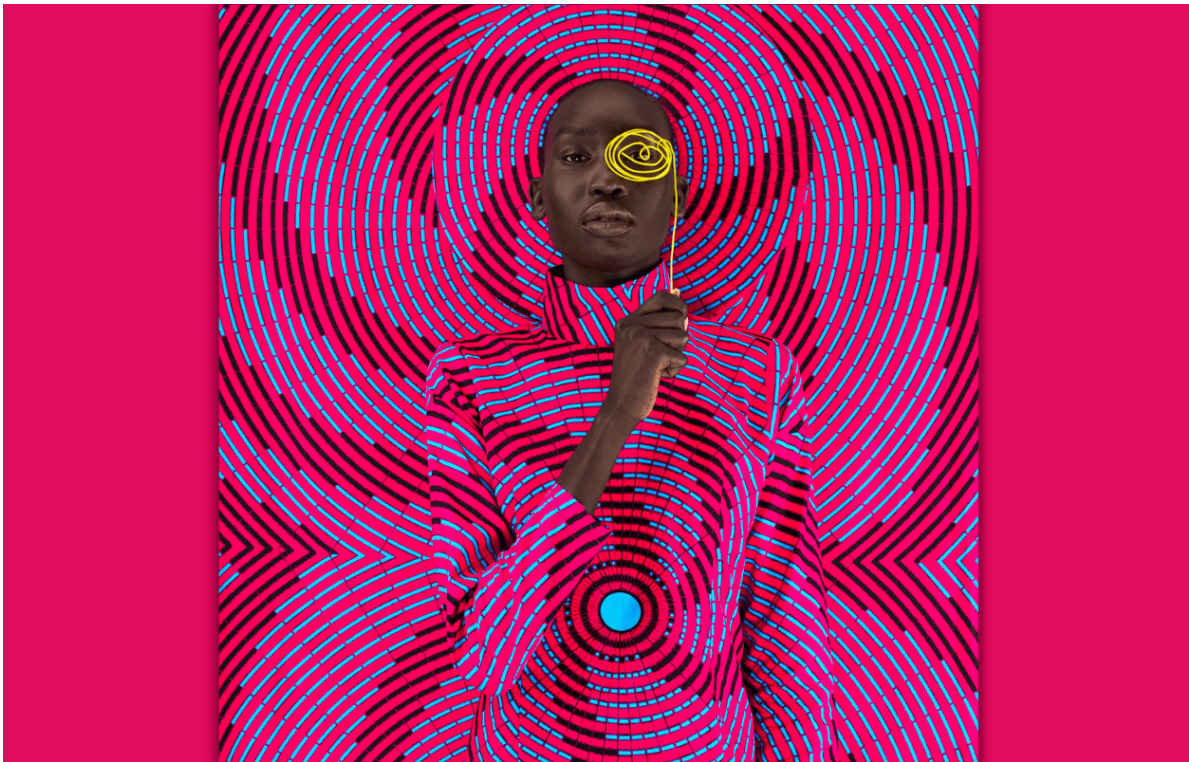


ECONOMIC PROPECTS AND DIGITAL CHALLENGES

Artificial Intelligence and health technologies in Africa

The role of emerging technologies for inclusive, cost effective and quality health systems

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Unifying Artificial Intelligence (AI) for health ecosystems across the world presents tremendous opportunities for global health in general and, in particular, for Africa to transform its health care system and propel the continent at the forefront of health care innovation. This paper explores the scope of opportunities being offered by AI and associated emerging technologies for health care transformation and provides recommendations for adoption and scaling-up of these solutions.

The pressing challenges for the use of Artificial Intelligence for health in Africa

Provision of healthcare with international standards remains a major challenge in Africa.

Health systems on the continent are lacking the necessary resources and relevant strategies to provide inclusive quality healthcare at a reasonable cost to patients. Efficient and adequate digital health solutions based on cutting edge technology such as AI, Big Data, robotics, cloud computing, to name few, are becoming increasingly important and will ultimately reduce the burden on the current health care ecosystems by complementing existing health mechanisms in closing gaps within the health value chain: shortage of healthcare professionals to cater to an ever-growing number of patients; high cost of healthcare; lack of robust disease prevention strategies; inadequate health infrastructure to name a few. For this to happen, a number of challenges and prerequisites must first be addressed.

Ethics and Governance of AI for Health

Regulatory oversight mechanisms must be developed to make private sector accountable and responsive to those who can benefit from AI products and services. If employed wisely, AI has the potential to empower patients and communities to assume control of their own health care and better understand their evolving needs. Otherwise, AI could lead to situations where decisions that should be made by providers and patients together are transferred to machines, which would undermine human autonomy. Patients may neither understand how an AI technology arrives at a decision, nor be able to negotiate with a technology to reach a shared decision. Patients should remain in full control of their health records and associated medical decisions.

If employed wisely, AI has the potential to empower patients and communities to assume control of their own health care

The World Health Organization (WHO) has produced a guidance document [1] which provides six core principles to promote the ethical use of AI for health. To implement these principles, a holistic approach involving all stakeholders is required to integrate ethical norms at every stage of a technology's design, development, and deployment.

Data infrastructure for AI deployment

Most countries on the continent exhibit a pyramidal healthcare structure. The first layer of the health pyramid, consists of community health workers, followed by home based practitioners, and the remaining layers consists of health facilities with varying operating capacity. This health structure is largely credited to bring about inclusion. Nonetheless, there are still challenges in terms of efficiency because the different layers of the health pyramid operate in silos. With respect to data infrastructures, adaptation is required to enable efficient data collection, storage and processing to develop and deploy AI solutions. Within this pyramidal architecture, managing data flow and dependency is challenging for many reasons: lack of interoperability; lack of national identification in most African

countries, etc.

In addition, the lack of trust in digital solutions used to collect clinical data (e.g. blood pressure, cholesterol, etc.) combines with the ability to interpret basic data and understand the value of data, often delays the development and adoption of AI solutions. In short, vertical and horizontal integration of health record systems within this pyramidal architecture, upskilling and reskilling of the existing workforce, mostly nurses, are important areas of focus.

Finally, missing digital infrastructure and last mile connectivity at the base of the pyramid underscore the critical importance of communication with patients for remote consultations, family planning, prevention and diagnosis, as well as the need to focus on solutions that are human-centered designed at Point-Of-Care.

Digital inclusion and biases

There are several practical challenges to AI adoption such as gaps in digital infrastructure and inclusion: mobile handsets are not always smartphones. These account for 39% of the registered cell phones in Africa and the number is expected to grow to 66% by 2025; access to affordable hardware (smartphone, tablets, computers) is an issue. However, it is to be noted that several companies located in countries such as Egypt, Algeria, South Africa or Rwanda are now locally manufacturing such devices; effective skills are lacking. AI can indeed empower patients and communities to assume control of their own health care and better understand their evolving needs, but adequate equipment is needed on both the health workers and the patients' sides. AI solutions must therefore be carefully designed to reflect the diversity of socio-economic and health-care settings and be accompanied by training in digital skills, community engagement and awareness-raising.

For AI to have a beneficial impact, ethical considerations and human rights must be placed at the center of the design, development, and deployment of the solutions

For AI to have a beneficial impact, ethical considerations and human rights must be placed at the center of the design, development, and deployment of the solutions. The question of biases in healthcare services and systems based on race, ethnicity, age, and gender, that are encoded in data used to train algorithms, is a critical one to address for an effective use of AI in healthcare. The proliferation of AI solutions for healthcare services in unregulated contexts and by unregulated providers, might create challenges for government.

Health financing

With the advent of the COVID-19 pandemic, there is a sudden spotlight on e-health startups in Africa [2]. The number of startups active in the health-tech space on the continent has grown by 56.5 per cent over the last three years, with 180 ventures currently in operation. This is echoed by investors, with more than half of all funding for e-health in the past five years having been transacted in the first half of 2020 and totaling over US\$90 million. Major pharmaceutical multinationals such as Sanofi, Bayer, Merck or Pierre Fabre are also providing mentoring & financial support to e-Health start-ups in Africa [3].

Nonetheless, the amount of funds being raised on the continent is still comparatively limited, compared to the US\$8.4 billion raised in the first quarter of 2020 by about 500 AI startups across 42 countries outside the continent [4]. African start-ups only get a tiny slice of these funds due to the small venture capital base on the continent, particularly sub-Saharan Africa.

Underdeveloped Policy framework

Given the fast-pace of technology innovation, policymakers face challenges in formulating agile governance and policy frameworks. The lack of exchange between health tech innovators and health public policymakers delays the implementation of AI solutions, which could bring efficiency in healthcare.

In most African countries, the Artificial Intelligence policy framework is still work in progress

As a consequence, in most African countries, the AI policy framework is still work in progress with the result that aspects of data protection and consent regulations, as well as cyber security standards are yet to be addressed. In the absence of these health policy frameworks around the continent, fast adoption of e-health solutions is delayed

Selected AI for Health case studies

Cost-effective diagnosis of birth asphyxia

Birth asphyxia, one of the top three causes of neonatal mortality, is reported to be responsible for the death and disability (e.g. cerebral palsy, deafness, and paralysis) of up to 2 million newborns every year. In addition, many hospitals in low-resource settings do not have the specialized equipment nor the expertise to rapidly identify these patients and provide the urgently needed care to prevent the occurrence of irreversible brain damage, or worse.

According to clinical research, there are telltale patterns in baby's cries resulting from the fact that the same region of the brain controls both speech and breathing. This correlation leads to the assumption that one can identify a baby's state of asphyxia simply from the cry. In practice, by comparing the frequency patterns in the cries of babies that have asphyxia and the cries of babies that do not and establishing differences, one can build a machine learning model for birth asphyxia detection.

Ubenwa, a start up from Nigeria, has developed a solution that analyzes the amplitude and frequency patterns in the cry, to provide instant diagnosis of birth asphyxia. The technology is deployed via mobile devices and wearables and offers multiple benefits: It is fast when compared to the current method using a blood gas analyzer (10 seconds to detect a baby birth asphyxia); non-invasive as it requires only cry rather than blood; about 95% cheaper than clinical alternative; and requires little or no skill to operate; parents can monitor themselves their children.

The obtention of regulatory approval for the system requires a large database of clinically-annotated infant cries to validate the Ubenwa's algorithm in a real setting. Clinical studies are underway in several countries including Nigeria and Canada with the possibility to perform additional studies in South America and Asia. The purpose of these studies is to acquire large amounts of high-quality, clinically-annotated data to refine and validate the Ubenwa's algorithms. The objective is to acquire up to 10,000 cries from 2,500 patients, to ensure diversity of data and demonstrate efficacy.

Birth asphyxia is one of the top three causes of neonatal mortality. Analyzing and identifying acoustic biomarkers in the infant cry is a powerful diagnosis tool

This AI for health solution opens multiple interesting avenues. Analyzing and identifying acoustic biomarkers in the infant cry is a powerful diagnosis tool. Being able to predict long-term disability in newborns that have suffered severe, hypoxic events at birth by correlating the cry sound at discharge with developmental indices at 18-24 months is a valuable prognostic instrument. Finally, the automation of cry analysis to extract indicators of basic needs (pain, hunger, sleep) when translated to parents will lead to improved and optimal care.

Early detection and prevention of noncommunicable diseases (NCDs)

The burden of NCDs in Africa is gradually increasing while the continent is still struggling with lowering the mortality and morbidity from communicable diseases. The leading NCDs are: cardiovascular diseases, diabetes mellitus type 2, chronic obstructive lung disease, and cancer. The main risk factors for these NCDs are: tobacco use, harmful use of alcohol,

unhealthy diet and physical inactivity. The intermediate risk factors include obesity, high blood pressure, raised blood sugar and high cholesterol. AI models based on life style analysis combined with targeted exams (e.g. body mass index, blood pressure, glucose, cholesterol, etc.) lead to intelligent risks stratification approaches for early detection and prevention of NCDs.

The technology proposed by EDPU™ ©Africa endeavors to detect and prevent most noncommunicable diseases in the early stages through AI supported modules. The preventive healthcare screening platform connects various stakeholders in the healthcare system such as doctors, nurses, pharmacists and patients and delivers quality preventive healthcare through scientific, intelligent and evidence-based exchange, control and analysis of patient information. It provides a user-friendly overview of each risk factor, details various treatment modules when applicable, suggests relevant examinations and diagnoses and presents the final synopsis of all examinations, diagnosis and treatments in a quick, easy, objective, reliable and comfortable manner. The technology operates in two steps by first collecting the patient's lifestyle data. Depending on possible risks triggered by this first qualitative step, targeted quantitative clinical data are then collected. For each identified risk, the technology proposes a treatment, following best clinical practices, to keep the patient in the preventive level as long as possible. Even if these AI algorithms are based on hundreds of WHO studies and are developed in cooperation with governmental health care bodies and universities, each time the technology is deploy in a new geographic setting, an adaption to local market is needed.

Diagnosis of cardiopulmonary diseases in primary care

Respiratory diseases are the cause of over 2.5 million deaths globally, which is likely to increase with the prominence of COVID-19 and its devastating effect on healthy lungs. As for NCDs, early diagnosis is critical to successfully treat respiratory diseases. The existing technologies for respiratory diseases detection include stethoscopes, which is prone to misdiagnosis as it depends on the doctor's hearing and presents limitations to detect low-frequency sounds. Medical imaging devices like computed tomography (CT) scans or magnetic resonance imaging (MRI) use radiation are costly and could be harmful on the long run.

AI models based on life style analysis combined with targeted exams lead to intelligent risks stratification approaches for early detection and prevention of diseases

Tambua Health developed an AI platform on convolutional neural networks trained on thousands of experts annotated ultrasound images, auscultation spectrograms and electrocardiograms (ECG) data. T-sense, which is the name of the technology, detects the vibration of sound as air moves in and out of the lungs and generates images of lungs

accordingly. The technology uses sensor arrays, which consists in tiny non-invasive microphones placed on the back of the patient, to detect healthy and unhealthy lungs with the same accuracy as MRI and XRay machines. This is done by using spatial distribution algorithms that have been trained against the company's proprietary database of lung sound images. The technology is deployed on smartphones with a basic internet connection to crunch the data. The product is being piloted as a diagnostics tool in 267 clinics worldwide.

Others

In addition to the innovative e-health startups mentioned above, there are other, broadly speaking, digital solutions slowly taking root on the continent and strategically positioning themselves in the health value chain closing thereby some of the structural gaps. For instance, a start up like 54Gene will ultimately ease drug manufacturing on the continent based on Africans genomic data. LifeBank, is leveraging mobile technology to facilitate the delivery of medical products. Healthcent provides a platform, to manage communication offering predictive analytics including patient engagement and care team coordination. Babylon Health, in Rwanda, provides remote access, with mobile phones, to quality health care services to the population throughout the country. The delivery model is an AI-power triage and symptoms checker called 'Digital-First Integrated Care'. Rology, in Egypt, is an on-demand teleradiology platform that connects hospitals and other healthcare providers with radiologists according to the sub-specialization and expertise.

Conclusions

Digital health is a growing sector marked by the expansion of preventive medicine and more accessible online healthcare. The covid-19 pandemic is generating tremendous growth in this sector and is raising awareness towards e-health solutions. With the trend toward self-care, patients will increasingly carry sensors to monitor vital parameters, promoting personalized treatment supported by AI.

African health startups have understood the needs of the health systems and are moving fast to fill structural gaps by improving the patient journey process, though this is only limited to a few countries. The selected case studies have illustrated the need for interoperability with the existing health infrastructure, to develop a robust and enabling policy framework covering data governance and responsible AI and to allocate more funds to deploy these innovative solutions. The cases also illustrate opportunities such the adoption of individual global medical file (as a result of interoperability), close skills, technology and knowledge gaps through transcontinental partnerships.

Transcontinental partnerships appeared to be extremely important to develop, to pilot and to scale-up innovative AI solutions. As a matter of fact, digital innovation ecosystems across the world are at different levels of maturity but neither of them is performing to full potential. Bringing them together can bring enormous benefits for global health in general and for Africa in particular.

Fewer than 25% of African students follow science, technology, engineering or mathematics (STEM) courses [5]. Employers complain of too few well-prepared graduates seeking science-related careers. Only around 1% of global R&D investment is spent in Africa and the continent produces just 1.1% of scientific knowledge. Europe, for instance, has made remarkable efforts to improve research. It has earmarked €44bn for helping poorer nations build research infrastructure, set up a special research council and increased the budget share of innovation and research from 4% to 8% from 2014 to 2020, dedicating almost €80bn to the Horizon 2020 program.

However, regulatory rigidities and market dominance by established corporations hold back commercialization of innovative ideas. Obviously, Africa and Europe can forge a win-win relationship by building on synergies between their innovation ecosystems including building a transcontinental Africa-Europe AI policy framework and setting-up an Africa-Europe circular AI-based innovation model. Obviously, the same opportunity holds between Africa and other continents.

Digital health is a growing sector, and the pandemic is raising awareness towards e-health. Transcontinental partnerships appeared to be extremely important to develop innovative AI solutions

However, to seize the above opportunities, we need to overcome a number of challenges such as securing endorsement and buy-in from stakeholders, building and structuring multi-stakeholder partnerships and optimizing methods of piloting and sustaining joint initiatives. Such transcontinental collaborative models can generate unified ecosystems able to churn out AI for health solutions for global health. In addition, creating a pipeline for high performing AI for health startups can provide solutions to pressing social and economic needs of Africa.

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