health data is sensitive. Some patients do not want their treating physicians to have access to their earlier recorded information. In many countries, health data are guarded by special data protection rules that are stricter than those for other kinds of data. Hospitals have specific and comprehensive data governance rules to protect patient data.
  On the other hand, in times of big data analytics, health data have gained in (monetary) value. Industries like the pharmaceutical sector as well as various service providers are prepared to pay considerable sums for access to health data warehouses.

- **IT complexity and vendor lock-in:** Monolithic, proprietary, non-interoperable software systems
  Many hospitals or district structures have invested in proprietary hospital information systems that are highly complex. They may consist of 30+ modules that need to connect and exchange data with numerous other systems in different divisions or wards. Moreover, few systems allow for seamless integration of telemedicine or smart phone applications. This so-called vendor lock-in leads to market inflexibility, which in turn hampers competition and innovation, since switching to a more advanced or suitable system is often cost-prohibitive.

Opportunities and challenges for digital health

Opportunities
Digital health can provide beneficial applications in many different areas of health systems and can facilitate an urgently needed transformation of health care delivery. A few examples illustrate the opportunities:

- **Faster, more effective and efficient health care provision**
  Digital health enables health care teams to access a patient's core or even complete health data. This saves time, reduces duplicate tests and leads to better patient care decisions. It may connect electronic patient or medical records with measuring devices and mobile phones (mHealth), allowing patients to be informed and input their own data.

*The **mHealth4Afrika** consortium, a collaboration between African and European companies, has developed an open source, multilingual digital health platform that helps to improve community-based **maternal and newborn health care delivery in Ethiopia, Kenya, Malawi and South Africa**. It combines electronic medical records to store patient history and associated test results with sensors that capture the results of a range of standardised tests, analytical and visualisation tools as well as speech synthesis to address literacy deficits.*

- **Telemedicine, making health care accessible in rural areas**
  Telemedicine applications, such as virtual visits or measurements at a distance, allow connecting with patients, health workers, nurses and doctors remotely, which renders health care accessible to un- or underserved people. It reduces the need to travel long distances and makes specialist knowledge and experience available on the spot.

*In Tanzania, the **Thamini Uhai's Maternal Health Program** is an innovative approach to reduce maternal and neonatal deaths in rural areas of Tanzania. To take advantage of digital health in addressing some of the challenges in providing accessible, cost-effective and high-quality health care, since 2012 the program has designed and implemented an eHealth platform in three districts, addressing the crisis of skilled care providers and improve maternal health care delivery. It helped to teach clinical decision-making skills to mid-level care providers, support emergency care and establish an eHealth model solution for maternal health care in underserved rural settings. Teleconsultation equipment to support obstetric emergency care in rural and outmost areas was installed in ten upgraded rural health centres, four rural district hospitals and one regional hospital. The model has been successfully copied by other regions. Thamini Uhai is an NGO supported by various international donors.*

→ **mHealth**
Mobile devices and smart phones provide a promising application area due to Africa's high mobile penetration rates. In the health care sector, smart phones can serve as hubs to connect sensors, electronic measurement devices, printers and other equipment at the local level, while connecting more complex systems at community centres and district hospitals.

*The UNICEF-supported **MomConnect** service in South Africa links pregnant women and young mothers to health care centres. **Ghana** and **Nigeria** have introduced similar services that support digital forms and checklists to ease the regulatory process at pharmacies or clinics.*

→ **Administration and management services**
Patient administration, workflow support, billing, personnel, resource management and accounting are services that are often neglected, although they can benefit greatly from digital applications, especially in cases of large populations.

*The **Western Cape's Primary Health Care Information System** (PHCIS) is an administrative system in **South Africa** for managing patient throughput in primary care clinics through electronically drawing information on past clinic visits, creating electronic appointments and providing patient and facility management tools for reporting purposes.*

→ **Public Health surveillance and disaster preparedness**
Health surveillance is the systematic collection and analysis of health-related data for planning, implementation and evaluation. Electronic data collection can fundamentally strengthen national health information systems and decision-making. Combining an integrated geographic and early warning system with mHealth devices, may serve as a dashboard as well as early warning system for citizens.

*A good example is the introduction of a mobile **Electronic Integrated Disease Surveillance and Response (eIDSR)** application by Sierra Leone's Ministry of Health and Sanitation (MoHS). In just 10 months—between November 2015 and September 2016—weekly disease reporting improved from 35 % of health facilities responding to 96 % of all facilities. It has also cut the number of data entry errors in half and verifies data 60 % faster than the previous paper-based reporting system.*

→ **eLearning**
Learning in the health care sector, among health professionals as well as patients, is an often under-explored field within digital health, despite its considerable potential due to ease of scalability.

*The **Tanzanian Training Centre for International Health** uses an audio teleconferencing model and an online eLearning platform to teach health workers and nurses about maternal and perinatal health care in rural areas.*

"Digital health provides access to a patient's core or even complete health data. This saves time, reduces duplicate tests and leads to better patient care decisions."

Challenges

In spite of these promising applications and the concrete benefits demonstrated by them, there remain serious challenges and implementation problems remain (see Graph 1). Some of the key aspects relate to:

- **Coordination**
  Various eHealth systems are run by organisations that do not coordinate their activities with each other. Donors, governments, private investors and implementing partners often work in the same district on similar health issues, duplicating each other's efforts, as succinctly described by Mr. Kumalija from the Ministry of Health in Tanzania: "The existence of parallel routine reporting systems of IVD, HIV, PEPFAR-DATIM is a challenge. Uncoordinated national surveys such as SPA (USAID), SARA (Global Fund), SDI (World Bank) collect almost the same indicators".[i]

  This relates to a dearth in most countries of an appropriate framework to guide resource allocation, structures and processes (like establishing a National eHealth Steering Committee), which should be part of a high-level governance set-up. The framework could then take advantage of the capacity and capabilities of regional economic communities (RECs) and regional networks like the West African Health Organisation (WAHO), the East African Integrated Disease Surveillance Network (EAIDSNet) or the Southern Africa Centre for Infectious Disease Surveillance (SACIDS) to leverage the collective expertise and experience of professionals from different countries and diverse settings.[ii]

- **"Pilotitis"**
  The global digital health landscape is burdened by the expansion of numerous pilot projects that rarely reach scale. Of the many interesting endeavours in the field, most are neither sustainable nor scalable and thus remain speculative pilots.[iii] In Kenya, for example, only 44 % of 183 innovative health care programmes have been implemented and are working efficiently.[iv]

  Even worse seems to be the success rate of mHealth services. A USAID publication featuring 167 profiles of mobile health programmes remarked that most have phased out by the time of publication.[v]

- **Integration into a national platform**
  Regularly deployed eHealth systems are stand-alone implementations that are not integrated with one another through a national digital health infrastructure platform. Due to these system silos, health professionals struggle to access patient records at other health facilities, while health politics and public health stakeholders can't access timely information for easy and quick decision making or for tracking service levels and health outcomes across the whole health sector.

  Even if digital health applications are coordinated and complement each other, they often fail to connect to a national Digital Health Ecosystem, since they do not meet requirements for interoperability specifications and data formats. Technical solutions and messaging standards for exchanging or accessing electronic "paper" documents are usually available. Nevertheless, standardisation alone will not necessarily lead to higher levels of (semantic) interoperability.

- **Governance, legal and regulatory basis**
  Health care provision is laden with complex situations that involve confidentiality, privacy and ethical decisions. The introduction of an eHealth system must not undermine the core values that underpin the trust inherent in the doctor-patient relationship. It is fundamental that the open exchange of information and trust that usually exists between patients and their physicians must be maintained. Improper access to patient data is a core legal and regulatory challenge. Digital Health Ecosystems must be designed to be non-disruptive and, with the proper safeguards in place, easily accessible to all those who take care of an individual patient.

  In an analysis of regulatory and governance aspects across 48 Sub-Saharan African countries covering 64 eHealth items, only four countries scored high with respect to their "regulatory readiness", six more were assessed as ready and the remaining 38 countries—achieving on average only 50 % of the scores compared to "ready" countries—were judged as not ready.[vi]

- **Sustainability**
  Many digital health projects do not lay out a long-term plan or matching funding perspective, which are both essential for success. Digital health projects should demonstrate sustained benefits, for example in areas where a substantial population does not access basic health care or an increase in the efficiency of service delivery due to ICT implementation. They should also complement the national hospital and community health care infrastructure development plan in order to benefit from the allocated budget.

  In this context, it is recommended to first pursue digital health opportunities that have a clear impact on the improvement of the operational delivery of services (processes, procedures and organisation), particularly those that affect professional capacity, such as eLearning and eAdministration, which then strengthen the health care organisations themselves prior to extending or improving the efficiency of

clinical services.[vii] The earlier mentioned Western Cape's Primary Health Care Information System (PHCIS) is a good example of this approach.

→ **Human resources and absorption capacity**
The ability to successfully invest in eHealth solutions depends on adequate human resources: health professionals and experts with ICT knowledge within health care provider organisations, external IT support and infrastructure service providers. In a small survey of health care workers and professionals in Tanzania, the demand for local technical capacity dramatically exceeded availability, in particular in fields like software development, digital health programme implementation, health informatics and enterprise architecture. The same applies to governments to guide their investment in digital health solutions.[viii]

In September 2017, the African Capacity Building Foundation (ACBF) at its 26th ACBF Board of Governors meeting in Accra, Ghana, underlined that "Africa's ability to mobilize resources, utilize and absorb them in the right way, in the right areas and in the right time has become critical for the implementation of the African Union's Agenda 2063, but also for the UN Sustainable Development Goals (SDGs) as well as for regional and national development plans. There is a compelling body of knowledge pointing to limited absorptive capacity as a key impediment to the implementation and effectiveness of various development projects and programmes in Africa".[ix]

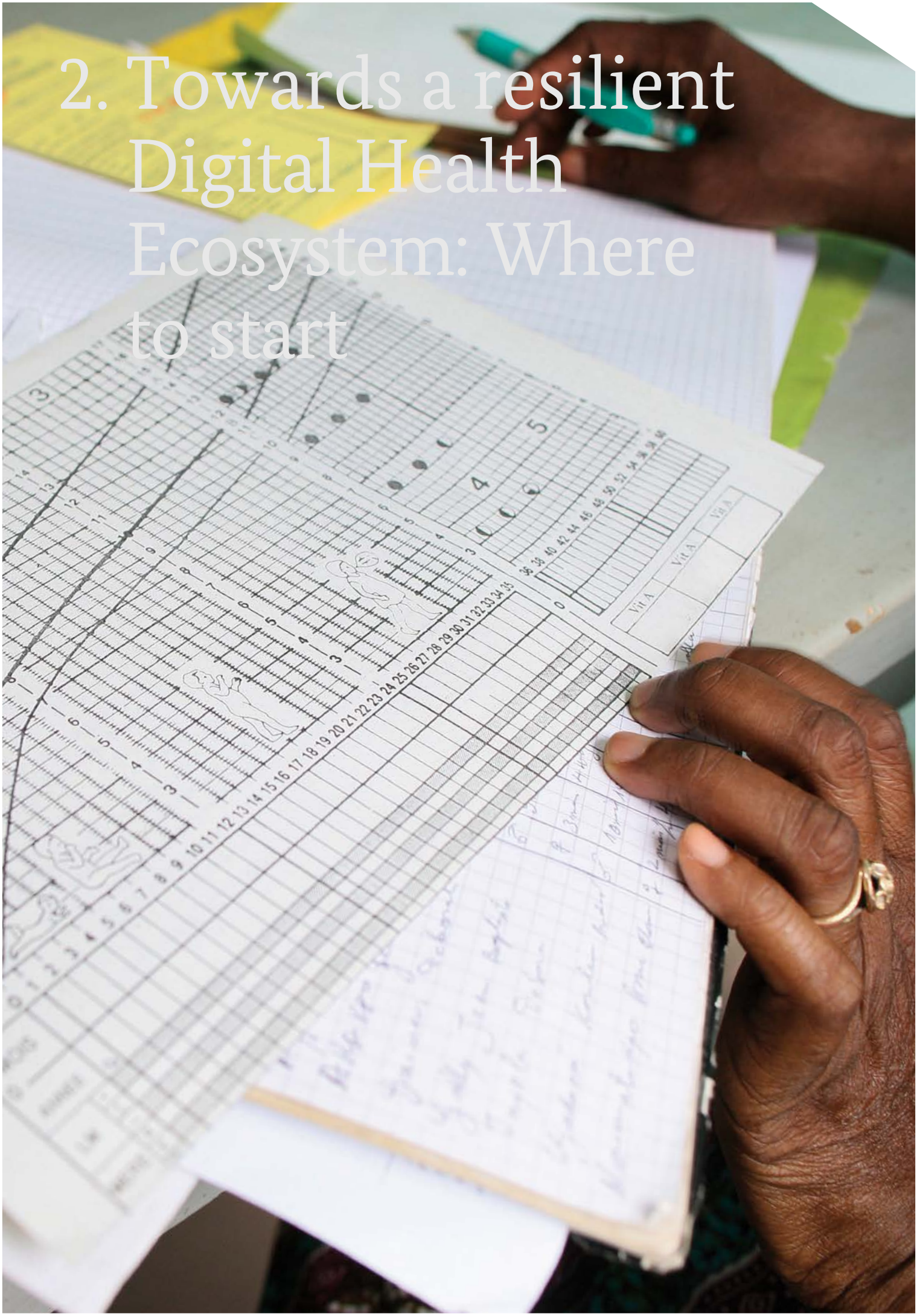
→ **Infrastructure and connectivity**
In almost all African countries, ICT infrastructure and fixed line or mobile phone connectivity is a challenge, particularly in rural areas. eHealth technologies and services have to be adapted to take into account such limitations and cater to these specific needs.

Reliable access to electricity may be an even more pressing challenge. Alternative sources of energy, such as solar power, are increasingly becoming available, but need investment funds, expert knowledge and maintenance, which is not always ensured.

GRAPH 1

KEY CHALLENGES ON THE WAY TOWARDS A DIGITAL HEALTH ECOSYSTEM

2. Towards a resilient Digital Health Ecosystem: Where to start



Improving patient safety, delivering better health care, increasing the economic efficiency of service provision—there are many reasons to invest in a Digital Health Ecosystems. Opportunities are abundant, but so are the challenges. To be successful, an initial concentration of efforts and resources is indispensable.

Responding to policy priorities and stakeholder needs

Successful national or district Digital Health Ecosystems respond to **health policy priorities** and **stakeholder needs**. Establishing such a platform is a complex and long-term venture. Attempting to build a comprehensive, all-encompassing ecosystem at once carries a high risk and can lead to delays or even failure.

Global experience in developed and in emerging market economies suggests that initially a **focused approach that delivers early benefits to core actor groups** is essential. It will convince physicians and politicians to continue, expand and support further development of digital health policies. This leads to an evolutionary path, guided by stakeholder needs and based on a reliable resource base.

Such a needs-driven approach will avoid a **common pitfall** of digital health investments, namely **technology push**. As stated in an article on eHealth solutions in Africa: "A lot of solutions have come from technologists and engineers who are excited by the technology, but at times, they are not starting with the true need. (...) end-users must be central to the design. The problem with African countries is that eHealth systems are not integrated and are instead run by different independent organisations".[xiii]

BELIZE HEALTH INFORMATION SYSTEM

*In 2007, the **Belize Health Information System (BHIS)** was deployed as a country-wide fully integrated health information system with eight embedded disease management algorithms and simple analytics. Design and development had started in 2003. By 2012, within 5 years, significant decreases in maternal mortality, infant mortality and mother to child transmission of HIV were observed.*[x]

SCOTLAND'S NATION-WIDE EMERGENCY CARE SUMMARY (ECS)

***Scotland's nation-wide Emergency Care Summary (ECS)** system provides up-to-date, basic patient information on 99 % of the population. The information is used by National Health Services call centres, Out of Hours services, accident and emergency departments and others. With general practitioners in the lead, discussions started in 2002, initial pilots were launched in 2004 and the nation-wide rollout was completed in 2007. The system has allowed family physicians to no longer be on duty 24 / 7. Responding to physician and patient demands, it has been continuously expanded towards more detailed patient data and new application domains.*[xi]

SIGA SAÚDE HEALTH INFORMATION SYSTEM OF SÃO PAULO

***The SIGA Saúde Health Information System of São Paulo** City Department of Health in Brazil supports health care services for 20 million people in the Greater São Paulo region. Its initial goal was to enable improved patient flow, better data capture for billing, safer medication dispensation and faster referral to specialized services. Development started in 2003 and in 2004, a first module was already operational. Others followed in the years to come, such as a scheduling application in 2006 and a lab application in 2010. A fully operational patient record system is under way. Based on an open source and modular architecture approach, this highly flexible system that starts with deploying the most needed functionalities has been replicated by other cities.*[xii]

Taking into consideration the development stage of the country, the resources of the underlying economy and the maturity of the health system, urgent health system priorities relate to:

- Support for basic administrative tasks and patient workflow processes
- eAdministration processes facilitating billing and health insurance services
- Basic district electronic patient record systems and platforms focusing on basic, summary patient data, particular diseases like HIV or malaria or on the perinatal situation
- Surveillance, collection of Public Health data, disaster preparedness
- National framework platforms with common infrastructure components such as health care organisation and physician electronic IDs, data protection and security services and common data formats in support of and connecting district platforms
- Capacity development through eLearning for health workers, nurses, physicians and citizens

In combination with basic infrastructure components of an **open infrastructure platform**, any starting point can serve as a steppingstone towards a more comprehensive Digital Health Ecosystem.

Starting point: national or regional?

Depending on the size of the country and the set-up of health care as a national or district responsibility, the analysis domain will relate to the respective geographic region. Evidence indicates that a good starting point for a holistic, successful ecosystem **is an area with 5 million to 10 million people**. In larger countries, health care is usually a locally or regionally organised service, not a national "business".

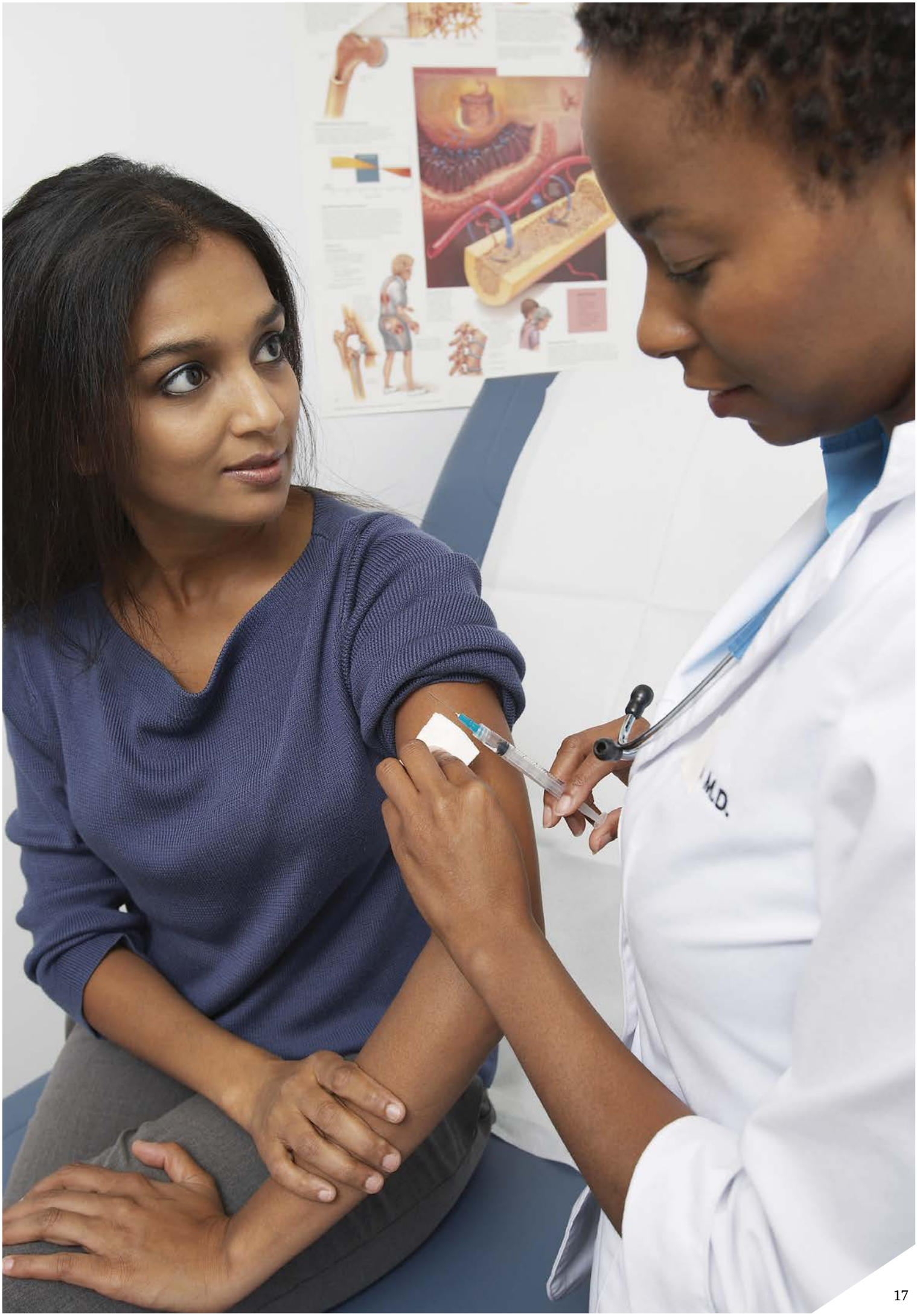
TO SUM UP

Policy priorities, stakeholder needs and already existing, functional digital health services will guide the initial focus and starting point for a Digital Health Ecosystem.

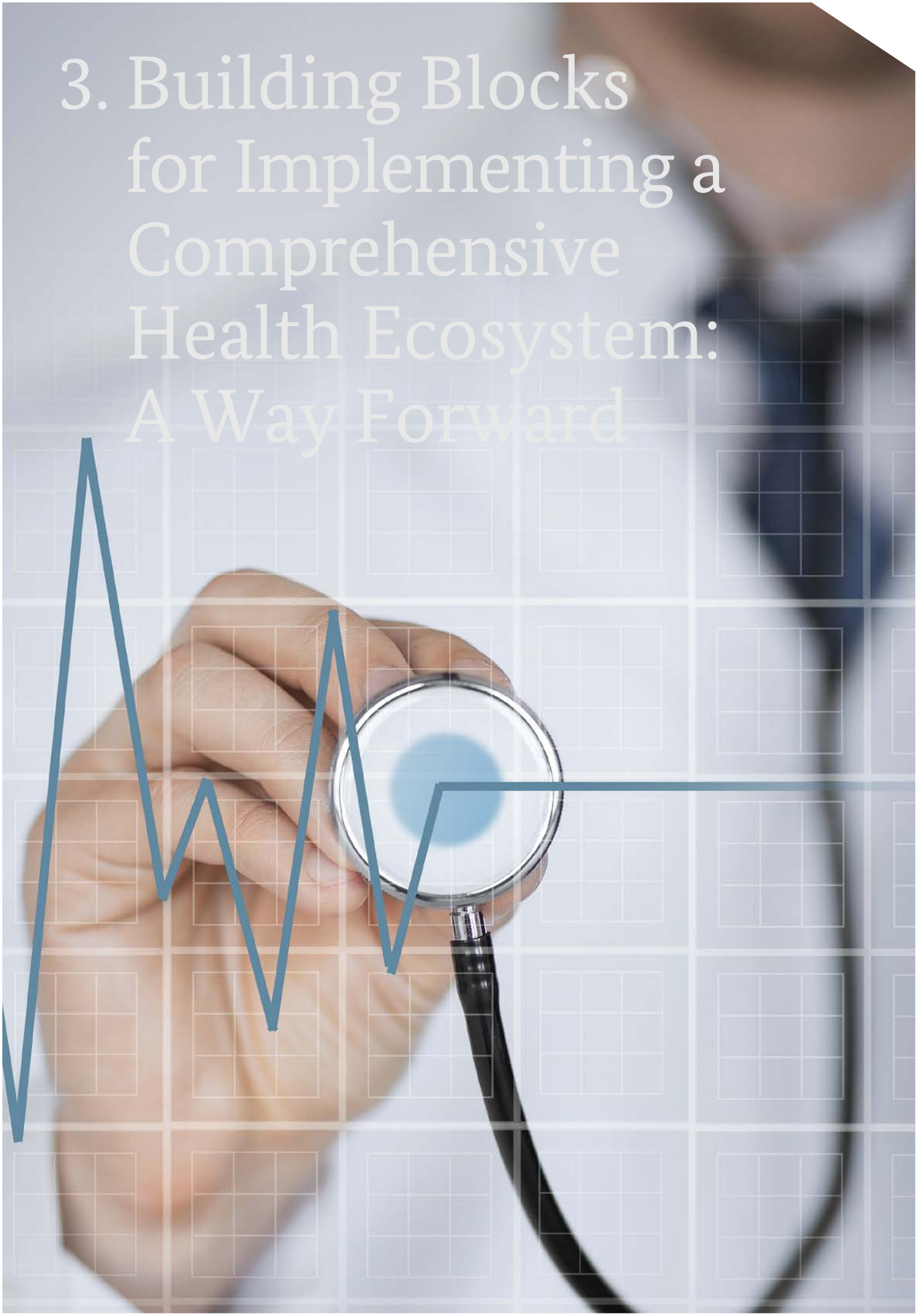
Guiding questions to assess the starting point towards a comprehensive Digital Health Ecosystem

When planning to invest in an integrative, comprehensive Digital Health Ecosystem, it is useful to evaluate a country's state of eHealth measures and identify starting points for implementation. The following questions will help identify first steps, key actors and policies:

- Which health policy objectives will particularly benefit from digital health support?
- Is eHealth a priority for key political stakeholders? Has a national eHealth policy and implementation strategy been formulated and agreed upon?
- Are physicians' association(s), group(s) of nurses / health workers, NGOs, (foreign) development agencies / foundation(s) or other stakeholder groups engaged and cooperating?
- Is there a strong promoter at a high political level with power to garner sustained, longer-term support for such an activity?
- Is there an implementation champion who has good (project) management capabilities to lead this development to a long-term success?
- Have initial (platform) components / services already been implemented (like an electronic patient ID / master patient index (MPI), an electronic medicinal products data base, data protection regulations and tools as part of already existing eGovernment services, etc.)?
- Which functional eHealth implementations by health care providers, telemedicine services, government health statistics efforts, etc. exist that can be built upon?
- Are health care provider organisations and physicians / health care workers familiar with eHealth applications and actively engaged in their further development?
- Does an eHealth division in a Ministry (or a separate public institute) already exist? Are sufficient, sustainable resources forthcoming?
- Are there eGovernment activities that can be built upon?



3. Building Blocks for Implementing a Comprehensive Health Ecosystem: A Way Forward



3.1. FOUR FOUNDATIONAL BUILDING BLOCKS

Drafting a digital health strategy is only a very first, albeit necessary step towards establishing and maintaining a Digital Health Ecosystem. Translating the strategy into an operational roadmap with clear action steps and a realistic time frame is already a much more demanding task that comes with concrete implementation, continuous maintenance, taking into account both technical developments and changing demand. An often neglected forth building block is measuring and assessing outcomes and impact, which is indispensable for updating and adapting the ecosystem to changing and newly arising needs.

Understanding these building blocks (see Graph 2), their contents and related action steps as well as their logical relationship and how they interact with each other is mandatory for everyone involved in planning, developing, implementing and maintaining the Digital Health Ecosystem—be they decision makers or users (or both) at the health policy level, from health care services, health professionals, patients, industry involved in implementation, donors or financiers.

The four foundational building blocks to be considered and analysed for a resilient Digital Health Ecosystem:

1. **Agreement on an operational digital health strategy**

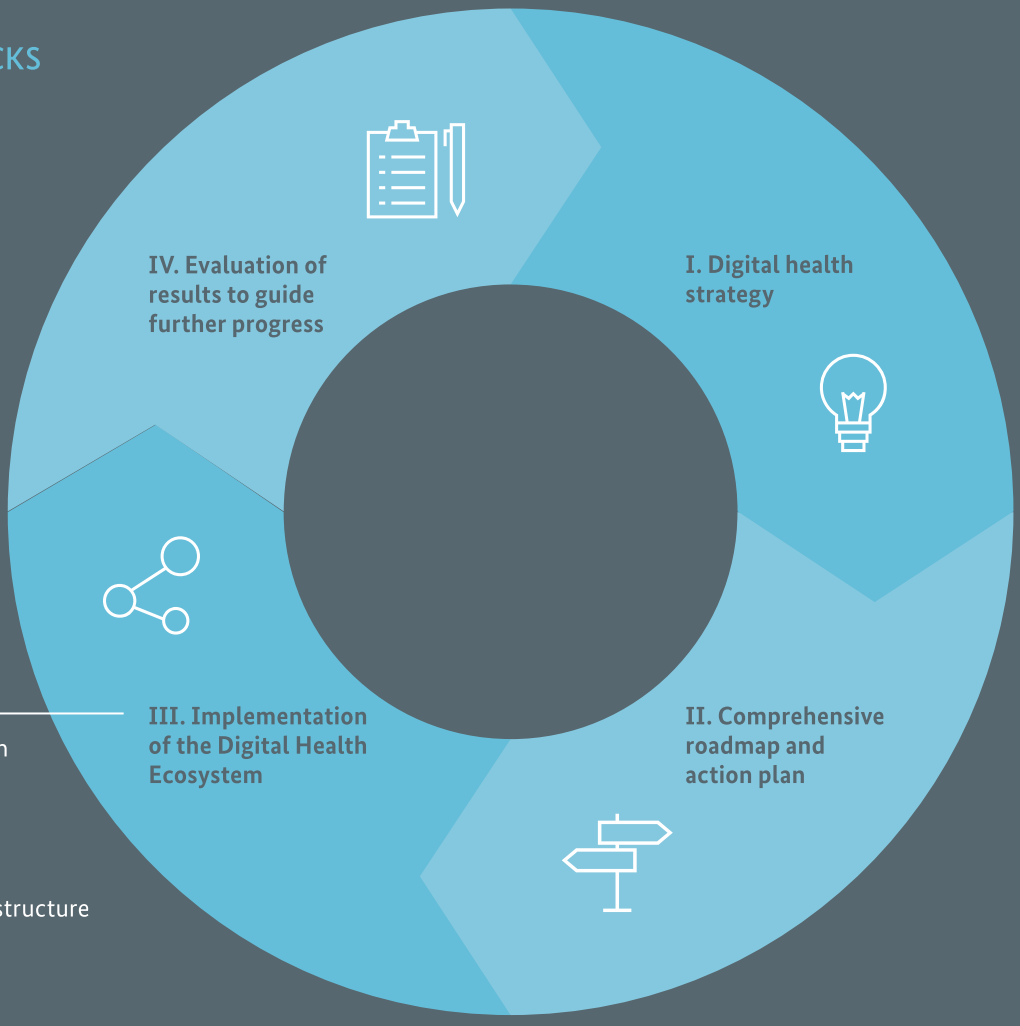
2. **Development of a comprehensive roadmap, translating the strategy into long-term sustainability**

3. **Implementation of the Digital Health Ecosystem:**
   - → Open digital health platform and infrastructure services
   - → Core health care services and applications
   - → Interoperability framework
   - → "Open" source and platform approach
   - → Change management
   - → Legal and governance infrastructure

4. **Monitoring and evaluation of outcomes and results achieved to guide further progress**

GRAPH 2

FOUR BUILDING BLOCKS FOR A RESILIENT DIGITAL HEALTH ECOSYSTEM



3.2. DRAFTING A DIGITAL HEALTH STRATEGY (I.)

Drafting and agreeing on a strategic paper builds trust across all stakeholders who are involved in or impacted by the development of a Digital Health Ecosystem. The strategy should not be concerned with great detail, but rather with designing the broad vision and mission. A fine-grained plan, translated into a roadmap with expert support, will follow as a next step.

The process of developing and drafting the strategy should involve all relevant actors and stakeholders, to ensure prior agreement on major goals, concrete objectives, appropriate implementation structures and resources. This may involve dedicated working groups dealing with specific subjects, plus a coordinating and integrating steering committee. Governance rules establish how the stakeholder groups and actors will be represented, who is to lead and who is to participate in which working group, which outcomes are to be achieved, the time line, the decision processes, how to deal with disagreements and controversies, provision of resources to finance meetings, travel costs and expert time involved. Initially, such a procedure may be time-consuming and slow, but it is essential to achieve trust, inclusiveness, involvement, ownership and faster progress when implementing the strategy.

The eHealth strategy should support and enable the realisation of a set of health system priorities and objectives, based on a strategic digital concept and concrete implementation objectives.

The strategy should include concrete implementation responsibilities and could cover the following issues and challenges:

- Core health policy goals
- Value added by digitial health in the short and long term
- High level policy support to ensure long-term stability
- Agreement on political and operational responsibility / ies
- Agreement on temporary and permanent organisation(s), structures and processes to be established
- Analysis of already available digital health services and implementations
- Specification of indispensable digital infrastructure services, IT architecture and platform design, including exploitation of eGovernment services, if available
- Core digital health services and applications needed to support the most important health care improvement goals
- Initial interoperability framework, based on health data capture, access and exchange needs (covering technical, structural and semantic issues of health data recording, processing and analysis, as necessary)
- Workforce and training needs
- Awareness raising and change management
- Broad timeline for strategy implementation
- Cost-benefit analysis
- Budget and resource allocations
- Identification of the existing governance framework
- Monitoring / quality control and feedback for strategy revision

3.3. THE ROAD FROM eHEALTH STRATEGY TO LONG-TERM SUSTAINABILITY (II.)

According to the World Health Organisation (WHO), about 60 % of its 194 member countries have posted a national eHealth strategy. However, most of these strategies were never implemented and some failed miserably. Therefore, a digital health strategy must be complemented by a concrete actionable roadmap to achieve the results and benefits envisioned.

Roadmap concept

A roadmap is a detailed, fine-grained plan, translating a strategy into implementation actions. It is based on identifying the starting point and destination and should answer in operational detail the critical questions of why, what, how and when? Whereas a strategy already touches upon these issues at a generic level, the roadmap breaks the questions down to serve as a master plan for investment and implementation.

- **WHY:** The first part defines and delineates the roadmap's domain, the core as well as derived objectives which policy and strategic considerations have indicated.

- **WHAT:** The second part identifies the problems to be solved and the challenges to be met on the road in detail. This includes intermediate outcomes as well as the final destination to be reached and measurable performance targets to achieve the objectives.

- **HOW:** The third part describes the framework conditions, organisational structures, processes, digital technologies and solutions needed to achieve the objectives; this includes a detailed estimate of human and financial resources required, risk identification and mitigation options technology development and investment needs.

- **WHEN:** The fourth part defines the timing of the required actions, their interrelationships and dependencies identified, e.g. by a critical path analysis.

The **SMART** roadmapping rules should be used when drafting the contents of these four parts:

- **S** Be **specific** about what has to be achieved, avoid ambiguity and communicate clearly with all stakeholders.
- **M** Ensure results are **measurable**, with clearly defined outcomes such as key performance indicators (KPI).
- **A** Make sure that proposed actions have **appropriate** and **achievable** outcomes.
- **R** Check that each foreseen actions is **realistic**, taking account of time, capacity, appropriate technologies and financial resources.
- **T** Agree on a realistic and achievable **time** frame reflecting risks and interdependencies, with set deadlines, milestones and progress checks.

Roadmapping framework

Drafting a comprehensive roadmap is a demanding task, exploring what needs to be in place to implement the envisaged Digital Health Ecosystem in the short to medium term. There are choices to be made at every step of the way and to make those, the peculiar country's starting point, context, priorities and strategy have to be taken into account.

Nevertheless, certain generic structural elements can be identified for any roadmap. The WHO / ITU toolkit identifies three action levels:[xiv]

- **Action lines** are broad areas to group national activities of similar focus and intent that are required to deliver a nation's eHealth vision
- **eHealth outputs** are the specific achievements, deliverables, results or changes that are required to deliver on these action lines
- **Activities** denote the set of activities which need to be undertaken to deliver a particular output

Action lines and activities together lead to the following generic structure:

- Governance
- Establish a national eHealth governing council
- Establish a national eHealth entity to direct and manage national eHealth investment
- Formalize governance interactions with other national, regional and local government bodies
- Foundations
- Develop high-level requirements and design for national eHealth platform and core infrastructure services

- Deploy and operate national eHealth platform and core infrastructure services
- Select and approve digital health standards, specifications, terminologies and other coding systems as needed
- Adopt a regulatory framework for health information protection
- Establish mechanisms to improve computing infrastructure in health care organisations
- Deploy priority data connectivity infrastructure
- Develop high-level requirement and design for priority national eHealth services and applications
- Identify and select or when necessary develop, high-priority eHealth services and applications
- Establish a national solutions compliance certification function
- Publish certification and compliance criteria
- Undertake a competitive call for identifying implementation partner(s) to perform detailed design and build up of national eHealth services
- Deploy and operate national eHealth services and applications
- Change management and adoption
- Develop and roll-out eHealth awareness campaigns
- Develop and roll-out financial incentive regimes
- Monitor eHealth solution adoption
- Implement education and training courses
- Engage and consult with stakeholder reference and working groups

A second dimension to be considered for each action and reflected in the roadmap is the time line, split into strategic phases. eHealth outputs will be allocated along the timeline of each action. Global experience suggests that it will take many years to indeed realise a digital health strategy and that it is a never-ending endeavour.

Finally, a third dimension concerns human, organisational and financial resources needed to realise these actions. Particularly the human resource needs should not be underestimated. Both, time line and resource estimates, need to reflect implementation risks and take appropriate precautions.

Depending on the strategy and its context, the roadmap will cover both establishing a (national) platform and implementing one or more digital health care services. Particularly in resource-constrained environments, it may prove advantageous to start more complex digital health services on a smaller scale to first experiment and learn. The article “Lessons from large-scale [health care] improvement initiatives in Africa”[xv] suggests a four-step process:

1. Initial set-up, preparing the ground for introduction and testing of the intervention
2. Development of the scalable unit, which is an early testing phase
3. Test of scale-up, which applies the intervention in a variety of settings
4. Going to full scale which unfolds rapidly to enable a larger number of sites or divisions to adopt and / or replicate the intervention

3.4. IMPLEMENTATION OF THE DIGITAL HEALTH ECOSYSTEM (III.)

After agreeing on a strategy and having translated it into a detailed roadmap, the hard work of realising a Digital Health Ecosystem begins. Towards this end, six core challenges will be explored:

- Implementing an open digital health platform
- Identifying and scaling up core health care services and applications
- Establishing a comprehensive interoperability framework and infrastructure
- Incorporating an open source approach
- Change management
- Providing for a supportive legal and governance framework

Open digital health platform

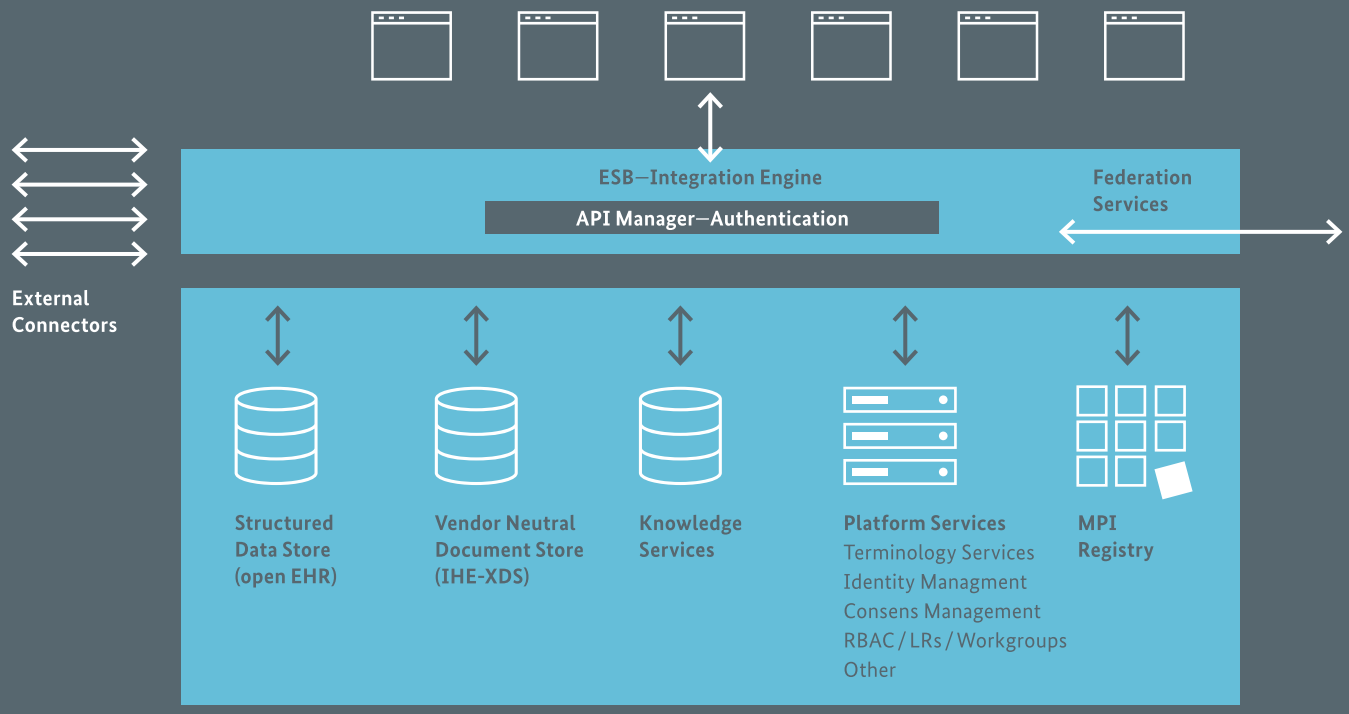
Comprehensive Digital Health Ecosystems have often been provided by commercial companies, applying proprietary architectures and standards. This renders it difficult, sometimes impossible and usually expensive to integrate new applications, extract and transfer patient data to other applications or even change the software supplier completely.

Open Digital Health Ecosystems, implemented at the national or district level, will help to overcome such barriers. This approach also facilitates the development and flexible integration of innovative third-party applications that support safe, high-quality health care. It allows apps and services from multiple vendors to work together, so that there is a many-to-many substitutability between applications and services. An application requiring access to an infrastructure service, e.g. the master patient index (MPI), can use any available infrastructure service as well as patient data provided by other applications via common, open and standardised data models and application programming interfaces (APIs). In this way, open platforms liberate both data and applications, making them portable and interoperable across different platforms.

Such an open Digital Health Ecosystem is vendor- and technology-neutral and facilitates innovation in smaller companies and start-ups that face lower barriers to market entry. Any application built for such an open platform will operate on any other given platform, applying the same standards. It forces vendors to compete solely on quality, value and service.

GRAPH 3

GENERIC OPEN DIGITAL HEALTH ECOSYSTEM ARCHITECTURE



Source: http://openehr.org/home

Graph 3 illustrates the generic architecture of such an open Digital Health Ecosystem. It shows how different electronic health care applications are separated by platform tools and services. Their integration is ensured via an enterprise service bus (ESB), the integration engine. For its overall functionality, it is mandatory that every software provider implements the agreed-upon and openly available standards and data models, like those developed by the openEHR (open electronic health record) community and many others. Furthermore, any software solution will have to be tested and certified as compliant with these requirements.

For data that need to be highly structured in quantified form, commonly agreed detailed clinical models must be available. Such models and their elements provide an unambiguous description of a piece of information, its structure and parameters and how they are measured or represented. This may apply to key elements of a basic patient or emergency summary (like a diagnosis coded by ICD 10, the 10th version of the WHO International Classification of Diseases), quantifiable elements of an electronic prescription or patient data needed as input for an electronic clinical decision support system.

For other information needs, an electronic copy of a paper document like a referral letter or a lab report may suffice. Other options include a consistently structured document complying with agreed-upon document standards like the clinical document architecture (CDA) of Health Level 7 (HL7) or message profiles, as specified by Integrating the Health Care Enterprise (IHE).

"Worldwide, the community of cooperating commercial suppliers of software, cloud and other platform services, infrastructure tools, implementation and management support is growing."

Data and information extracted from the respective data stores can be consolidated into a clinical data warehouse (CDW) or clinical data repository (CDR). This may be used to obtain a comprehensive overview of a single patient or to gain data for medical research, epidemiological analyses or public health purposes. If an open data approach is pursued and the required patient consent, data protection, anonymisation and security services have been implemented, such data may also be exposed to other users for purposes, as sanctioned, e.g. by regulation.

Whether such an open Digital Health Ecosystem is managed and maintained by a public institute, a cooperative of health care provider organisations or a private entity will depend on the respective circumstances. For IT companies to stay involved, it may require them to engage in new business models, based on delivering cloud services, software as a service (SaaS) and licensing agreements rather than selling hard- and software.

Worldwide, the community of cooperating commercial suppliers of software, cloud and other platform services, infrastructure tools, implementation and management support is growing. This trend, complemented by open source and proprietary application providers, offers a wide spectrum of electronic health care tools and systems, all able to connect to an open platform and exchange data in open standards and specifications.

Core starting services and applications

From the wide spectrum of open platform infrastructure services and digital health application tools, a small set of highly recommended services and application should be explored. The following represent proven options that need to be refined, based on a given context:

Infrastructure services
To ensure a future-oriented open ecosystem, a few core infrastructure services should be in place, independent of the longer-term vision for the holistic ecosystem. These may concern:

- **Electronic master patient index (eMPI)**
  The eMPI ensures the electronic identification (eID) of all persons covered by (public, statutory) health insurance or the national health care service, including their family members, in order to allow the univocal identification of each individual patient and the safe integration of their administrative and medical data independent of where, how and by whom such data are entered. An MPI may include administrative and basic demographic data.

- **Registry of health care professionals**
  The registry of health care professionals provides an authoritative eID for all persons, licenced to engage in health care interventions, including their domain of specialty.

- **Registry of health care provider organisations**
  The registry of health care provider organisations provides an authoritative eID of all organisations (hospitals, pharmacies, laboratories, etc.), licenced to undertake health care interventions on their premises or at a distance, including their respective specialties.

- **Data repositories**
  Data repositories ensure the safe, protected storage of patient data, held in an open, shareable format. This may concern structured quantitative data, documents (like a referral letter or a lab report) or pointers directing to the location of patient data in other federated systems or platforms.

- **Information governance and cyber security services**
  Information governance and cyber security services concern the management of information sharing, audit control of access and usage, encryption, privacy and data protection services.

- **Digital Health Institute**
  The Digital Health Institute is an organisational unit that is responsible for the establishment, management and maintenance of the digital health platform. Its infrastructure service is indispensable, where necessary in collaboration with specialised organisations like those responsible for granting physicians a licence to engage in medical services.

Electronic Administration (eAdmin) tools
Depending on the national platform context, administration support tools may be an integral part of infrastructure services or health care applications. In terms of cost efficiency improvements, tools that help to convert traditional paper processes into electronic ones may be considered as separate entities. These may concern logistics / ordering of supplies or electronic health insurance management systems.

Health care applications
As the need arises, this cursory review of digital health tools and applications should be specified in more detail and / or expanded and each generic service will need to be adapted in line with local health needs, requirements, health care organisational structures, policy priorities as well as access to telecommunications and electricity.

- **Electronic patient summary (ePS)**
  The ePS assembles a minimum or core set of data, which provides a health professional with essential information in the case of unscheduled care (e.g. emergency, accident) or when delivered to a hitherto unknown person. Such summaries are also designed for other contexts, like in support of care continuity, specific chronic diseases or the perinatal condition.

- **Electronic health record (eHR)**
  An eHR may denote an electronic medical record (eMR) of an individual in a physician's office or clinic, an electronic Patient Record (ePR) that assembles all patient data generated in various units of a health care facility or a longitudinal, life-long register of all health-related information for a specific person. The latter may be of great interest for medical research but will lead to information overload for a case-based intervention in a family practice.

- **Primary Health Care Information System (PHCIS)**
  A PHCIS is not a full-fledged eHR but rather an administrative system for managing patient throughput in primary care clinics. It may be complemented by a patient monitoring service, registering basic status-quo and disease process information for selected priority conditions like HIV, malaria and others.

- **Electronic prescription (ePrescription)**
  ePrescription is a computer-generated order for a medication, transferred by electronic communication to a national / regional repository or directly to a pharmacy. Up to 50 % of paper documents in a health care system may concern prescriptions for medicinal products. Therefore, ePrescription services can reduce costs and combat fraud and corruption at the same time.

- **Telemedicine applications (tMed)**
  tMed allow the remote diagnosis and treatment of patients. By connecting with health workers in remote regions, they render health care accessible to un- or underserved people and reduce the need to travel. A large variety of generic and disease-specific tools are available.

- **Mobile health applications (mHealth)**
  Smart phones have been engineered to serve as hubs to connect other devices, sensors and electronic tests, printers, etc. at the local level and more complex digital health platforms at community centres and district hospitals.

Electronic learning (eLearning)
As a summary term, eLearning refers to electronic training and (continuing) education platforms and tools. They provide access to learning when teacher and learners are separated by time, distance or both. Commonly, a website acts as a central directory / repository for various types of learning materials.

Public health applications
Public Health is concerned with the prevention of diseases, prolonging life and health promotion. This requires optimal allocation of public resources to medical care and rehabilitation, measuring the quality of health care services and controlling health outcomes. All of this, in turn, requires strong interorganisational cooperation and a comprehensive information base for political decision making—domains where digital health can play a key enabling role.

- **Electronic surveillance (eSurveillance)**
  eSurveillance refers to the electronic collection and analysis of health data about a clinical syndrome that has a significant impact on public health, which is used to drive decisions about health policy and health education. Many countries—including beyond the African context—regard an eSurveillance system as a strategic module of a national digital health strategy.

It may be complemented by an

- **Early warning systems (EWS),**
  a tool to generate and disseminate timely warning information to enable individuals, communities and organisations threatened by a health hazard to prepare and act appropriately to reduce the possibility of harm.

eSURVEILLANCE OF EBOLA

In October of 2014, during the Ebola outbreak in Western Africa, IBM launched a disease-mapping system in Sierra Leone that allow citizens to send free text messages about Ebola via mobile connections to the government. The same infrastructure was used by the Red Cross to send informative text messages to people in the most affected areas.

Towards a goal-oriented digital health interoperability framework

Defining health interoperability

Interoperability touches on issues beyond the technical level that are unique to health. Health system interoperability can be defined as

"facilitating the sharing, understanding and acting on patient and other health information among linguistically and culturally disparate medical professionals, patients and other actors within and across health systems in a collaborative manner".[xvi]

Dealing with interoperability issues is a strategic necessity for any successful Digital Health Ecosystem; it requires the full attention of all stakeholders. All digital health strategies talk about the need of interoperability, but most of them fail due to a lack of precision and translating the generic concept into a strategic perspective before creating a concrete action plan that meets the real needs of stakeholders.

Determining interoperability requirements

Interoperability must always be seen and analysed in the wider context of establishing a Digital Health Ecosystem. This implies that interoperability requirements cannot be identified *ex ante* but rather firstly need to reflect the respective data access and exchange needs of health system actors to be supported by the electronic tools and applications to be implemented. These, in turn, are driven by the overall health policy goals and the specific health system / health services domain in question, which may be the overall health system, only primary care, public health, administration and billing, any other of the earlier discussed specific implementation fields or a combination of them.

Furthermore, the geographic context within which interoperability is to be achieved can have a considerable impact, e.g. the languages spoken and the languages in which health records are maintained, the health care structures and resulting process and information sharing needs for cooperation between rural health stations, community centres, district hospitals, laboratories and others.

Core interoperability questions

After selecting the digital health applications for immediate or medium-term implementation, the next step is to address these challenges and implement interoperability solutions that meet the requirements of the stakeholders concerned. These requirements are defined by the physicians, nurses and health workers who will make use of the tools, but public health information needs should also be taken into account. Some core questions include:

- Who will gather the information and measure, record and transfer patient data to others, or make them available in a central repository?
- Who must or should know the information and data, and who does not (or should not) gather these data?
- What are data and information needs? For which intervention, analysis, decision, etc.?
- In which form should the data and information therefore be made available, as a narrative text, a named document (e.g. referral letter, discharge letter, lab report), structured document / report (at which level of granularity?), quantitatively measured data, semantically coded information item, picture, video?
- At which level of quality is the data needed?

Analysing and answering these questions will help determine the level of data complexity needed (a short text of a few sentences in a secure e-mail or a simple electronic 'paper' document sent via a secure network vs. detailed clinical data models and data elements with semantic coding (term binding) and value sets). It will also determine whether an ex ante agreement and value sets to allow for seamless, safe integration and aggregation of data for further analysis are mandatory.

The long-term benefits for stakeholders and the health system should be weighed against the considerable implementation and maintenance costs for ensuring the desired mode and detail of the interoperable solution.

Interoperability domains

When planning and organising a comprehensive interoperability framework and tools, four domains need to be analysed (for an overview, see Graph 4):

- **Policy domain**
  It is in the policy and strategy domain where high-level decisions are made, including which data should become interoperable for which health policy needs and for which health care / clinical or public health purposes. Implementation measures must be foreseen to assure that these interoperability objectives are indeed reachable.

- **Governance and legal domain**
  Interoperability is concerned with accessing and exchanging data. Governance and legal / regulatory issues are core success factors for realising a certain degree of interoperability within national Digital Health Ecosystems. Usually, it will be mandatory to clarify ownership and access rights, privacy, confidentiality and system security to respond to increasing challenges in this field, thereby, strengthening trust and confidence of all stakeholders, particularly patients and health professionals. Often, it is advisable to advance regulations that determine interoperability objectives, actors to be involved, processes to reach agreement, standards and specifications.

→ **Organisational domain**
Securing interoperability is a long-term activity. Successful eHealth interoperability frameworks, therefore, require dedicated organisational support structures and processes to not only guide and direct digital health infrastructure investments and controlling, but to also run daily administration and production or to commission appropriate private enterprises for selected tasks. This also includes maintenance of national versions of international standards and terminologies.

→ **Data format, modelling and coding domain**
In technical and engineering contexts, the focus predominantly lies on this domain. It does not only concern the technically correct, univocal transfer of data so that the person (or machine) accessing or receiving the data can indeed see and use them 'as is', but also the application of conventions or standards, such that the receiver fully understands the structure in which the data, information or knowledge are presented, e.g. header information / metadata; and it concerns lastly the conceptual level, i.e. to ensure that the data and information transferred are understood correctly with respect to their 'meaning'. Accordingly, there are at least three levels of interoperability that build on each other and may be present, to different degrees, in a given set of data:

Technical interoperability
As an initial and in many health system contexts already highly relevant step, basic data interoperability is achieved via an exchange of e.g. electronic 'paper' documents in basic PDF format or similar, meaning the document is accessed or transferred as it is and cannot be integrated with similar data from other documents or health care providers.

Structural interoperability
Within structural interoperability, documents are structured according to standardised headings, such as the HealthLevel 7 (HL7) Common Document Architecture (CDA) standards, e.g. for prescriptions, continuity of care documents, etc. This allows for regrouping and assembling patient data according to headings on the contents of the sub-fields, such as medications prescribed, symptoms and allergies.

Semantic interoperability
A further integration level is achieved when the data elements measuring or describing a clinical concept are standardised in a detailed logical clinical model, an archetype or similar standard form and fully coded (like diagnoses coded in WHO ICD 10 with three digits; some countries maintain national versions with up to 5 digits). This is necessary in case (patient) data like active medications are to be integrated across various health care providers the patient has consulted or are to be aggregated and analysed, e.g. for research or surveillance purposes.

Information and data measured consistently in a quantitative, semantically coded manner can be extracted from the respective clinical data stores and easily consolidates into a clinical data warehouse (CDW) or clinical data repository (CDR). This may be used to obtain a comprehensive overview of a single patient, for medical research, epidemiological analyses or public health purposes.

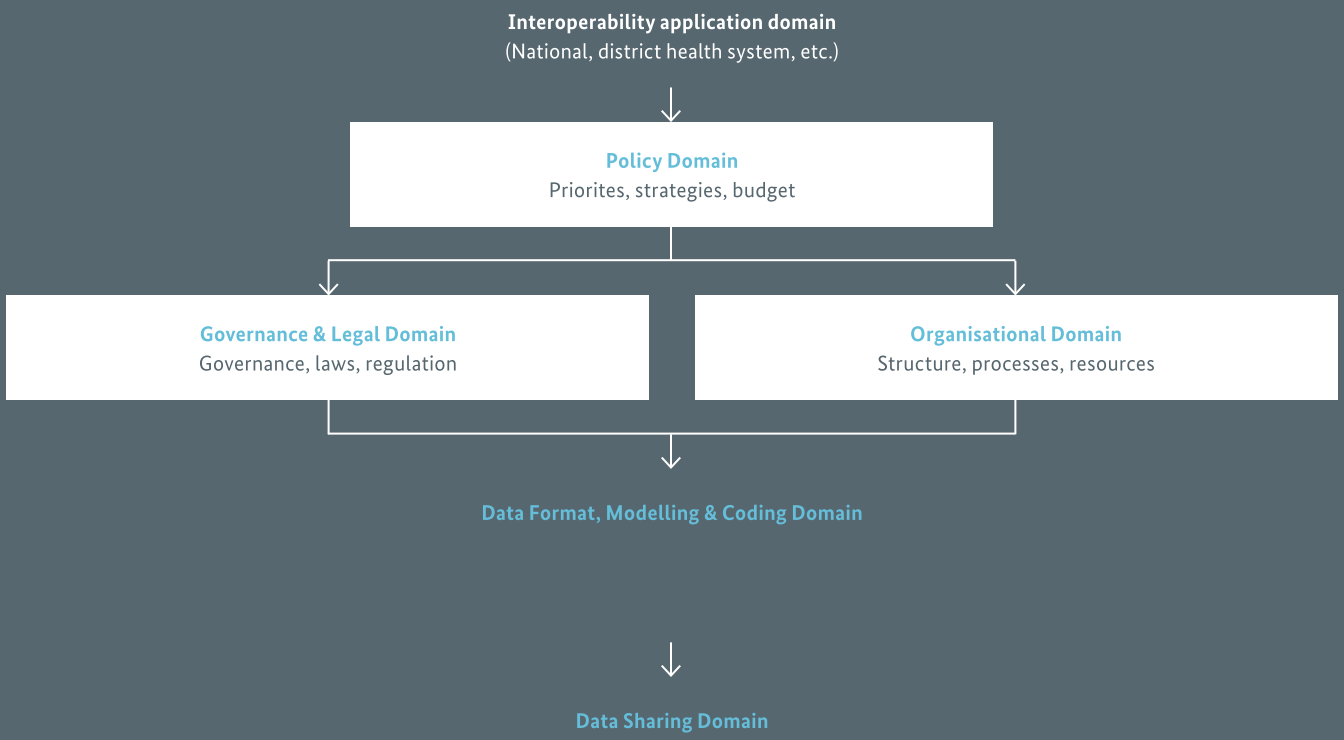
→ **Data sharing domain**
As its final objective, interoperability is concerned with the sharing of information and data. In a digital environment, this relates to how patient and other health information becomes available to stakeholders who need that data for a particular purpose, for instance to receive information about active medications, allergies and lab results other physicians or organisations have already recorded for that patient. The data can be stored in the cloud or a central (or several linked, distributed) data repository(ies) where the authorised actors can directly access the patient data whenever needed.

An alternative is to leave the data in each actor's own digital repository. Upon authorisation by the patient, the presently treating physician may search a central digital resource for links related to that patient, which guide the professional to specified and briefly described data stored by a professional the patient has consulted earlier. This, however, requires permanent online access for physicians and hospitals. Yet another option is transferring data, usually in the form of a message, to the requestor after receiving a dedicated note asking for that data.

"Successful eHealth interoperability frameworks require dedicated organisational support structures and processes to not only guide and direct digital health infrastructure investments and controlling, but to also run daily administration and production."

GRAPH 4

INTEROPERABILITY DOMAINS[xvii]



Independent of the sharing option is the decision how to share data. The ecosystem must be designed accordingly, based on the required technical, organisational and governance solutions.

A related aspect is data storage length. Usually, countries decree by law how long a physician or a hospital have to store and retain in an accessible format the data measured or gathered by them. This compulsory period of record-keeping may be different (and usually shorter) with respect to data that have been additionally stored in a central data repository for access by other entities, as authorised by the patient. Physicians and other health professionals may neither be inclined nor have the time to sift through many, perhaps hundreds of old documents or take the risk and legal liability for missing crucial information.

It may be advisable to start making documents available at a technical interoperability level or as structured documents before a comprehensive, fully specified, holistic national interoperability framework has been agreed upon and a supportive institutional structure has been established. Starting early and leveraging the "open" approach will enable improved, more efficient sharing of data and integration of health care services.

Globally, "openSource" software, "openData" access, "openStandard" availability and "openPlatform" approaches have gained momentum both in industrialised and resource-constrained environments. This "open" movement is now ubiquitous, recognised across public and private entities as a fundamental course of action towards building interoperable, easy to use infrastructure components as well as a critical factor for driving innovation in 'vertical' markets. The source code of software and tools developed by the open source community is not proprietary, but can be freely copied, modified and distributed; it is managed and continuously improved by engaged participants. Some of the biggest companies in the world like Google and Facebook have released software to this community to allow it to evolve through support and feedback to improve their own services.

In the health sector, working together at a global scale to improve both interoperability and economic efficiency of Digital Health Ecosystems and applications is well-established. It fosters competition across suppliers, triggering new business models and markets and is easing market entry barriers for small, innovative companies. At the same time, this approach also counteracts vendor lock-in. Some exemplary applications and tools include:

- **Open Medical Record System (OpenMRS)**
  OpenMRS is an open source medical record platform that allows for designing a customised medical records system with little programming skills. Its features include a central concept dictionary, modular architecture and standards support. Instead of just releasing a generic enterprise-grade platform and leaving it up to each implementation to configure, the new OpenMRS2 includes functionalities 'outside of the box', such as patient summary, visit view for data clerks, vital signs capture, diagnosis capture and support for multiple wards / health services.

- **Open domain-driven platform for developing flexible eHealth systems (OpenEHR)**
  OpenEHR is a virtual community working on means of turning health data from physical into electronic form and ensuring universal interoperability among all forms of electronic data. The primary focus is on electronic health records (eHR) and related systems. Components and systems conforming to openEHR are 'open' in terms of data, models and APIs. They share adaptability, due to the archetypes being external to the software and significant parts of the software being machine-derived from the archetypes. The archetype specification is now an ISO standard (ISO 13606-2) and used by several national governments to specify national eHealth information standards.

- **District Health Information System 2 (DHIS 2)**
  DHIS 2 is a free software tool for the collection, validation, analysis and presentation of aggregate and transactional data, tailored to integrated health information management activities. It is used at various levels in about 50 countries.

- **Open Health Insurance Management Information System (OpenIMIS)**
  OpenIMIS is an initiative for providing a comprehensive system, linking patient, provider, and payer data. The system is designed to manage any health insurance scheme, from enrolling patients to transmitting and processing claims and calculating reimbursements. The initiative has created a community of practice for software developers and users and provides capacity-building services.

- **OpenHIE**
  OpenHIE is a global mission-driven community of practice to promote interoperability in the health sector. It has developed a Health Information Exchange architecture and freely available standards-based approaches and reference technologies that leverage existing Health Information standards like HL7, DICOM, etc.

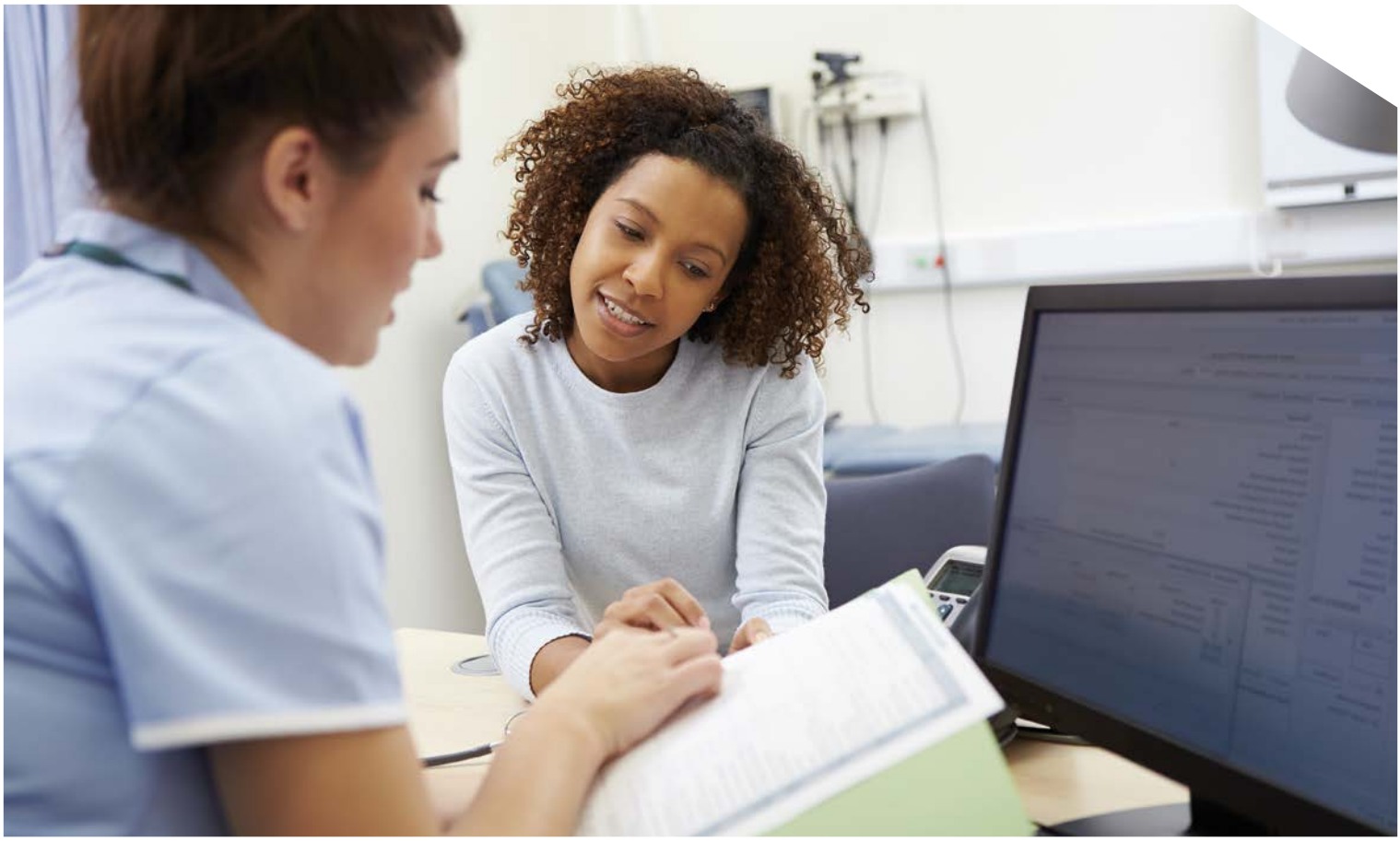
- **Open Health Information Mediator (OpenHIM)**
  OpenHIM is a middleware component designed to facilitate secure communications and data governance support between disparate clinical information systems as well as support for routing, orchestrating and translating requests. It also supports information sharing among infrastructure tools and applications.

- **Magpi**
  Magpi is an OpenSource tool that can be used for any kind of mobile data collection, e.g. as input into an electronic health record system or for a medical research project. The community started with applications in global health but is now applied in many other domains. Critical patient data values may be identified to trigger alerts, to-do items or other actions.

- **open-eLearning**
  Various software platforms and tools support eLearning, e.g. iPath, an open source web application service that provides a free platform for "case based collaboration", especially designed for medical applications (telemedicine, etc.). The iPath-Server package provides a medical bulletin board system (BBS) to discuss / consult cases online. A BBS is an application dedicated to the sharing or exchanging of messages or other files on a network.

The need for change management

Substituting hitherto paper-based recording and information exchange systems by introducing digital services is not simply a means for improving the efficiency of existing processes. A Digital Health Ecosystem with all its potential for the health system to evolve towards safer, better health for all and more efficient, integrated health care processes is quite different from what it was before. It enables fundamental change in the way health professionals and others work together within and across organisational borders, share patient data, manage the resources of their organisation, supervise and guide the allocation of public funds, organise health system surveillance and quality control. Eventually, a different health system will emerge.



To guide and direct this process of moving from one state of the system to the other, professional change management is mandatory. This is a regularly neglected success factor in establishing a Digital Health Ecosystem. Applying professional change management principles and processes will help to implement the new ecosystem. First and foremost, change management is about people—they are the ones who have to transform their organisation and / or the national system. Therefore, they must be convinced that change is necessary and will benefit not only the organisation or the whole health care system, but also them. Professional change management experts should be involved to explore questions, such as:

- How must the organisation / system change to seize new opportunities and meet new demands?
- Who should lead the change?
- How can all stakeholders be involved?
- What steps should be taken to accomplish the change?

To ensure shared ownership, a participative approach is critical. A rigorous and often time-consuming process of information sharing and dialogue is necessary to create an alignment of a core, multidisciplinary group, composed of key stakeholders with a strong champion or change agent in the lead. Ideally, this will be a health care professional with IT knowledge. Time and energy spent in tough meetings with the right people will produce strong strategies and leadership throughout the organisation.[xviii]

Experience has shown that implementing a Digital Health Ecosystem is a rather complex, long-standing process, usually extending over three to five and often many more years, before starting to deliver the desired benefits. This long-term process in combination with the fast-changing IT technology environment has shown that a key success factor is a pragmatic, step-by-step roadmap approach, guided by a clear digital health vision, but not an unchangeable, long-term strategy. A certain degree of flexibility and regular review of digital health achievements will be critical when dealing with such a complex and changing environment.

Another cornerstone of successful change management in a digital health context is a focus on user-friendly software tools and applications that improve clinical workflows, facilitate information sharing and save time. Intensive training, taking full account of the learning needs of clinical staff in addition to sufficient help-desk support during the final stages of implementation and going online is indispensable.

Resistance to change will not disappear overnight, trust will not magically materialise and governance challenges will not melt away simply because of a new policy, strategy or roadmap. However, professional change management will help to overcome these barriers and foster digital health, thereby helping health personnel spend less time on paperwork and more time on health, catch gaps in health services early and better understand populations and their health needs.

Governance and legal framework

To function efficiently, reliably and amicably, open societies need a well-designed governance and legal framework. "Governance" can refer to civil society level laws and regulations—"rules that guide the course of a system" or a country—as well as to "rules of order" or procedure for small group activities.

Health governance is important because it affects the choice in implementation policies and sustainability procedures, how they are applied and how well they work in the respective context. Making and implementing authoritative collective decisions by involving key actors is fundamental. At the level of *health system governance*, the WHO has recently proposed the "TAPIC framework for analysing and improving health". It identifies and defines five mutually exclusive attributes of governance that influence decisions made in a health system and the resulting consequences:

- Transparency
- Accountability
- Participation
- Integrity
- Capacity[xix]

Each attribute is linked to specific policy and administrative tools. Transparency is enhanced by freedom of information legislation, accountability is promoted by clear mandates and reporting, participation is ensured by requirements to involve the impacted stakeholders, integrity is enhanced by clear job and organisational role definitions and capacity is improved by hiring or training skilled policy staff. Other tools, such as conflict of interest policies, promote several attributes (transparency, integrity and accountability).[xx]

These properties apply to *individual health organisations* as well. Each health service provider must be accountable to the overall health services system. Transparent national maps of accountability relationships and capacity building can help in reaching this level of accountability.

These attributes also hold for *generic digital health governance* as part of the overall health system. When planning, realising and expanding a Digital Health Ecosystem, they should be supplemented by *digital health implementation governance* aspects that are concerned with agreements or formal rules based on:

- decision making, including how it is prepared, and the role of stakeholder groups
- how to resolve conflicts in the case of serious disagreement
- establishing organisational structures and administrative processes
- securing funding and allocation of financial resources
- procurement processes
- determining timelines and outcomes to measure performance
- allocating responsibilities and control functions

Digital Health Ecosystem governance is responsible for "decision-making and authority on matters relating to data and information". Depending on the respective context and country, already existing governance rules, regulations and legislation concerning

- protection and privacy of citizen data
- telecommunications connectivity by any mode of transfer
- cyber security

need to be explored.

"Health governance is important because it affects the choice in implementation policies and sustainability procedures, how they are applied and how well they work in the respective context."

As health-related data is usually considered particularly sensitive, additional, more strict or specific governance rules and laws will become necessary to deal with issues such as

- ownership of health data and patient consent
- privacy and confidentiality
- secure storage
- sharing of data across health care providers and for public health purposes
- authorisation, authentication and means of access
- assuring transparency and control of access through audit trails
- securing quality and integrity of data
- anonymisation of patient data when used for medical research, management purposes or resource planning and utilisation analyses
- functionality, reliability and security of eHealth devices and applications
- accreditation of eHealth suppliers for procurement, implementation and operation
- standards and specifications to enable interoperability, including requirements for an (open) platform architecture, clinical data models and semantic dictionaries to be used when implementing and operating eHealth services
- enforcement of governance rules and regulations

As digital technologies develop at an everfaster rate, digital health governance and regulation is becoming more complex. In most African countries, basic frameworks of governance rules need to be strengthened.[xxi] This will require considerable resources, time and pragmatic decisions based on priority challenges to start with and progressing in line with the rollout and expansion of the Digital Health Ecosystem.

3.5. ASSESSING AND MEASURING IMPACT (IV.)

Evaluating and controlling health and financial benefits versus economic costs of digital health investments is essential. The evaluation should also involve comparing the realised economic efficiency with that of other investment opportunities. Learning from past lessons will help to guide further development of the Digital Health Ecosystem. However, assessing and measuring the impact of eHealth systems and services, their benefits and costs and ultimately of improved health outcomes is a challenging, if not elusive undertaking.

Nevertheless, as resource allocations and investments grow, it is particularly important for the health ministry and health system institutions to build robust performance measurement systems to successfully compete with other policy domains in the parliamentary process. Doing so will enable them to demonstrate the importance of such programmes and provide evidence in the political arena to secure sufficient allocation of scarce public and private resources.

A comprehensive digital health monitoring and evaluation framework and toolkit has been developed and proposed by the WHO. It defines indicators for eHealth results, provides for baseline and target measures for these indicators and proposes a supporting governance structure and processes to execute the framework. This will enable to track and assess the results of implementing a Digital Health Ecosystem strategy and action plan. The suggested "Results-based Management" (see Graph 5) approach, as developed by the United Nations, focuses on performance and outputs, outcomes and impacts by:

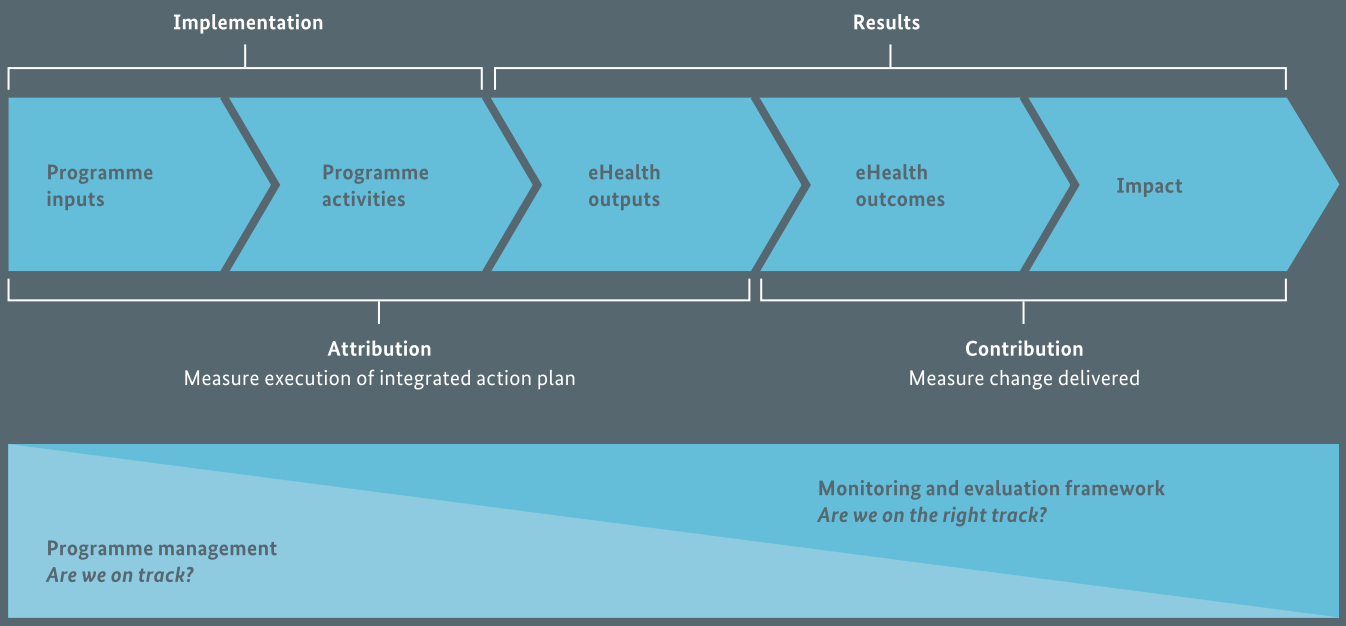
- defining indicators that provide insight into the adoption of digital health and resulting tangible results for health and non-health stakeholders;
- identifying indicator baseline and target measures to allow monitoring and evaluation of progress over the duration of the plan; and
- describing the governance and processes required

A clear distinction exists between a monitoring and evaluation framework for a national eHealth strategy and the programme management activities that help implement and manage a large-scale eHealth action plan. Programme management monitors the execution of the action plan and is central in answering the question of whether the country is on track in terms of its implementation of a national eHealth environment. Monitoring and evaluation, on the other hand, plays an essential role in demonstrating the progress that a country is making towards the development of its national eHealth environment and the results or changes that these efforts are delivering. The outputs of monitoring and evaluation form a critical part of ongoing communication regarding a country's national eHealth programme, which in turn is essential to building the support of stakeholders for further adoption and investment in eHealth.

In particular, communicating the progress and results of the eHealth action plan is important in demonstrating to donors or funders the impact of their investments. It can also help in building trust and understanding with potential funders as to how their contribution would be used to further the country's national eHealth programme.

GRAPH 5

RESULTS-BASED EVALUATION MANAGEMENT



Source: WHO eHealth toolkit, Part III, p.1

3.6. SUMMARY: KEY SUCCESS FACTORS

Global experience and insights have shown that investing in isolated, local and disconnected eHealth activities will not lead to nation-wide, efficient and sustained digital health services. Rather, a comprehensive approach is needed that builds on a well-founded health policy and sets clear priorities for health care. The resulting eHealth strategy defines limited, reachable goals in supporting and realising these policy priorities.

While lessons can be derived from other countries and districts, it will be impossible to simply "copy and paste" solutions found elsewhere. Each country is different and approaches must always to be adapted to local conditions, needs and capacities.

To start, the following preconditions should be met:

- Political and economic stability
- High-level national leadership support (at the political, clinical and citizen / patient level)
- Full engagement of critical stakeholders
- Longer-term affordability / financial support
- Minimum ICT and eHealth capacity (human resources, technology, infrastructure)
- Local ownership

- Furthermore, it is important to realise that a sound strategy is only a very first step towards a Digital Health Ecosystem.
  To increase the chances of success:
  - Use a comprehensive, yet simple and flexible roadmapping approach
  - Take a medium to long-term time horizon
  - Initially, go for low hanging fruit, i.e. drive for early benefits for key actors, particularly health care professionals / workers
  - Ensure regular reviews and assessments
  - Buffer against day-to-day interference by politicians (they usually have a relatively short time horizon)
  - Create trust, keep stakeholders informed, involved and committed
  - Provide for longer-term affordability / financial support
  - No technology-push: get physicians (with IT knowledge) in the driver's seat (local ownership)
  - Build on and integrate with what is already there, not another separate project

4. The Way Forward

Clearly, the way forward to successfully establish and maintain Digital Health Ecosystems in developed as well as in resource-constrained countries and districts is investing in a holistic vision, driven by overarching health system priorities and needs and an integrative approach that assures that the deployed eHealth systems are integrated with one another through a national digital health infrastructure platform.

Considering the diversity of African countries, there are ample opportunities to support the endeavour to upgrade health systems and health care delivery and to invest in national or district Digital Health Ecosystems. Indeed, well-planned and well-implemented eHealth services and applications present a great potential towards facilitating better health care, improving public health and bringing health services to remote areas. This will, in turn, underpin economic growth, wealth and overall well-being.

To identify concrete investment opportunities in African Digital Health Ecosystems, broad-based (eHealth) readiness rankings of Sub-Saharan African countries assisted in identifying four promising countries.

To translate opportunities into action, a cooperative investment approach is proposed. Customers (local Ministries of Health, health care providers and health professionals), national and international donors and financiers, not-for-profit and commercial suppliers (providers of digital health software, hardware and services) have to come together and collaboratively pursue country or district-specific opportunities. A promising way forward could be working in a regional cluster of excellence with a medium-term "business plan".

4.1. INVESTMENT OPPORTUNITIES IN AFRICAN DIGITAL HEALTH ECOSYSTEMS

A careful analysis of a country's eHealth readiness should precede any action towards supporting the implementation of a Digital Health Ecosystem and connected digital health applications. eHealth services enable and can improve concrete, hands-on health care delivery, but usually do not substitute them. Therefore, political stability and sufficient infrastructure are key ingredients for a successful initiative.

Country rankings

The European Space Agency (ESA) study on "Interoperable eHealth Systems for Africa"[xxiii] collected primary and secondary data on the overall political and socio-economic situation as well as health systems and their eHealth potential in 48 Sub-Saharan African countries. After analysing the overall development stage and health system status of these countries, 28 of them were selected for further analysis, including visits to local government authorities and health system stakeholders.

In a first assessment round, the researchers measured political stability and societal governance, availability or plans for basic national eGovernment and / or eHealth platforms and their financial base, nation-wide communications infrastructure and connectivity, as well as political interest in and anticipated impact on population health. Then, the countries were ranked accordingly.

Selecting the 16 top ranked countries, a second round of assessment followed, which focused on an in-depth survey of the countries' eHealth-readiness, based on concrete plans, platform / service implementations as well as resources available to sustain eHealth services once implemented. This led to a final eHealth ranking to indicate countries that at that point in time could be considered promising for successful and sustainable investments in Digital Health Ecosystems and tools.

The results are depicted in Table 1. The final ranking was performed by averaging the scores obtained from both the eHealth platforms, applications and services currently deployed in Sub-Saharan African countries (25 % of total score) and the availability and coverage of eHealth necessary resources (75 % of total score). This reflects the fact that nation-wide digital health implementations are still relatively scarce and therefore, the expected potential for successful implementations was deemed more important, based on resources available.

TABLE 1

eHEALTH PRIORITY RANKING OF SUB-SAHARAN AFRICAN COUNTRIES

Country	Platforms	Resources	Combined Score	Rank
Uganda	7,1	4,8	10,7	1
Tanzania	6,4	4,6	10,2	2
Rwanda	5,7	4,9	10,2	3
Namibia	3,9	5,4	10,0	4
Kenya	5,7	4,7	9,9	5
Lesotho	5,0	4,9	9,8	6
Ghana	4,6	4,9	9,6	7
Botswana	2,9	5,4	9,5	8
Zimbabwe	4,6	4,7	9,4	9
Mozambique	4,6	4,4	8,9	10
Zambia	4,6	4,3	8,8	11
Cameroon	3,9	4,5	8,7	12
Benin	4,3	4,4	8,7	13
Madagascar	3,6	4,4	8,4	14
Senegal	3,6	3,6	7,1	15
Côte d'Ivoire	3,2	3,6	7,1	16

Source: ESA Interoperability study

Another ESA-supported study ranked Sub-Saharan African countries using the developed eHealth Regulation Readiness Index (RRI). This index measures the current, estimated percentage coverage of eHealth regulation and governance items, based on 64 regulatory and governance aspects organised in six categories. The outcomes for the highest ranked countries are shown in Table 2.

The countries covered by these two ranking exercises are not fully identical due to missing information. Nevertheless, they show a considerable degree of overlap, allowing a closer focus on the most promising countries. In addition, these rankings are based on available objective information, while investment decisions include the actual political and economic context as well as subjective aspects like familiarity with the country, mutual trust or long-established contacts.

Overview of four highly ranked countries

In the eHealth priority ranking of Sub-Saharan African countries, Tanzania, Rwanda, Namibia and Kenya scored 2nd to 5th place. In the following section, the challenges and opportunities in each are briefly explored.

Kenya

Kenya's national health policy objectives include minimizing exposure to health risk factors, providing essential health care, strengthening collaboration with health-related sectors, reducing the burden of violence and injuries, halting and reversing the rising burden from non-communicable diseases and eliminating communicable diseases. Health care facilities are operated by a wide range of government offices, faith-based organisations (FBOs), non-governmental organisations (NGOs), international development organisations and individuals. Government-operated health facilities are classified into six levels, as defined in the National Health Sector Strategic Plan II (NHSSP II), depending on their proficiency and geographic responsibility. Local community health units fall within level 1, whereas level 6 organisations are national hospitals.

Kenya's eHealth vision is to develop efficient, accessible, equitable, secure and consumer-friendly health care services, enabled by ICT. Within the Ministry of Health, a special eHealth unit developed the eHealth strategy of 2011–2017, which concentrated on five key areas: telemedicine, health information systems (HIS), information services for citizens, mHealth and eLearning.

Electronic health record and telemedicine / remote diagnostic systems are prime services in use, as are mHealth applications and eLearning tools. Software packages that are widely used include open source OpenMRS and DHIS 2. Most eHealth interventions are delivered through mHealth services due to high geographical connectivity ensured by mobile networks.

TABLE 2

SUB-SAHARAN AFRICAN COUNTRIES RANKED ACCORDING TO THEIR eHEALTH REGULATION READINESS

Country	Score	Rank
Mauritius	7,5	1
Botswana	6,0	2
Seychelles	5,5	3
Cape Verde	5,0	4
Ghana	5,0	5
Senegal	5,0	6
Rwanda	4,5	7
Namibia	4,5	8
Uganda	4,5	9
Kenya	4,5	10
Zimbabwe	4,0	11
Gabon	4,0	12
Mali	3,5	13
Mozambique	3,5	14
Nigeria	3,5	15
Sudan	3,5	16
Zambia	3,5	17

Source: ESA Regulatory study

The following electronic infrastructure tools exist or are under development: an electronic citizen identity card, a health professionals database provided by the Kenya Medical Practitioners and Dentists Board, an electronic health facilities database (eHealth Kenya Facilities), a Health Professionals Registration System (HPRS) of the Kenya Medical Practitioners and Dentists Board, a national eHealth website and a secure e-mail systems (eHealth Kenya Facilities). In some instances, health workers in rural / remote areas are able to email x-ray images, medical notes and digital photographs of critically ill patients for expert clinical diagnostic support from experienced professional clinicians hundreds of miles away, therefore bringing health care to the most remote areas. Telemedicine is one of the most compelling eHealth examples of life-saving importance in Kenya, where mortality rates in remote areas have dropped significantly.

At the core of eHealth political drivers is the Ministry of Health. Since 2008, it has been responsible for the national eHealth strategic plan and its implementation. Additional actors and stakeholders include other government ministries and departments, universities, private sector players, hospitals, civil society organisations and development partners. Contributing factors are an already enforced national ICT policy and eGovernment strategy, available skilled labour, high-quality health institutions as well as

a national ICT infrastructure. Others include competent health training institutions at all levels, a high level of ICT awareness among the general population, health practitioners interested in eHealth technologies, relatively widespread internet and mobile connectivity, alternative sources of electrical power infrastructure and non-grid based power solutions.

Through the centre for Open and Distance Learning (CODL), an initiative of the University of Nairobi, Kenyans without access to quality university education can learn ICT skills, which has facilitated the application of eHealth solutions.

In spite of these positive and highly applauded digital health developments and deployments, the new eHealth Policy for 2016—2030 notes that isolated eHealth initiatives and implementations are widely scattered in different counties across the country; around 35 of them (75 %) have at least one eHealth project. Usually, they do not communicate with each other, thereby foregoing the benefits of information and data sharing. One reason is the diversity of disparate health service provider owners; most eHealth projects are funded by development partners and non-governmental organisations. This also renders it particularly difficult for the Ministry of Health to assess, monitor and regulate eHealth systems operating in Kenya. A maintained, central registry of eHealth projects in Kenya does not exist. Further challenges include:

- Parallelism: system exist as silos and do not talk to each other
- lack of agreed upon or regulated eHealth standards and guidelines
- Inadequate technical expertise
- Weak regulatory framework
- Lack of ownership and sustainability of eHealth projects
- Multiplicity of systems that do not scale up

In view of this state of affairs, three core policy objectives include:

1. Enhance interactions between clients and health service providers through the following priority actions:
   - Promote electronic access to quality health care by establishing interactive platforms between clients and health service providers
   - Enable health service providers and their clients to easily collaborate and consult each other electronically
   - Improve client-provider interaction through ICTs
   - Promote clients' decision-making and management of their own health

2. Accelerate universal health coverage:
   - Improve health literacy levels by providing materials, including but not limited to written, printed and spoken words to patients on how to use eHealth
   - Promote availability, accessibility and affordability of ICT infrastructure, devices and connectivity
   - Ensure deployment of user-friendly eHealth platforms

3. Enhance the electronic exchange of health data and information:
   - Ensure standardisation of stored data to promote interoperability of eHealth systems
   - Continuous improvement of infrastructure and resources to support cost-effective implementation of tele-health applications
   - Ensure prompt and convenient access to patient's demographic and clinical data to privileged health care providers

To support the Kenyan Ministry of Health in integrating public health and surveillance data systems into a unified, more efficient framework, global health partners are now working together as a Health Data Collaborative to align and harmonise their financial and technical resources. Kenya is the first African country to officially launch such a Health Data Collaborative. Through this global initiative, more than 30 global partners, including BMZ and GIZ, align to strengthen public health data systems worldwide.

Namibia

Developing a health systems and investing in eHealth are a priority for Namibia. Its Fourth National Development Plan (NDP 4), which ran from 2012 / 13 to 2016 / 17, identified health as a part of public infrastructure and a key enabler for economic development.[xxiv] Namibia's spending on health is low by global standards, albeit higher than in most other countries in the Southern African Development Community (SADC). The recent, fifth development plan reiterates the core importance of the health system, where investment needs to be strategic and results-oriented. In particular, the Namibian government plans to address the shortage of health infrastructure facilities. A basic Digital Health Ecosystem with priority functionalities could be of major support.

The National Health Policy Framework 2010—2020 underlines that "health information is for management and policy change and development". However, existing health information systems suffer from fragmentation, where resource-strong programmes "push" their own information system agenda. The central electronic health information system (HIS) is understaffed and slow. To cope, various strategic response directions include:

- "Integration of parallel resource-strong programme information systems in the mainstream health information system, which is server-based;
- creating closer links between information and policy and planning;
- enabling health workers / health managers at all levels to access and utilize information;
- timely delivery of information related to nationally and internationally agreed indicators, e.g. Millennium Development Goal indicators;
- developing and maintaining relevant linkages as much as possible between various information systems"

Health sector ICT solutions are part of "The Harambee Prosperity Plan—E-Governance" and an e-Health project of the Ministry of Health and Social Services (MHSS) is one of eleven prioritised initiatives. These activities strengthen the 2011 announced "Integrated Health Care Information Management System (IHCIMS)". In 2017, the Ministry of Health and Social Services added that it is "in the process of finalising the implementation of the E-health project for state facilities that will provide for the use of paperless health passports at state hospitals".[xxv]

Rwanda

Health policy in Rwanda is driven by a decentralisation agenda to strengthen health care financing through community-based health insurances called "mutuelles de santé". It includes building local human and organisational capacity of service providers, significant investment in eHealth systems as well as innovative solutions. The health system is also characterised by a growing number of private hospitals, clinics, laboratories and pharmacies.

Decentralisation in the health sector has ensured that at the village level, at least one health unit or health post provides basic services in addition to the district, provincial and referral hospitals. Both hospitals and health units often possess their own internal information system that, however, is not connected to others. A single optical fibre runs through Rwanda; a 4G LTE mobile network provides additional connectivity in all districts. Mobile phone penetration levels are relatively high but do not yet extend to smart phones, computers, iPads and other smart mobile devices. Nevertheless, the core telecommunications infrastructures required for a national health grid system are available.

Presently, health care record keeping is mostly paper-based and the eHealth tools and services in use are not interconnected, i.e. quick, accurate and secure access / sharing of patient data at the point of care is not possible. In addition, the private health care sector requires connectivity to a national grid. Recently, data breaches, medical identity thefts, ransom wares that target centralised systems and increased cyber-attacks have become a ubiquitous challenge.

Over the past decade, the government of Rwanda has invested significantly in eHealth interventions in a bid to improve health care delivery. These interventions include deploying a number of information systems, such as an integrated routine reporting health management information System (IS), electronic medical records, electronic logistics management IS, mobile community based IS, a human resources IS, resource tracking IS, laboratory IS, integrated disease surveillance IS, blood bank IS as well as telemedicine devices and systems.

In spite of these investments, there are still numerous challenges. In a recent statement on the "Enhancement of Rwanda National Digital Health Care System—'Smart Health'", the Ministry of Health made the following observations:

> *"The earlier interventions only focused more on routine reporting and disease surveillance systems. The deployed systems are in silos and there is no system that is integrated with another. There is no timely information for easy and quick decision-making; there is no ability to track service levels across the whole health sector. Due to the silos of systems, patient records are only limited to the health facility visited. Medical records are still paper-based, which renders sharing of medical records and patients follow-up very difficult. Due to Rwanda's hilly terrain and inefficient transport infrastructure especially in rural areas, patients find it difficult to access health facilities. Patients also have to make long-distance travels to urban areas to access specialised medical services. Multiple reporting systems impose a burden on health workers and make it difficult to access data for evidence-based decision-making. An increasing share of services delivered by the private sector, that does not report systematically, means that a growing piece of the epidemiological situation is missing. Sustainability is always a concern in the health sector, which is heavily dependent on donor funding. With decentralisation, health facilities need robust financial management systems to improve efficiency, accountability and enhance revenue collection. There is no proper interoperability framework in place for all these system. These systems were also developed on different platforms and data stored in legacy systems. This has resulted in considerable duplication and difficulty to access and consolidate data for evidence-based decision-making. Terminology and technology standards need to be implemented to ensure system interoperability".*[xxvi]

Being fully aware of this situation, the Ministry of Health of Rwanda intends to put in place an integrated, comprehensive information system across health care facilities nationwide. Components and functionalities envisaged encompass:

- Electronic Medical Record System (EMR)
- Health Information Management System (HIMS): Patient administration, basic health care, laboratory, radiology, in-patient, out-patient, prescription & pharmacy, imagery, appointment request & scheduling, payment, special treatment, etc.
- Enterprise Resource Management for administration and management of health organisations (Health Care ERP)
- Reporting: Business Intelligence (BI) & Analytics for decision support
- Mobility support (Apps)
- Telemedicine and eLearning component
- Effective monitoring and evaluation capabilities
- Relevant regulatory and compliance guidelines

These components would call for an open, interoperable Digital Health Ecosystem approach to fundamentally improve the eHealth infrastructure and applications of the Rwandan health care system.

Tanzania

The Tanzania Development Vision 2025 identifies health as one of its priority sectors. The Ministry of Health strives to raise and improve the health status and life expectancy of the people of Tanzania by ensuring delivery of effective, efficient and quality curative, preventive and rehabilitative health services at all levels. Tanzania's

health policy aims to improve the health and well-being of all Tanzanians with a focus on those most at risk and to encourage the health system to be more responsive to the needs of the people.

The Ministry of Health and Social Work (MoHSW) partners with other governmental institutions, NGOs and private sector organisations to achieve its objectives. Among the chief priorities for Tanzania are the high prevalence of HIV, tuberculosis and malaria. The country also faces a significant shortage of health care professionals. According to the MoHSW, Tanzania is only able to meet about 35 % of its health care staffing needs. Another hurdle is reaching the approximately two-thirds of Tanzanians who live in rural areas. Many can only access small facilities that offer limited specialty care services.

In 2012, an initial national eHealth strategy was developed. Its implementation was foreseen in three phases from 2013 to 2018. It guides implementation of eHealth initiatives, the provision of ICT access to rural Tanzania and supports linking dispensaries and health centres through the Information and Communication Technology for Rural Development project (ICT4RD). The growing mobile communications connectivity is used to support mHealth tools, services and related applications. Overall, it is based on four strategic pillars:

- eHealth foundations: The basic infrastructural building blocks required to enable the effective electronic sharing of information across the Tanzanian health sector
- eHealth solutions: The specific computing systems and tools to address the high priority needs of consumers, care providers and health care managers
- Change and adoption: Actions that need to be carried out to encourage and enable participants in the health care system to adopt eHealth solutions and change their work practices to enable effective solutions.
- eHealth governance: The appropriate national eHealth governance structures and mechanisms needed to provide leadership and oversight to ensure the successful implementation of the national eHealth programme

Tanzania has four eCare services, namely eReferral, electronic health records, a clinical information system (Integrated Management of Childhood Illness) and telemedicine (World Lung Foundation project), that operate nationally. Several eSurveillance services are available nationally, based on the open source DHIS2 software. eLearning is well established with all components operating nationally. Among available eAdministration services are a health professionals database (for eID), online health facilities database (Online Health Facility Registry—Ministry of Health and Social Welfare) and eBilling (Vodafone M-Pesa). Various mHealth applications have also been introduced and an eHealth / ICT regulatory authority has been established.

Tanzania still faces many challenges to fully realise the benefits of eHealth. These challenges include a fragmented landscape of pilot projects and non-cooperating stakeholders, a lack of coordination on ICT matters among ministries, departments and agencies (MDAs), data and health information system silos that lack interoperability and an insufficient capacity of well-trained ICT workers. Other hindering aspects are the lack of governance structure to guide the development of eHealth across the health sector, unreliable power supply and low accessibility to electricity as well as financial constraints. Tanzania is ranked relatively low on the World Economic Forum's Networked Readiness Index (123rd of 143 in 2015). However, the Tanzanian ICT environment is rapidly changing, in large part due to the Eastern Africa Submarine Cable System and the National ICT Broadband Backbone. The increased competition in both voice and data markets has led to reduced pricing, though it is still relatively expensive.

Overall, promising aspects include the government and a national ICT policy that advocates for the use of ICT in all sectors, including the health care system. In addition, the national eGovernment strategy recognises eHealth as a priority area.

Summary

This short review of the digital health situation in four countries vividly illustrates the wide diversity of health systems and tools in Sub-Saharan Africa. It also points to a common challenge in all countries that aspire to establish or expand a national Digital Health Ecosystem: the absence of a holistic, integrated infrastructure for applications to securely connect to and share patient and other health-related data as well as report core public health information.

National eHealth policies usually acknowledge the need for such a comprehensive, integrative approach and eHealth strategies underline the goals, objectives and necessary achievements. However, the great diversity of health care facility owners, donors and financing sources, the regulatory dearth of adequate governance and laws and the inability to enforce such regulations where they do exist, obviate the achievement and realisation of the needed holistic ecosystem. Achieving such a system is a long-term, comprehensive, complex and highly demanding enterprise.

4.2. VISION FOR A COOPERATIVE INVESTMENT APPROACH

A cooperative investment approach could translate opportunities into action. Customers, health ministries, health care providers and health professionals, national and international donors and financiers, not-for-profit and commercial suppliers, providers of digital health software, hardware and services should come together and collaboratively pursue country or district-specific opportunities.

The "customers"

Many African governments and ministries of health realise that present investments in eHealth services and applications do not quite deliver the benefits promised and expected. Data sharing fails due to vendor-specific data models and implementations as well as missing interoperability at the structural and semantic level. Often, the regulatory impact of government institutions is too weak and the expert capacity is not available to drive a national interoperability agenda with all the requirements for an adequately sourced institute, the expertise and the need to localise standards and profiles for national implementation. Competing health care providers and donor organisations may exacerbate this situation.

Governments increasingly realise that only a fundamental change, carefully guided and implemented, will allow them to reap the benefits from digital health for their citizens, health care providers and the overall health system. The open Digital Health Ecosystem approach developed in this paper can, when applied and implemented appropriately, deliver the expected results in the longer term.

In principle, smaller-scale applications are also possible. For instance, a chain of hospitals in need of a common, distributed infrastructure, a set of community health centres and small hospitals in a given district or other groups and clusters of health care providers and public health institutions wanting to cooperate more closely, benefit from well-organised data sharing and together provide better, more integrated care to their clients. However, the larger the number of network participants, the greater the expected beneficial network effect and the higher the positive impact on health care delivery.

Development partners and financiers

The interests of development partners, financiers and commercial owners of health care facilities do not always align. However, cooperation via digital health infrastructures and data sharing—potentially enforced by national regulatory interventions or government incentives—will benefit all and lead to better services for patients.

Providers of Digital Health Ecosystems

The market for digital health hardware, software, devices as well as for services around such investments will change, as governments aspire for more integrated, open and flexible infrastructures, with individual applications that are fully interoperable and meet the country's priority needs. For commercial companies, this may require an adaptation of their business model. The longer-term business perspective is no longer just selling individual hardware and software pieces but cooperating with the open source community and many other organisations, such as government IT institutions and infrastructure providers, open source and / or not-for-profit and commercial providers of platform services and other competitors.

Depending on the respective health system requirements and the resulting platform configuration and individual application needs, quite different coalitions of suppliers will evolve. The implied avoidance of vendor lock-in reduces the entry barriers for newcomers and stimulates competition. Given sufficiently reliable connectivity in a country, new service models around cloud services, platform as a service (PaaS), software as a service (SaaS) and other business models become feasible.

All of this implies that agile actors—be they customers, financiers or suppliers—understand the new economics of health care services, enabled by digital systems, and related opportunities. Open Digital Health Ecosystems present a platform for pursuing flexible approaches towards meeting continually evolving health system needs, thereby transforming health sector ecosystems. This will result in new alliances and cooperation patterns, creating value with and for a wide range of cooperating actors and stakeholders, e.g. by integrating external partners directly into the health value creation process.

An industry perspective

As a corollary, this opens up new opportunities for digital health suppliers, for instance by establishing a coalition of suppliers that jointly develops a modular platform concept, where every partner focuses on their specific knowledge, experience and products. Providing a comprehensive, yet flexibly adaptable structure for a Digital Health Ecosystem that meets a country's or district's health system requirements would allow the potential coalition to form a competitive advantage.

Such a cooperative approach could be further strengthened by supporting and integrating local capacity building and ownership, for instance by involving local ICT companies and experts, universities, educational / vocational schools and setting up educational programmes to teach the specific qualifications and expertise needed as well as practical "learning by doing". Small and medium-sized local enterprises (SMEs) and start-ups could be supported in adapting and localising technology solutions with the future potential to jointly export to third markets.

One promising opportunity would be to join investments of European and African entrepreneurs with the support of governments, donor organisations, development institutions and others in a regional Digital Health Hub or Cluster of Excellence. Such a hub could coordinate and foster the cooperative development of open platform systems, infrastructure services and concrete health care applications. It could offer necessary services, hardware and software in a flexible, modular manner to any country, district or group of health care providers. Initially, it could focus on a specific region in order not to overextend its capacity, but in the long-term, it may become competitive in the global digital health market.

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