Africa’s Digital Health Revolution: Leapfrogging Challenges to Deliver Healthcare for All

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Abstract

Proposed Article Abstract: In the African context, digital health solutions can leapfrog numerous health systems challenges to delivering effective and high quality care. However, the last 25 years of digital health innovation for Africa has resulted in numerous prototypes with very few implemented and sustained at large scales. In this viewpoint, we discuss opportunities for [HB2] and challenges in developing , evaluating and scaling digital technologies that are context specific to sub-Saharan Africa. We then explore a ‘people, process, tech’ approache to empower stakeholders to effectively navigate this complex landscape: bundling interventions, committing to open source, focusing on systems and technology integration[HB4] , and becoming the platform. We will illustrate these strategic approaches with case studies from the African continent.

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Introduction

Digital health tools promise to transform healthcare delivery and improve health globally by addressing long-standing challenges in healthcare access, quality and efficiency[1]. This transformative potential is particularly salient in sub-Saharan Africa, where persistent barriers to healthcare, including inadequate infrastructure, workforce shortages, and resource limitation, could be alleviated or entirely bypassed with digital health interventions.[2,3]

Digital health tools encompass a range of technology-enabled products and services developed to improve healthcare services.[4] These can range from large-scale national health infrastructure such as electronic medical records systems to mobile health apps for individual and commercial use. Broadly, digital health tools have been categorized into virtual interactions (such as platforms for teleconsultations); paperless data (such as electronic health records); patient self-care (such as mobile applications to support chronic-disease management); patient self-service (such as e-booking platforms); decision intelligence systems (such as hospital patient flow management systems); workflow automation (such as medical equipment tracking systems using radio-frequency identification).[4]

The potential for digital health in Africa

Enthusiasm for digital health interventions in Africa is fueled by substantial developments in the digital sector across the continent. In 2021, Sub-Saharan Africa alone had over 515 million unique mobile phone subscribers in 2021 (compared with 373 million in the USA.) And this is projected to rise by almost 100 million by 2025.[5] Mobile data quality and accessibility are also increasing with over half of users owning smartphones and 5G connectivity projected to grow from 1.5 million in 2022 to 40 million by 2025[5]. Additionally, there has been innovation in generative and predictive Artificial Intelligence (AI) and secure data-sharing methods, such as blockchain [6 7]. Innovation in the digital landscape creates a unique opportunity to deploy digital health solutions to overcome existing barriers to health in Africa. At health facilities, electronic medical records can improve clinicians’ ability to document and engage with patient histories and provide the basis for using predictive models, including AI-driven models.[8] Widespread mobile phone use can reduce barriers to healthcare access by bringing care directly to patients’ homes through telehealth technologies and empowering community health workers equipped with portable technologies for in-home health assessments.[9] This provides a unique opportunity for deploying mobile health solutions to remote and underserved areas.[3]

Transforming Digital Innovation to Digital Interventions

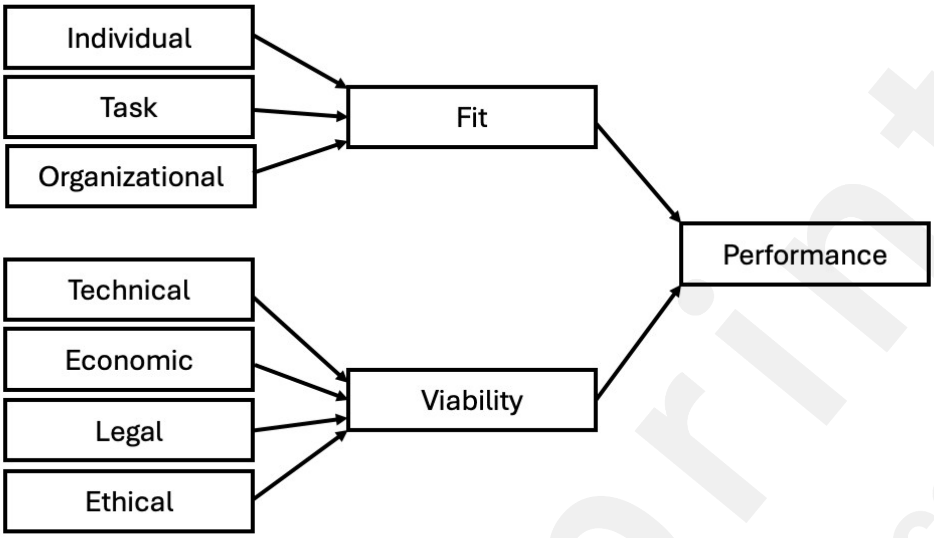
Digital health innovations are novel technologies, whereas digital health interventions encompass the services, practices, and strategies needed to implement an innovation. Whilst there has been a surge in digital health innovations over the past decade, few digital health interventions have achieved widespread, sustained implementation and integration into healthcare systems, particularly in Africa.[1]

Recognizing this gap, we convened a multi-disciplinary group of academic clinicians, researchers, technologists, entrepreneurs, policymakers, and health delivery service providers, with representation from both the global north and the global south, to conceptualize how to bridge this gap collaboratively. From this viewpoint, we share the key challenges in the innovation-to-intervention pipeline from our diverse perspectives, with particular reference to the African context, and highlight untapped opportunities. We then propose cross-cutting strategies to guide the region's development, evaluation, and scaling of context-appropriate and sustainable digital health solutions.

Key challenges limiting the digital health potential

We summarize the most significant challenges to be addressed to unlock the full potential of digital health interventions in sub-Saharan Africa using the fit-viability model as a framework[10–12]. This framework assesses both the suitability (fit) of a technology within its intended environment and the feasibility (viability) of its implementation considering local constraints (Figure 1). Both elements are critical to the successful performance of the chosen technology at scale in a specific setting.

FIg 1 - Fit/viability model adapted from Liang et al. 2007[10]



Fit: Identifying, developing, implementing, and maintaining a digital health intervention are critical to sustained success. However, the integration of digital technologies requires that the technology be a proper and appropriate fit to the task, as well as to the specific user and the organization. Many digital health interventions have not yet achieved a good "fit" for sub-Saharan Africa due to gaps in digital literacy, talent and expertise, training, staff turnover, and management that must be addressed to improve fit. For example, limited digital literacy and expertise in many African settings[13,14] has stilted engagement between high-income country (HIC) big technology experts (e.g. OpenAI, Google, GE, Medtronic, Johnson and Johnson) and local health service providers. This translates into a poor understanding of the local healthcare context by the technology holders and a restricted vision of how digital health interventions can be integrated into care by the local clinicians. Furthermore, a scarcity of experienced local technology talent may result in missed opportunities to identify digital interventions based on existing technology advancements. For example, the definitive technological solution to a digital health problem may exist globally; however, those experiencing the problem locally may not be aware of this solution or can't adapt the solution to the local problem with their current levels of expertise. Additionally, at an organizational level, limited digital literacy and understanding may cause organizational leaders to block or obstruct the implementation of effective and useful digital health interventions due to their limited understanding or comfort with the technology.

Additional challenges of fit surround the availability of reliable and relevant locally derived data sources. Electronic medical record systems are just beginning to emerge in the African context, and access to large, robust, and continually updated medical databases are similarly scarce due to funding constraints. Consequently, importing digital health interventions built using external data sources is common and yet highly problematic given differences in culture, race, ethnicity, language, and disease burden, among other factors, that can result in algorithmic bias. For example, many AI models developed to enable dermatologic diagnosis have been primarily built using images from databases where most skin images are from Caucasian patients, with few from African patients[15].

Viability: Viability challenges within technical, economic, legal, security, and ethical dimensions also impede translating digital advances into sustainable health interventions in Africa[16]. The fragmentation of digital health solutions in Africa continues to be a substantial barrier to widespread adoption and sustained impact[16]. At the technical and economic level, a lack of economy of scale resulting from individual-led efforts by academics, individual clinics or clinicians, small companies, and non-governmental institutions leads to substantial vulnerability to external factors largely mediated by the available national infrastructure. This includes, among other infrastructure challenges, erratic and unreliable electricity supply, poor internet connectivity, and some of the highest costs of mobile internet data in the world[17]. A recent example is the subsea internet cable damage resulting in widespread internet outages across Africa in 2024[18]. These challenges are often insurmountable for smaller institutions and may also present substantial barriers for larger and more stable corporations, requiring national and, at times, international coordination to overcome. New technologies like satellite internet may offer temporary solutions. However, these are typically only accessible to companies with substantial financial stability or clear pathways for further venture capital funding. The initial high capital requirements and lower availability of seed funding place an additional burden on small companies and individual entrepreneurs, leading to rare and isolated success. Furthermore, individual-led or small-scale efforts for digital intervention implementation may also face supply chain and production barriers that influence sustainable implementation. Many pioneers in digital health interventions have not been exposed to large production systems and manufacturing plants, global operations, corporate deal-making, bilateral agreements, mergers and acquisitions, and all the “unseen” operations that facilitate implementation at scale.

Legal and ethical factors are equally important to consider. The development of national and regional policies and regulations around adopting digital health interventions and integration into health systems is relatively nascent in Africa. Without clear policies and regulations regarding data privacy, security, and interoperability, implementers of digital health interventions may be subject to rapidly changing regulatory frameworks, which, in the development phase, may lack the maturity to provide clear guidance. This may complicate the landscape for implementers and make it difficult for these implementers and countries to establish a strong foundation for technological advancement.[19]

Providing a cross-cutting approach for scaling and advancing digital health

Addressing the key challenges identified above will take a multi-disciplinary, collaborative effort, with ongoing iteration to determine the most effective solutions. Based on our initial exploration of potential solutions, we suggest the following cross-cutting approaches targeting ‘people,’ ‘processes’ and ‘technology’ to overcome some of the identified challenges with the goal of bridging the innovation-intervention gap.

People: Building local talent and enhancing interdisciplinary collaboration for integrated health solutions

Successful implementation of digital health innovations requires a commitment to capacity building, local talent and expertise development, and building interdisciplinary collaboration. In the short term, this can result from immersion programs, joint curricula for multidisciplinary learners, and internships with big technology companies for emerging talent on the continent which will advance expertise at the individual level. However, in the long term substantial investment is needed to ensure that Africa develops adequate local talent and builds the requisite expertise. A recent study examining the supply and demand for digital skills in Cote D’Ivoire, Kenya, Mozambique, Nigeria and Rwanda found that an additional 114 million training opportunities are needed across the IT sector, with a market opportunity or investment of $11.1 billion across the five countries. This may seem a significant sum given the competing need for resources in many African countries. However, given the projection for 25-55% of all jobs requiring digital skills by 2030, including those within health care, the imperative for this investment cannot be understated[14].

Formal pathways towards Interdisciplinary collaboration are also necessary. By integrating insights from healthcare, technology, business, government, and cultural studies, stakeholders can better adapt and design solutions that respect local communities' unique cultural contexts by leveraging different skill sets from stakeholders in different sectors. This approach fosters sustainability by aligning interventions with existing healthcare processes and infrastructures and enhances their likelihood of widespread adoption and long-term use by healthcare providers and patients.

The LEAP mHealth platform in Kenya exemplifies such success through its people-centered and multidisciplinary approach[20]. LEAP addresses the educational needs of frontline health providers by providing mobile-based training to CHWs, enhancing their skills in a practical, accessible manner and connects community health workers with healthcare professionals to encourage multidisciplinary care. This platform was developed in Africa, by Africans, in a collaborative effort that combined leadership strategy and consulting (Accenture), mobile services (Safaricom), academia (Mpesa Foundation), policy and government (Kenyan Ministry of Health), a health technology start-up (Mezzanine) and a health non-governmental organization (Amref Health Africa). Over 57,000 community health workers have been successfully upskilled, demonstrating that by using a 'people's approach' and leveraging interdisciplinary insights for tech applications, stakeholders can ensure that digital health interventions in Africa are not only effective but also sustainable and transformative.

Processes: Streamlining delivery through bundled interventions and comprehensive platform development

Achieving the full potential of digital health solutions in Africa requires a holistic and integrative systems approach that aligns with existing healthcare infrastructures and workflows. Bundling multiple interventions into a comprehensive package allows stakeholders to leverage synergies and address diverse healthcare needs simultaneously. Such an approach also benefits from a larger economy of scale, enhancing the overall value proposition and increasing the likelihood of successful implementation and scaling. Bundled approaches also offer operational efficiencies by streamlining service delivery and leveraging shared infrastructure and resources. Defining the level at which to bundle approaches and the ownership and implementation of the bundle may depend on the particular digital intervention. Electronic medical record systems, for example, may be best bundled at a health sector level, such as a national health delivery system or within a private health system, whereas research trials could be bundled across international sites to facilitate ethics approvals and institutional review boards and help navigate regulatory frameworks [21,22]. This model is becoming more recognised and is now supported by regulatory frameworks like Health Level Seven International (HL7), a set of international standards for exchanging, integrating, sharing, and retrieving electronic health information to promote collaboration. A good example of bundling at the national level is the recent deployment of the Lightwave Health Information Management System by the Ghana Health Services across all teaching and regional referral hospitals in the public sector, with plans to expand to district hospitals[23]. Other digital interventions may be better bundled by disease condition or health focus, such as maternal and child health, HIV or tuberculosis, or non-communicable diseases (NCDs). A case study that exemplifies the power of bundling digital interventions by disease condition is the mHealth for NCDs program in Ghana[24]. This initiative tackles the growing burden of chronic conditions such as hypertension and diabetes by integrating multiple digital health components into a single platform. Features include SMS reminders to encourage medication adherence and educational messages on healthy lifestyles. The mobile platform also facilitates appointment scheduling and communication with healthcare providers. This multifaceted bundled approach demonstrated significant improvements in health outcomes, with enrolled patients experiencing a 25% increase in medication adherence and a 15% improvement in blood pressure control over six months[24].

Additionally, developing digital health platforms has become essential for driving long-term impact. Well-designed platforms facilitate the development, management, and deployment of digital health interventions for a wider stakeholder group, reducing the dependence on individual engineering expertise and, more naturally, fostering interdisciplinary collaboration. Platform-based approaches promote flexibility; as technology advances and user needs change, new features and functionalities can be easily added to the platform. This adaptability ensures that digital health solutions remain relevant and useful over time. Moreover, platforms facilitate data integration by enabling the exchange and consolidation of data from various sources and systems, allowing for multivariate analysis, evidence-based decision-making, and coordinated care delivery across different healthcare settings.

District Health Information Software 2 (DHIS2) [25] is an open-source software platform, which has become the world's largest health management information system, used in over 60 countries, including numerous nations in sub-Saharan Africa and highlights the power of platform development in digital health. Its versatile and modular architecture allows for tracking, analyzing, and reporting health data across various programs with use cases ranging from disease surveillance and monitoring to supply chain management and healthcare workforce planning. DHIS2 also provides a flexible and scalable platform for data integration and decision support.

Whilst bundling and platform integration is key, we also recognize the importance of empowering entrepreneurs and startups by providing resources to scale and collaborate. Entrepreneurs often find creative and affordable ways to solve hard problems by leveraging technology that may not be feasible at the national level or in the public sector. For example, LifeBank leverages mobile logistics technology to accelerate the delivery of blood products in emergencies[26], Zipline uses drone technology to deliver drugs and essential medical supplies to hard-to-reach areas[27], mPharma digitizes community pharmacies, and Emergency Response Africa in Nigeria[28] and Flare in Kenya are creating privately run 911-style emergency response services in Africa[29]. Innovating funding mechanisms that leverage socially responsible venture capital, venture philanthropy, multilateral organizations, and seed funding from the public sector should be encouraged to provide a pool of resources for for-profit startups to help scale innovative digital health technologies across the continent.

Technology: Strengthening infrastructure and leveraging open-source and accessible solutions for sustainable digital health innovation

Creating a supportive digital infrastructure environment is a foundational and a “behind the scenes” requisite for unlocking the potential of digital innovation. This is multi-dimensional and will require simultaneously supporting digital infrastructure development, fostering open-source technologies and open-access data repositories, whilst also developing and mandating standards for interoperability and data integration and recognizing the appropriate fit for digital hardware.

At the national and international level, more advocacy is needed for multi-lateral government and non-governmental agencies to develop initiatives to enhance national efforts to accelerate digital sector coverage by expanding and stabilizing internet and electricity coverage across the continent. For example, initiatives like Health Connect Africa [30], a partnership between CDC Africa and Global

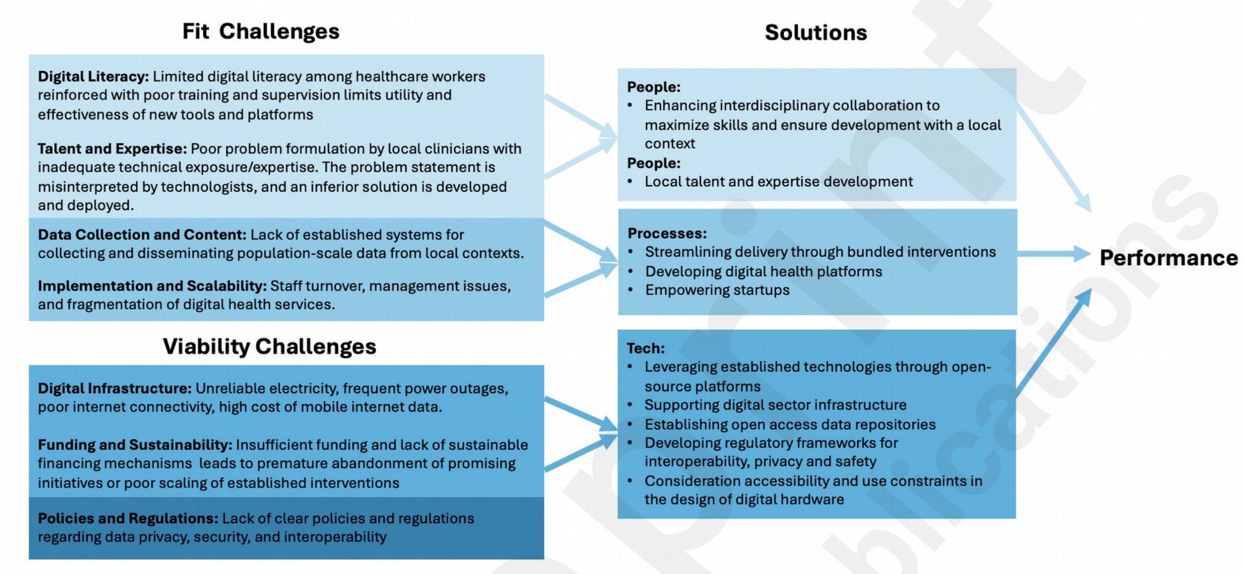
System for Mobile Communications Association (GSMA) (connecting 10,000 healthcare facilities to the Internet by 2030) and Power Africa[31], a USAID initiative to electrify 10,000 healthcare facilities in Sub-Saharan Africa, should be promoted and accelerated to enable sustainable healthcare.

Similarly, efforts to support open-source technologies and open-access data repositories will accelerate the uptake of locally relevant digital health interventions. Open-source software, freely available to use, modify, and share, promotes interdisciplinary collaboration, enhances cost-effectiveness, and supports local adaptation by eliminating proprietary licensing fees and encouraging shared development costs among contributors. Furthermore, open-source software enables greater transparency, fostering trust and facilitating continuous improvement through global community-driven collaboration and peer review processes. For example, OpenLMIS[32,33], an open-source logistics management information system, has been widely adopted across over 30 African countries to strengthen essential medicine supply chains. Its open architecture allows local customization to align with specific supply chain processes, data needs, and regulatory environments, promoting ownership and sustainable use. OpenMRS (an open-source electronic medical record platform) and mHero (an open-source two-way communication system that connects health officials with health workers) were rapidly adapted during the Ebola outbreak in West Africa to enhance case management, contact tracing and to facilitate communication, demonstrating the ability of such open source software for adaptation enabling nimble, rapid and effective response[34]. Similarly, during the COVID-19 pandemic, platforms like DHIS2 were instrumental to the response in many African countries by enabling surveillance packages that could be rapidly deployed and customized to local needs. In addition, the open-source nature of DHIS2 allowed for continuous updates and improvements based on user feedback, ensuring that the tool remained effective as the pandemic evolved [35,36].

Building data repositories on the African continent is critical to inform ongoing disease surveillance and management and has become even more imperative with the burgeoning of generative and predictive AI. Without this data backbone, sub-Saharan Africa could become reliant on generative algorithms predominantly trained on patient databases from HICs, raising issues of AI coloniality in addition to bias and irrelevance. To date, building such data repositories in Africa have been limited by funding constraints and variability in data formatting across and within different African countries. Recent Initiatives like NIH-funded Data Science for Health Discovery and Innovation (DS-i Africa) [37], Wellcome Trust and NIH-funded Human Heredity & Health in Africa (H3Africa) program, Masakhane[38], Lacuna Fund[39], Zindi[40], and other initiatives are working to overcome funding constraints and create shared open data repositories and data extraction tools that accelerate discovery and technology development. Such repositories will facilitate advances in basic science research and accelerate healthcare innovation by providing human datasets that can be mined for diagnostic, therapeutic, and preventive health insights. Beyond these funding initiatives, we also advocate for countries to adopt and mandate standards that foster interoperability, such as Health Level Seven (HL7) and Fast Healthcare Interoperability Resource. These standards facilitate seamless data transfer between siloed EMRs, HMIS, Laboratory Information Systems, mobile apps, and other technology systems. Such data transfer and integration of repositories enables larger and more diverse data repositories and could facilitate real-time dashboards showing the prevalence of diseases to support cost-effective, evidence-based responses. Importantly, this approach also provides the data backbone to make digital interventions derived from the repositories more widely applicable and inclusive and address the critical issue of AI coloniality.

The appropriateness of hardware that supports digital tools must also be considered, including cost, size, portability, complexity, maintenance, power consumption, durability with unstable electrical power and thermoregulation within the African context. Too often, expensive medical instruments and digital hardware brought into African settings without attention to these considerations are moved to "equipment graveyards" due to lack of usability stemming from a variety of issues: costly consumables, expensive and difficult to source repairs, electrical damage from unstable electrical grids, and complicated and time-consuming protocols that require excessive training of personnel and/or infrastructure resources, and/or lack of skilled personnel for maintenance [41–44] Addressing these constraints in the design phase will help facilitate successful and sustained use and promote their adaptability beyond urban settings to maximize the proportion of patients that can benefit.

Fig 2 - Fit/Viability challenges and solutions



Conclusion

In conclusion, digital health innovations hold immense potential for transforming healthcare delivery and improving outcomes globally. However, their successful implementation in Africa requires addressing unique regional challenges and leveraging localized strategies. Bridging the gap between digital innovation and intervention necessitates a multi-disciplinary approach that emphasizes investing in and building local talent, fostering interdisciplinary collaboration, developing comprehensive platforms, bundled interventions, open-access repositories, and empowering startups. Embracing open-source technologies enhances sustainability and scalability. Underpinning these strategies is a need for robust but nimble regulatory frameworks and policies that enhance the development of and safeguard the implementation of digital interventions. By adopting these strategies, we can overcome roadblocks and unlock the transformative power of digital health, ultimately leading to significant improvements in healthcare access, quality, and efficiency across Africa.

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