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From Siloed Applications to National Digital Health Ecosystems: A Strategic Perspective for African Countries

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Abstract. Substantial investment in digital solutions for improved health services has occurred in recent years in Africa. Digital Health provides for proven, beneficial applications in many different areas of health systems. It supports the transformation of healthcare delivery, and its potential is seemingly boundless. However, the deployed systems are in silos, and interoperability and integration are largely missing. There is no timely information for easy and quick decision making; there is no ability to track service levels across the whole health sector. What is missing is an integrated information system across all healthcare facilities nationwide. Such a Digital Health Ecosystem, the holistic application of information and communications technologies, services and applications, will support health systems and improve healthcare delivery, coordination and integration across providers. Based on global experience in resource-constraint contexts, core steps necessary to develop and implement such an ecosystem are explored, and four fundamental building blocks and their elements are developed. The results presented are succinctly integrated into six statements on lessons learned and recommendations.

Keywords. Digital health, ecosystem, open platform, Africa, strategy, foundational building blocks, interoperability

1. The Integration Challenge

Innovative digital solutions have become a major determinant for the improvement of well-being and economic growth worldwide [1]. They help African economies to overcome limitations and costs of physical infrastructure in important areas of social and commercial life [2]. The health sector is also benefitting from this trend. Substantial investment in digital technology solutions for improved health services has occurred in recent years in Africa [3,4]. 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 [5].

Digital Health provides for beneficial applications in many different areas of health systems. It supports the transformation of healthcare delivery, and its potential is seemingly boundless. E.g., the path-setting mHealth4Afrika application platform [6] provides for more effective and efficient care provision through an open source, multilingual digital health platform improving the quality of community based maternal and newborn healthcare delivery in rural health service points of Ethiopia, Kenya,

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Malawi, and South Africa. – Telemedicine makes specialist knowledge and improved treatment accessible in rural areas: In Tanzania, for example, 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 [7]. – Mobile health (mHealth) makes use of cell and smart phones as well as other mobile devices, a promising application field in Africa due to the relatively ubiquitous mobile telecommunication connectivity when compared to other modes of communication. Smart phones have been engineered to serve as local hubs or platforms to connect sensors and electronic measurement devices, printers etc. at the local level, and to connect to more complex systems at community centres and district hospitals. Worldwide known applications focus on pregnant women, like the UNICEF-supported MomConnect service in South Africa which links pregnant women and young mothers to healthcare centres [8]. – Digital health also helps to better support administration and management services. Triggered by the need to reduce endless waiting times for patients, in South Africa the Western Cape's Primary Health Care Information System [PHCIS] [9] focuses on 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. – Improving Public Health surveillance is a core WHO goal for Africa [10]. Through the introduction of a mobile "Electronic Integrated Disease Surveillance and Response [eIDSR]" application by Sierra Leone's Ministry of Health and Sanitation weekly disease reporting drastically improved from occurring in 35% of health facilities to 96% [11]. – eLearning is another highly relevant application field. The Tanzanian Training Centre for International Health uses an audio teleconferencing service; and an online eLearning platform to teach health workers and nurses in maternal and perinatal health-care in rural areas [12].

However, such isolated eHealth investments do not yet comprehensively meet the needs of African countries. The core remaining challenge was neatly summarised in a recent statement on the "Enhancement of Rwanda National Digital Health Care System – 'Smart Health'" by the Ministry of Health: "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. … 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, which does not report systematically, means that a growing piece of the epidemiological situation is missing. … There is no proper interoperability framework in place for all these systems. They were developed on different platforms and data stored in legacy systems. This has resulted in considerable duplication of effort and difficulty to access and consolidate data for evidence-based decision-making. Terminology and technology standards need to be implemented to ensure system interoperability" [13].

2. Objective

What is missing is a holistic information system integrating patient and other data across all health system organisations and actors nationwide. We call this a *Digital Health Ecosystem*, defined as

the holistic application of information and communications technologies to support and improve health services, their coordination, integration and management across all actors in a given geographic domain (local, district, national).

To meet interoperability requirements and be future-proof in resource-constrained environments, it should rest upon an open digital health platform.

Based on global experience in resource-constraint contexts, the goal of this paper is to sketch the core steps necessary to develop and implement such an ecosystem, and to specify fundamental building blocks. Key problems and barriers encountered as well as success factors and lessons learned will be discussed.

3. Methods

Methodologically, earlier work on describing, structuring and comparing national eHealth policies has benefitted this work [14]. And it builds upon analytical research undertaken, approaches developed and empirical surveys undertaken in the context of Africa-related studies, inter alia, the "Interoperable eSystems for Africa Enhanced by Satellites" Study for the European Space Agency's (ESA) eHealth for Sub-Saharan Africa (eHSA) Programme [15]. There an initial interoperability approach and roadmap towards designing and implementing national eHealth platforms in Sub-Saharan Africa (SSA) countries was developed, based on detailed statistical analyses of the respective economic and health system situation in 48 SSA countries, as well as empirical surveys with key decision makers in 24 countries. Further methodological and empirical input was derived from detailed case studies of national or district eHealth platforms and electronic health record (EHR) systems covering eight countries on five continents, which – to render analysis results comparable – where structured and presented empirical material in a framework similar to the one applied in the results section here.

Key methodological input is also derived from research on „Digital Health Ecosystems for African countries - Integrated framework and approach" which was undertaken for the Strategic Partnership Digital Africa (SPDA), Berlin/Germany, an initiative of the German Federal Government and industry supported by the German Corporation for International Cooperation (GIZ) [16]. A critical review of further research, reports, papers, and literature were undertaken, too.

Reference is also made to eHealth strategy toolkits and guides as published by WHO/ITU [17] and other organisations [18, 19].

4. Results

Concerning how to best move from siloed applications to national Digital Health Ecosystems, these results can be summarised:

4.1 Responding to policy priorities and stakeholder needs

Successful national Digital Health Ecosystems respond to health policy priorities and stakeholder needs. Establishing such an (open) platform is a complex, long-term and never ending venture. Global experience suggests that starting with a focused approach delivering early benefits to core actor groups is essential. Real benefits will convince physicians and politicians alike to continue, expand and support further development of digital health infrastructures. Such a needs-driven approach avoids a common pitfall of

digital health investments, namely technology push. "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 e-health systems are not integrated and are instead run by different independent organisations" [20].

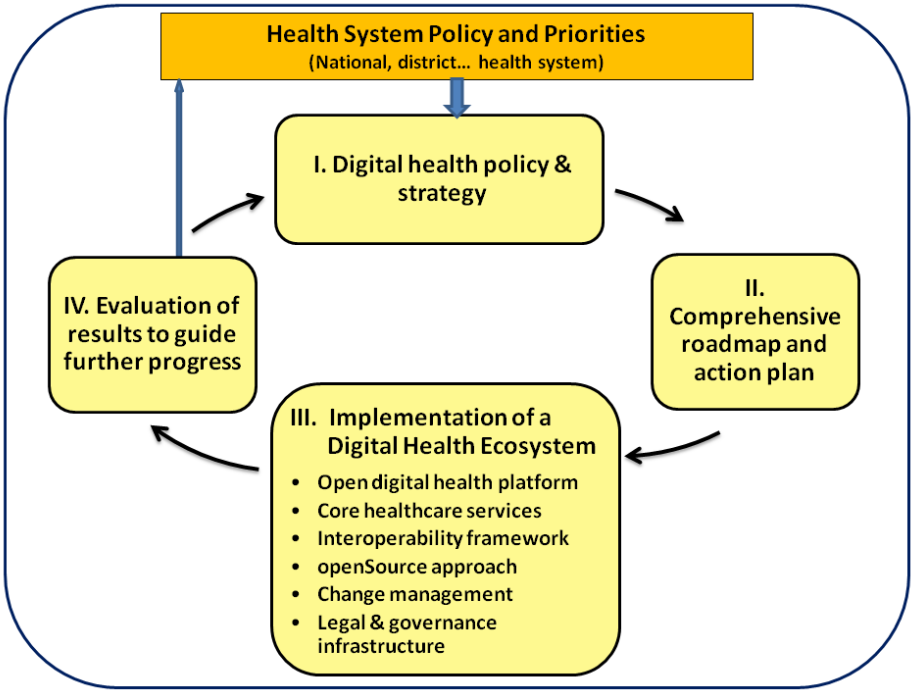
4.2 Four foundational building blocks for implementing a comprehensive Digital Health Ecosystem

When planning, implementing and maintaining a resilient Digital Health Ecosystem, four foundational building blocks need to be considered and analysed:

- Political agreement on an operational digital health strategy
- Development of a comprehensive roadmap translating the strategy into reality and targeting long-term sustainability
- Implementation of the chosen Digital Health Ecosystem
- Monitoring and evaluation of outcomes and results achieved to guide further progress.

Their logical relationship builds upon each other - respectively these blocks interact with each other - as shown in Figure 1.

Figure 1. Four building blocks for a resilient Digital Health Ecosystem



Understanding these building blocks, their contents and the action steps involved, as well as their logical relationship and how they interact with each other is mandatory for all involved in planning, developing, implementing and maintaining the Digital Health

Ecosystem – be they health policy decision makers, healthcare service providers, health professionals, patients, industry involved in implementation, donors and financiers.

4.2.1 Agreement on an operational digital health strategy

Guided by health policy priorities, it is fundamental to reach agreement across all stakeholders on an operational digital health strategy. Drafting together a strategic paper builds trust across all stakeholders who are involved in or impacted by the development of a Digital Health Ecosystem.

4.2.2 Development of a comprehensive roadmap

Drafting a digital health strategy is only a 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, and 'the proof of the pudding' comes with concrete implementation and continuous maintenance.

4.2.3 Implementation of a Digital Health Ecosystem

Six fields can be identified as particularly critical for successful implementations:

(1) Open digital health platform :
Open Digital Health Ecosystems implemented at the national or district level will help to overcome the common barriers experienced when relying on commercial system providers, like integrating new applications, transferring patient data to other applications, or changing the software supplier completely. An open approach allows apps and services from multiple vendors to work together such that there is a many-to-many substitutability between applications and services. This is based on 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 platform implementations [21].

(2) Core starting services and applications
From the wide spectrum of open platform infrastructure services and digital health applications and tools, a small set of priority services and application should be explored when analysing the needs for and benefits resulting from a national ecosystem. They may concern, e.g., essential eInfrastructure services like electronic identification and cyber security, eAdministration, electronic patient records (ePR) and other healthcare applications, eLearning, Public Health/eSurveillance. Starting small, but assuring the ability to scale up should be a particular concern [22].

(3) Interoperability framework
Interoperability must always be analysed in the context of the respective health system. This implies that interoperability requirements cannot be identified ex ante and as such, but rather need to reflect the data exchange and analysis needs of health system actors to be supported by the electronic tools and applications to be implemented. When planning and organising a comprehensive interoperability framework and tools, five domains should be analysed:

- *Policy domain*

It is in the policy and strategy domain where high level decisions are needed on which data should become interoperable for which health policy needs, for which healthcare/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 challenges when 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.
- *Organisational domain*
  Securing interoperability is a long-term activity. eHealth interoperability frameworks therefore require dedicated organisational support structures and processes to not only guide and direct digital health infrastructure investments and controlling in this sphere, but to also run daily administration and production.
- *Document format, data modelling and coding domain*
  Here three levels of interoperability may be discerned:
  i. Technical interoperability (like correctly transferring a static paper document electronically, e.g. in PDF-format)
  ii. Structural interoperability (documents structured according to standardised headings, which may allow for regrouping and assembling information according to such headings)
  iii. Semantic interoperability (information and data are presented in a standardised clinical model and fully coded, thereby e.g. allowing for safe translation into other languages if international dictionaries are available)
- *Data sharing domain*
  The issue to be solved here is whether data should be stored in a central (or several linked, distributed) data repository(ies) where the authorised actors can directly access the (patient) data whenever they need them, or whether data are communicated via an exchange of messages, etc. Cloud storage of such data is becoming another option.

(4) Leveraging the 'open' approach
Globally, support and engagement for 'openSource' software, 'openData' access, 'openStandard' availability and 'openPlatform' approaches has gained great momentum, both in industrialised and resource-constraint environments [21]. This "open" movement is now ubiquitous, recognized 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, it can be freely copied, modified and distributed; it is managed and continuously improved by engaged participants.

(5) 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 healthcare processes is quite different from what it was before. It enables substantial 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 [23].

(6) Governance and legal framework

To function efficiently, reliably and amicably, open societies need a well-designed governance and legal framework. This equally applies to the health sector. What the term "governance" means is vague and disputed, and it has variantly been located from civil society level laws and regulations – "rules that guide the course of a system" or a country - to "rules of order" or procedures for small group activities.

At the level of health system governance, WHO has recently proposed the "TAPIC framework for analysing and improving health. [24]" It identifies and defines five mutually exclusive attributes of governance that influence the kind and consequences of decisions a health system makes:

- Transparency
- Accountability
- Participation
- Integrity
- Capacity

4.2.4 Monitoring and evaluation

An often neglected forth building block is monitoring and evaluation of outcomes and results and the impact achieved. This is indispensible for updating and adapting the ecosystem to changing and newly arising needs, i.e. it will support and help to guide further progress [17].

5. Lessons learned and recommendations

The results presented can be succinctly integrated into six statements on lessons learned and recommendations:

1) *Digital health facilitates reaching health policy goals and Universal Health Coverage (UHC)*

When implemented appropriately, digital health is a great enabler towards better, safer and more efficient healthcare and UHC.

2) *Adopt the unifying approach of a national Digital Health Ecosystem*

The reliable, sustained transformation of health systems through digital health requires a holistic vision driven by focused health system priorities and a unifying approach assuring that the deployed eHealth applications are integrated through a national digital health infrastructure platform – a Digital

Health Ecosystem. Such an open Digital Health Ecosystem is vendor and technology neutral and eliminates the expensive and much-dreaded vendor lock-in. It facilitates innovation also by smaller companies and start-ups facing lower barriers to market entry. It forces vendors to develop new business models and compete solely on quality, value, and service.

3) *Implementing a national digital health platform is a rather unique challenge*
Implementing and sustaining digital applications in the health sector is more demanding, complicated and time-consuming than in any other sector – healthcare is an extremely complex undertaking. At the district or national level, there is no one-size-fits-all platform solution readily available, each one has to be tailored to local policy priorities, needs, capacities and resources.

4) *Avoid Pilotitis – Focus on integration*
Stand-alone eHealth implementations and pilot projects that rarely reach scale and sustainability must be avoided. Focus on few healthcare and/or Public Health priorities to guide nation-wide investments. Assure coordination and integration across all actors and stakeholders, whether public/government institutions, charities, foundations, development agencies, or private investors.

5) *Four building blocks will guide towards successfully implementing a national Digital Health Ecosystem*
Just drafting a Digital Health *Strategy* will not do the job. Three further building blocks are needed: An actionable, realistic *roadmap* how to move from the strategy to implementation and long-term sustainability, six *implementation* elements (national platform; core services; interoperability guidance; leveraging the "open" approach – with respect to software, data models, APIs etc.; change management; governance and legal framework), and finally *measuring impact* to guide further development of policy and infrastructure.

6) *Establish the role of governments, development partners, and industry*
In a democratic society, national governments – controlled by parliament – are in the driver's seat concerning health system structures, regulation and financing. They have to guide determining the needs, priorities and procedures of investments in Digital Health Ecosystems. To avoid the disparate development of siloed eHealth applications and thereby loosing many of the potential benefits for improved healthcare, a national framework must set the conditions and requirements within which development partners should act in close coordination with public authorities. It follows that specifications in national Calls for Tender to industry must fully align with the national digital health strategy. A cooperative investment approach in which African governments, donor and industry representatives join forces is strongly advised.

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