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Integrating Digital Health Services: An Open Platform Approach for Resource-Constrained Countries

Karl A. Stroetmann
Empirica Communication & Technology Research
Bonn, Germany
School of Health Information Science, University of Victoria
Victoria, BC, Canada

Abstract
Better health enables greater wealth. And digital health enables better healthcare. Also across resource-constraint countries digital health applications are becoming more prevalent. To establish a resilient national or district Digital Health Ecosystem, not only a holistic strategy – based on health policy priorities – is mandatory, but it must also be followed by a realistic roadmap and its comprehensive implementation, taking into account the success factors needed for its long-term sustainability and growth.
A key challenge in this context is that deployed eHealth systems are usually in silos, such that no system or application is integrated with another. It is the missing interoperability of the many siloed systems which constitutes a core barrier towards reaping greater benefits from digital health. To successfully transform the provision of quality healthcare services it is mandatory to put into place an *open digital health platform* that comprehensively integrates eHealth services across all healthcare facilities in a timely, efficient and seamless manner.
The open platform concept and its technical approach are developed, and core elements and aspects are critically explored. A constituent complement of such an open approach is a detailed interoperability framework which must be adhered to by all services and applications coordinated via the platform. The key question in this context of how to determine interoperability requirements is briefly discussed. This is complemented by identifying leading open source eHealth software products available and being applied in emerging market and developing economies around the world.
Digital health is different from almost any other sector. By identifying the challenges encountered in healthcare the discussion reviews how the open platform approach helps to overcome these barriers, and identifies important pitfalls to be avoided.

Keywords: Digital health, open platform, open source, integration, interoperability.

Context

Health, wealth, and growth

Investment in health system infrastructures and services benefits the people, and thereby improves productivity and wealth creation (WHO, 2001). Wealth means more resources are available for investing – amongst other things - in better health of the population. And it will allow to not only grow material products, but to also invest in education, security and governance – basic building blocks for a stable society and a growing economy. This gave free European cities and counties already in medieval times a significant competitive advantage (Cantoni, 2015), and modern development economists have proven this relationship for many countries (Robinson & Acemoglu, 2012). A 'good civic order', striving for principles of solidarity, legality, equality will provide a fertile ground also for a sustainable health services environment.

Digital Health

Digital Health services and applications will deliver an additional dimension to support national health services and enable better healthcare by individual providers. We define such a system as follows:

> *A 'Digital Health Ecosystem' is the holistic application of information and communications technologies to support and improve healthcare delivery, its coordination and integration across providers.*

Substantial investment in digital technology solutions for improved health services has occurred in recent years in Africa. But the need is growing further, and substantial opportunities to support the scale-up of digital health in the region remain. 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 to achieving strong digital health systems in their countries (Long, 2017). This presents ample opportunities for industry, donor organisations and agencies for international cooperation to constructively support, facilitate and participate in the further development of digital health ecosystems in districts, countries and regions of Africa – and elsewhere.

Objectives

The goal of this paper is not to cover the complex field of developing a consistent, holistic digital health strategy for an individual country, analyse its roadmap towards implementation, and explore the success factors needed for its long-term sustainability and growth. Rather, after briefly exploring the benefits from digital health experienced around the globe, and contrasting this with key problems and barriers encountered towards realisation, a core ingredient of any district or national eHealth infrastructure and its enabling power for delivering digital health service provision will be identified and explored – the open digital health platform. This will be complemented by identifying leading open source software products available and being applied in emerging market and developing economies (EMDE) around the world.

Methods

This paper is based on own research and experience as well as on critically reviewing research reports, papers, and literature. It builds upon work performed in the context of Africa-related studies undertaken by the author. This concerns, *inter alia*, the "Interoperable eSystems for Africa Enhanced by Satellites"(ISAES) Study for the European Space Agency's (ESA) eHealth for Sub-Saharan Africa (eHSA) Programme. There an interoperability approach and roadmap towards designing and implementing national eHealth platforms in Sub-Saharan Africa (SSA) countries was developed (ISAES Consortium, 2014). Part of the work involved collecting detailed statistical and health system data on 48 SSA countries to assess and evaluate their eHealth readiness. Other 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. Similar information on seven more platforms and national eHealth strategies was reviewed.

Key knowledge has also been derived from research on „Digital Health Ecosystems for African countries - Integrated framework and approach" which was undertaken for the Strategic Partnership Digital Africa (SPDA), an initiative of the German Federal Government and industry supported by the German Society for International Cooperation (GIZ) (German Federal Ministry for Economic Cooperation and Development , 2017).

Results

Global experience

Across the globe, developing and successfully implementing a digital health ecosystem is undertaken in order to improve patient safety, healthcare delivery and economic efficiency of the health sector. Invariably, this turns out to constitute a complex task requiring enthusiasm, political power, skilled people as well as many other resources and ingredients. The benefits, opportunities and challenges of creating such an ecosystem will briefly be traced – identifying the motivational base to realise such an ecosystem also in resource-constrained national or district contexts. It requires a dedicated, focused healthcare policy, the setting of priorities for digital health support, a realistic implementation plan, and the provision of adequate governance and technology infrastructures. No one-size-fits-all approach will be useful here – rather the identification and exploration of the respective core national health policy priorities guiding the development of a successful Digital Health Ecosystem.

The 'Why' of digital health

Progress in clinical knowledge, in medical technologies and devices, in management and administration of healthcare services will allow to

- Improve prevention, diagnosis and treatment
- Advance patient safety
- Foster public health
- Raise the cost effectiveness of healthcare

Digital Health systems and applications enable achievement of these goals through the provision of powerful tools for:

- ✓ Data/information gathering, exchange, access and analysis
- ✓ Communication and collaboration in health service processes across patients and their family members, healthcare professionals, provider organisations, administrators/managers, and Public Health services
- ✓ Medical knowledge generation and support of clinical decision making.

As a long-term vision, this will lead towards a learning healthcare system designed to generate and apply the best evidence for the collaborative healthcare choices of each patient and provider, and allow optimising resource allocation and efficiency. It will drive the process of discovery as a natural outgrowth of patient care and thereby ensure innovation, quality, safety, and value in health care (Institute of Medicine, 2012).

Benefits from Digital Health

Already during the '90s significant efforts towards the establishment of district or national digital health infrastructures emerged. They brought mixed results: some were quite successful – like those in some district health systems of northern European countries, in Scotland, or in Andalucía in the south of Spain (Stroetmann, Jones, Dobrev & Stroetmann, 2006). Others had mixed results like the NHS in England, or Australia, Canada, Germany. On the other hand, several developing countries or districts in such countries have been quite successful in investing in digital infrastructures and eHealth services (Stroetmann, 2014).

Opportunities

Digital Health provides for proven, often highly beneficial applications in many different areas of health systems. It can support the urgently needed transformation of healthcare delivery, and its potential is seemingly boundless. A few examples may illustrate this:

- ➢ Faster, more effective and efficient care provision

Digital health enables healthcare teams to access core or even complete patient health data and information, which 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), allow patients to be informed or even input their own data.

For example, a path-setting application platform has been developed by the mHealth4Afrika consortium – a collaboration between African and European companies. It provides an open source, multilingual digital health platform improving the quality of community based maternal and newborn healthcare delivery in districts of Ethiopia, Kenya, Malawi, and South Africa. It combines electronic medical records to store patient history, associated test results derived from sensors to capture the data of a range of standardised tests, with analytical and visualisation tools as well as speech synthesis to address literacy deficits.

- ➢ Telemedicine, virtual visits

Telemedicine applications allow connecting with patients, health workers, nurses, and doctors remotely, which renders healthcare accessible to hitherto unserved

people, reduces the need to travel, and makes specialist knowledge and experience available on the spot.
In Tanzania, e.g., 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.

- mHealth

Making use of cell and smart phones/mobile devices is a very promising application field in Africa due to the relatively ubiquitous mobile telecommunication connectivity when compared to other modes of telecommunications. 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 mothers to healthcare centres. Ghana and Nigeria have introduced forms and check-lists to be used on smart phones for regulatory process support of pharmacies or for consultations of patients.

- Administration and infrastructure services

This is an often neglected application domain, but in urgent need of attention where larger patient populations are concerned.
Triggered by the need to reduce endless waiting times for patients, in South Africa the Western Cape's Primary Health Care Information System (PHCIS) is an operational system 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, disaster preparedness

Health surveillance is the systematic collection and analysis of health-related data needed for the planning, implementation, and evaluation of Public Health practice. Electronic collection of such data can fundamentally strengthen national health information systems and decision making. Resulting benefits can be further improved by integrating into such a platform service a geographic information system (GIS) and early warning system (EWS), and combining them with mHealth devices which may serve not only as display devices and dashboard, but also for early warnings to citizens.

- eLearning

This is an underused resource with considerable potential. The Tanzanian Training Centre for International Health uses an audio teleconferencing model; and an online eLearning platform to teach health workers and nurses in maternal and perinatal healthcare in rural areas. In Gilgit-Baltistan, the thinly populated north of Pakistan, a multimedia platform based on open source software facilitates the continuing professional development of nurses and other healthcare workers through case based collaboration and a bulletin board system (BBS) for sharing and exchanging messages and files.

A key challenge: Integration

In spite of these promising applications and the concrete benefits demonstrated by them, there remain many serious challenges and implementation problems which need to be considered to assure long-term success. Perhaps the most serious challenge relates to coordination. Here the core problem in many countries is that various eHealth systems are not integrated, but are run by different independent organisations. It regularly happens that donors, charities/churches, governments, and (other) implementing partners work in the same district, without coordination, on similar health issues. This phenomenon was recently succinctly pointed at by Mr. Kumalija, Ministry of Health, Tanzania: "Existing of parallel routine reporting systems such as IVD, HIV, PEPFAR - DATIM is a challenge. Uncoordinated national surveys such as by SPA (USAD), SARA (Global Fund), SDI (World Bank) collect almost the same indicators" (Kumalija, 2017).

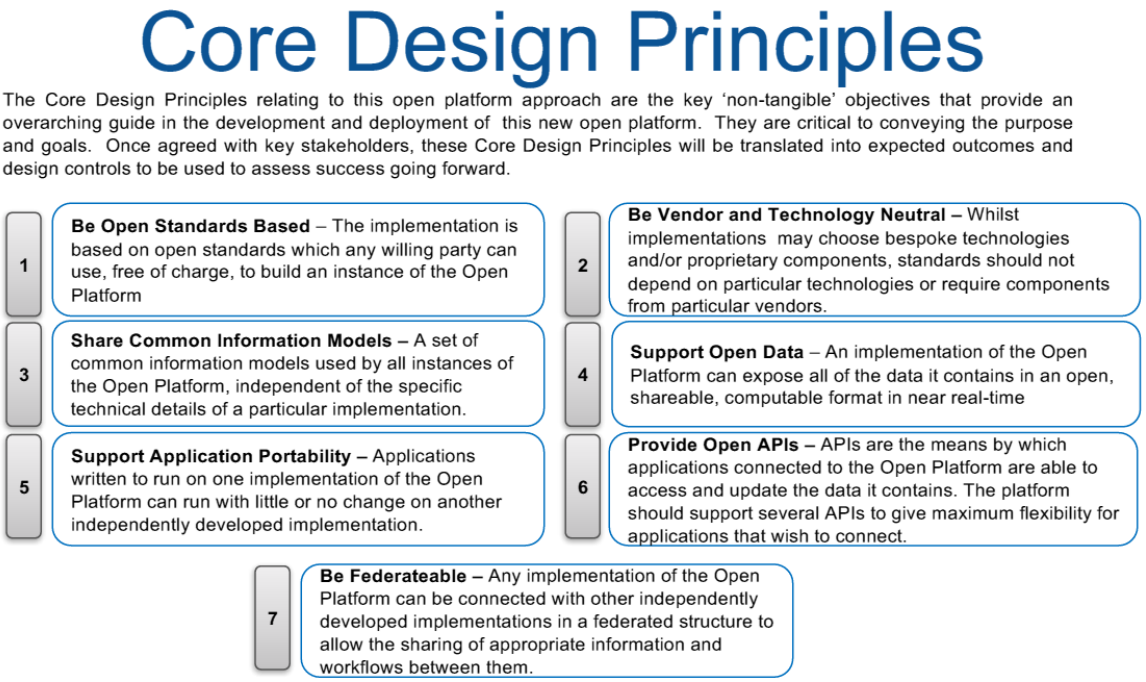
And in a recent Request for Expression of Interest on "Enhancement of Rwanda National Digital Health Care System 'Smart Health'" it was noted: "The deployed [eHealth] systems are in silos and there is no system that is integrated with another. There is no timely information for easy and quick decision 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. ... The Ministry of Health would like to transform the provision of quality healthcare services by putting in place an integrated, comprehensive information system across all the healthcare facilities nationwide in a timely, efficient and seamless manner." (Ministry of Health of Rwanda, 2018). It is here where open digital health platforms will provide an innovative solution.

Open digital health platform

Comprehensive digital health systems 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, often legacy applications, or even change the software supplier completely.

Open Digital Health Ecosystems implemented at the national or district level will help to overcome this core challenge. Such an approach also makes it easier to develop and flexibly integrate any time innovative third-party applications that support safe, high quality healthcare. It allows apps and services from multiple vendors to work together such 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 other infrastructure services 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 platform implementations.

Figure 1 briefly describes core design principles of such an open digital health platform.

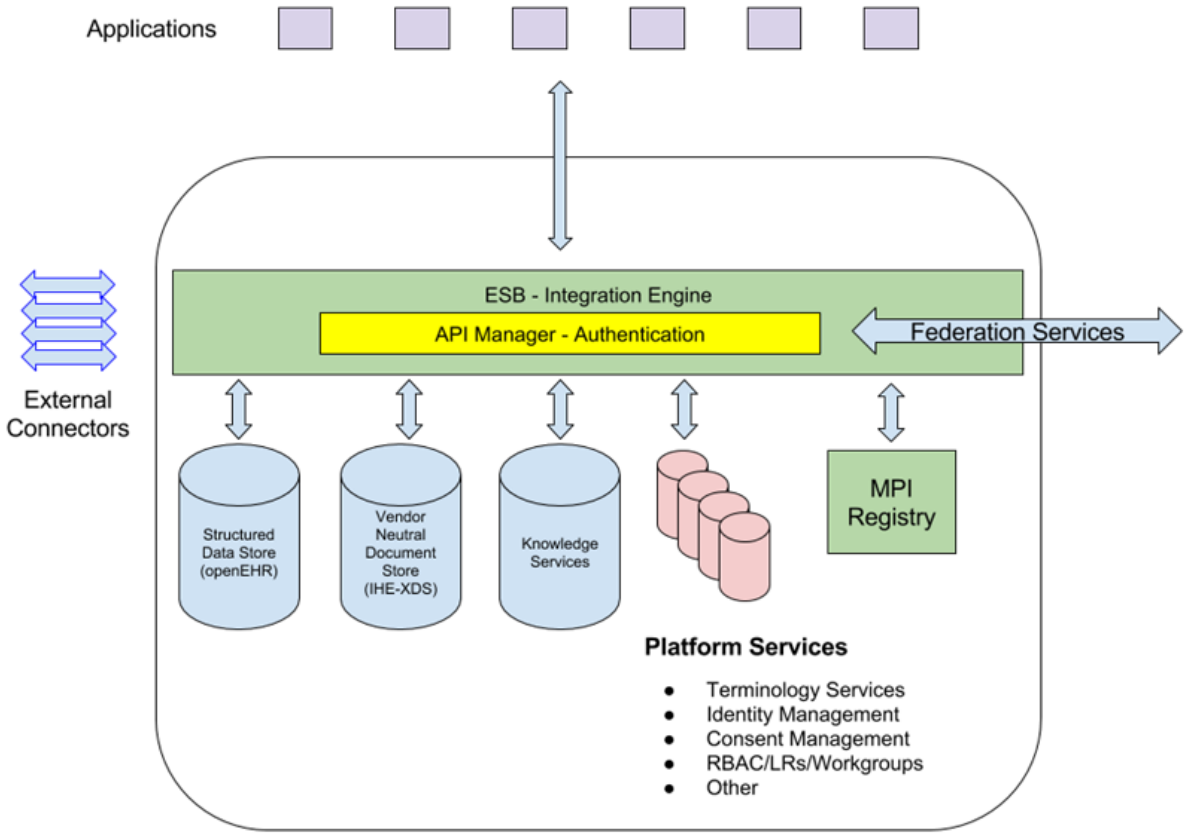


Source: Maidment (2017)

Figure 1 - Core Design Principles of an Open Digital Health Platform

Such an ecosystem is vendor and technology neutral and eliminates the expensive and much-dreaded vendor lock-in. It thereby facilitates innovation also by smaller companies and start-ups facing lower barriers to market entry, and any of their applications built for such an open platform will operate on any other open platform applying the same standards. It forces vendors to compete solely on quality, value, and service.

Figure 2 illustrates the generic architecture of such an open Digital Health Ecosystem. It is taken from the openEHR Foundation - an open domain-driven platform for developing flexible eHealth systems (openEHR, 2018). It shows how the different digital healthcare applications are separated from 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, the Health Level Seven International (HL7) standards developing organisation, the International Standards organisation (ISO) and many others. And that their software has been tested and certified as compliant with these requirements.



Source: openEHR Foundation

Figure 2 - Open Digital Health Ecosystem platform architecture

For data that need to become available in a highly structured, 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), to 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, or a consistently structured document complying with agreed-upon document standards like the clinical document architecture (CDA) of HL7 (Health Level 7) or message profiles as specified by IHE (Integrating the Healthcare Enterprise).

And 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 it may be applied 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 healthcare provider organisations, or a private entity will depend on the respective circumstances. For IT companies to stay involved, it may require to engage in new business models based on delivering cloud services, software as a service (SaaS), licensing agreements etc. rather than selling hardware and software.
Worldwide, there exists already a growing community of cooperating commercial suppliers of software, cloud and other platform services, of infrastructure tools, implementation and management support. This is complemented by open source and proprietary application providers offering a wide spectrum of electronic healthcare tools and systems, all able to connect to an open platform and to exchange data in open standards and specifications.

Determining interoperability requirements
However, for such a platform to be successful, it is mandatory to solve the related interoperability challenges. It is a strategic necessity for any Digital Health Ecosystem; it requires the full attention of all stakeholders. Globally, all national digital health strategies talk about the need to enable interoperability, but most of them failed here due to a lack of precision and translating this generic concept into a strategic perspective first, and from there into concrete actions meeting the real needs of stakeholders.
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 and as such, 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. And these in turn will be driven by the overall health policy goals and the specific health system/health services domain in question – which may be the overall health system, but perhaps only primary care, public health, administration and billing, or 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 – whatever the local situation may be.

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. 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, but can be freely copied, modified and distributed; it is managed and continuously improved by engaged participants. Even some of the biggest IT companies in the world like Google and Facebook have released software to this community to allow for it to evolve through community support and feedback to improve their own services.
Also in the health sector it is by now a well-established procedure to work together at global scale to improve both interoperability and economic efficiency of digital health systems and applications. Thereby it is fostering competition across suppliers, triggering new business models and markets, and easing market entry barriers for small, innovative companies. At the same time, vendor lock-in can be avoided. Some exemplar applications and tools are as follows:

- Open Medical Record System (OpenMRS)
  is an open source medical record platform. It allows designing a customized 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 more functionality 'out of the box' like patient summary, visit view for data clerks, vital signs capture, diagnosis capture, support for multiple wards/health services.
- Open domain-driven platform for developing flexible eHealth systems (openEHR)
  is a virtual community working on means of turning health data from the physical form 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). These are used by several national governments to specify national eHealth information standards.
- District Health Information System 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 being used at various levels in about 50 countries.
- Open Health Insurance Management Information System (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
  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 which leverage on existing Health Information standards like HL7, DICOM...
- Open Health Information Mediator (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 sharing of information among infrastructure tools and applications.
- 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 it is now applied also in many other domains. Critical patient data values may be identified to trigger alerts, to-do items, or other actions.
- openeLearning
  There exist various software platforms and tools to support eLearning. E.g. iPath, an open source web application service, is providing 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.

Discussion

Digital health is different

The results presented have to be seen against the often disappointing and sometimes disastrous results of attempting to develop and implement national Digital Health Ecosystems. Why do other service sectors like banking, retail, insurances and others succeed – and health systems not? And how can an open platform approach help to overcome the barriers experienced?

A few observations may help to explain this earlier experienced situation – and they can allow, at the same time, to better understand why the approach towards Digital Health Ecosystems presented may help to improve such experience in future:

- ✓ Clinical & care data is idiosyncratic, textual – and not easily interoperable (data complexity)

Clinical terminology is often ill defined – the same word may have different meaning in different contexts, and for the same 'fact', like a diagnosis, different terms may be in use. The details with which something is 'measured' will depend on the clinical situation – a brain surgeon needs much more detail than a general practitioner. For a liver transplant patient, it may be mandatory to not only have the latest lab analyses, but to also have information on which lab has measured them with which technical equipment.

- ✓ Wide variety of actors involved (cultural complexity)

In health systems, a wide variety of actors have to work together – general practitioners, specialists, nurses, health workers, administrators, managers, public health specialists, and many others – all with their own interests, 'language' and behaviour.

- ✓ Decision processes with countless options and interactions which may need to be fast (decision complexity)

For, e.g., multi-morbid patients, decision options may not be well defined or countless, no empirical evidence is often available to support the treating professional.

- ✓ Non-determination (no simple workflow rules) of healthcare processes (process complexity)

In spite, e.g., of clinical guidelines and defined clinical pathways, the respective pathway may be different in concrete detail for each patient (personalised medicine).

- ✓ Information governance/personal data, safety, cyber-security (regulatory complexity)

Patient health data are very special data – there are patients who do not want even their treating physicians to have access to all their earlier recoded information.

- ✓ Monolithic, proprietary, non-interoperable software systems (vendor lock-in – IT complexity)

Often hospitals or regional structures have invested in basic proprietary information systems, which in themselves are already technologically highly complex. They may consist of up to 30 or more different modules, need to connect and exchange data with sometimes hundreds of other (proprietary or bespoke) systems used in different divisions and wards of a hospital.

An open platform approach will not by itself solve these challenges, but it surely presents a more promising solution to obtain better outcomes in future and fundamentally help to overcome the identified barriers.

Pitfalls to be avoided

To indeed achieve the improvements promised by digital health systems and applications through an open platform approach, a few further observations on pitfalls to be avoided in such an endeavour will be helpful:

- ➢ Technology push versus user focus

"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. If you first start with the need, then consider the technologies to apply as well as the overall business model and ecosystem, the solution might be very different. 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."(Ligami, 2014)

- ➢ Pilotitis

The digital health landscape in Africa (and elsewhere) is plagued by 'pilotitis', the expansion of numerous pilot projects that rarely reach scale and fail to connect to a national strategy. Of the many interesting projects that have been taken to the field in Africa, most are neither sustainable nor scalable. Very few are expected to scale up

into sustainable enterprises with most remaining speculative pilots (Long, 2017). "In Kenya, for example, out of the 183 innovative health care programs, only 44 per cent have been implemented and are working efficiently." (Ligami, 2014)
Even worse seems to be the success rate of mHealth services. The USAid "African strategies for health - The mHealth Compendium Series" identified 167 profiles of mobile health programmes. It remarked that "while many of the pilot interventions featured in the series volumes have since phased out, some scaled up. Ten scaled mHealth programs are presented with in-depth profiles in the mHealth Compendium Special Edition 2016." (USAid, 2016)

- Human resources and absorption capacity

The ability to successfully invest in eHealth solutions is dependent on adequate human resources –health professionals/experts with ICT knowledge within healthcare provider organisations, and external IT support and infrastructure service providers. In a small survey of healthcare workers and professionals in Tanzania, it was noted that demand for local technical capacity dramatically exceeds availability in fields like software development, digital health program implementation, health informatics and enterprise architecture (Busagala & Kawono, 2013).

- Governance, legal and regulatory base

Healthcare provision is laden with complex situations that involve confidentiality and ethical decisions to be made. Privacy of patient data is mandatory to avoid abuse by unauthorised persons or the government. On the other hand, security and access issues must not impede proper patient care. They must be non-disruptive; and the system, with the proper safeguards in place, must be easily accessible. In principle, the technology is available to solve these issues, but the governance context must make sure that patient data are not shared with anyone the patient has not consented to.
When analysing these and related legal, regulatory and governance aspects across 48 Sub-Sahara countries, 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 sores of the "ready" countries – were judged as not ready (Greenfield, 2013).

Conclusion and outlook

Substantial investment in digital solutions for improved health services has occurred in many countries around the world in recent years. However, it has turned out that investing in isolated eHealth applications does not meet the needs of today's health systems, because this will not enable the urgently needed transformation towards better coordinated, integrated and sustained healthcare. Usually, proprietary architectures and software have been implemented, which render it difficult, sometimes impossible, and usually expensive to integrate new applications, extract and transfer patient data to other applications, or change the software.
Rather, a comprehensive approach is needed building on a well-founded health policy, setting clear priorities for healthcare and how digital applications can support it. Do not go for all the potential eHealth benefits at once; rather focus initially on most pressing policy needs, and develop from there. To implement

successfully a Digital Health Ecosystem, both the success factors and the challenges identified should be taken into account. A core building block of a holistic approach should be an open infrastructure platform and digital ecosystem implemented at the national or district level. This allows apps and services from multiple vendors to work together, facilitates innovation also by smaller companies and start-ups facing lower barriers to market entry, and forces vendors to compete solely on quality, value, and service.

This is all the more important because, when considering investments in digital health infrastructures and systems in years to come, the overall economic situation in African countries indicates a promising perspective. Inflow of foreign direct investment into Africa was at $14 billion in 2004, and is expected to grow to about $65 billion in 2017 (UNCTAD, 2017).

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