Digital Health in East Africa: Innovation, Experimentation and the Market

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Abstract

Across East Africa, mobile phones and tablets are increasingly sitting in the hands of community health workers, clinicians, managers and patients. They are being used for a widening range of functions from diagnostics to health insurance to treatment advice, generating hopes for new healthcare futures and establishing the region as an emerging hub of experimentation in digital health. Drawing on our on-going ethnographic and anthropological research in Kenya and Tanzania, this article explores the dynamic, varied, experimental, and increasingly financialised terrain of formal digital health projects. While innovation in digital health is a growing feature of healthcare across the globe, in East Africa it is entering into a region already long characterised by NGOised, fragmented and vertical healthcare systems and heavy dependence on foreign capital. This presents challenges to efforts, including the WHO's Universal Health Coverage agenda, to foster national and equitable public healthcare systems. In exploring these issues, we recognise the power, and often deleterious effects, of financial capital that foregrounds markets in global digital health, but we also open space for a (still critical) recognition of East African-led digital and data technology movements.

Policy Implications

- Digital health innovations targeted at creating or transforming markets are not necessarily inclusive or universal despite claims that they pursue Universal Health Coverage goals.
- The drive for innovation in digital health may distract from other older, often non-digital, solutions.
- The drive for innovation may create a fragmented and short-term digital health system, and thus policy makers must concentrate on coordination, sustainability, regulation, and interoperability.
- Digital health policy makers should carefully consider data privacy issues.
- Local actors, if given authority and control, have the potential to create more appropriate technologies for healthcare systems.

Scholars, activists and policy makers supportive of the aims of Universal Health Coverage (UHC), the idea that everyone should have access to 'health services they need without suffering financial hardship',[1] stress the importance of making national, public healthcare systems stronger and more accessible and affordable. In East Africa, though, efforts to pursue such aims have had to contend with existing and long-standing fragmented healthcare systems. For decades, these systems have been dominated by non-state actors, from religious institutions to donor agencies and NGOs, to both local and foreign private companies and entrepreneurs, which have often produced a vertically orientated and short-term projectified landscape of healthcare. Increasingly the terrain now includes East African and foreign digital healthtech start-ups and social enterprises, staffed by computer and data scientists, health researchers, software engineers and digital entrepreneurs.

In our current research into the UHC agenda, we have found ourselves immersed in these peoples' plans to design new digital technologies to improve medicine, healthcare, and public health. This has brought us into the growing phenomenon of what is sometimes called *mhealth* or *digital health*. Over the last two decades in East Africa, this has involved healthcare and medical actors experimenting with digital and mobile technologies in and around healthcare systems, drawing on the mobile phone revolution that began in the late 1990s (Friederici et al., 2020; Njoroge et al., 2017; Poggiali, 2016). If, in the colonial and immediate post-colonial period, the continent of Africa was often a recipient of technologies invented in and transferred from abroad, since the 1970s it has been more akin to a laboratory, within which foreigners and Africans alike experiment with a variety of technologies (Fejerskov, 2017). In this field, UHC and digital health, each with their own histories and trajectories, are intertwining (Mehl and Labrique, 2014), crossing paths for a variety of reasons, from the exigencies of funding to the shared desires to produce healthcare outcomes most efficiently and cost-effectively (Neumark, 2020; Prince, 2020).

An optimism for the ability of new technologies to help achieve UHC has accompanied and driven this experimentation. This connects to a wider techno-optimism, which, at its

zenith, portrays an almost revolutionary zeal, for instance, in the World Economic Forum's popular idea of the 'fourth industrial revolution' (Schwab, 2015), or the concept of 'leapfrogging' that challenges the idea of linear developmental and infrastructural pathways: mobile phones avoiding the need for landlines, mobile money obviating traditional banks, and off-grid solar giving clean electricity without the mains grid (Neumark, 2020). In health, a diverse set of actors are coalescing around these different technologies, often bringing them together in experimental processes of bricolage. In the process, they also reenergise forms of what have been called neophilia, a drive for novelty, first identified in the 1960s and clearly visible in contemporary humanitarian and global health architecture (Booker, 1969; Scott-Smith, 2016). This drive for technological innovation underlines what has been widely critiqued as an overly technological-centred approach to global health that is characteristic of the current Gates Foundation era (Birn, 2005). The emphasis on technical solutions, as scholars of development have long shown, may disguise the underlying social, political and economic, as well as moral, global and more local contexts through which they emerge, from the post-colonial state to processes of neoliberalisation and neocolonisation (De´ et al., 2018; Dahdah, 2020; Ferguson, 1994; Walsham, 2012; Webster, 2019a).

Despite the optimism for digital technologies for health and healthcare, there is not yet evidence that they are helping to produce stronger or more affordable national healthcare systems. There is therefore much to be cautious about the recent digital turn in the region – especially as it often dependent upon new forms of financial capital. As critical scholars, we are particularly concerned, for instance, about efforts to address the affordability of healthcare through new, often individualised, financial technologies, as observed by Prince in Kenya. Prince's research has focused on how mobile, digital technologies have become intertwined with government experiments in delivering UHC, combining with the mobile money system and the state's digital surveillance system, in efforts to scale-up subsidised private health insurance for the poor.[2] The Kenyan actors who work to extend and expand such digital health technologies describe their efforts at aiming to improve access to healthcare and financial protection for healthcare, approaching target populations as a market for health care products. Their products are embedded in and rely upon the extension of forms of financial capitalism and associated fintech and digital technologies. Tanzania, in comparison, has not experienced the same growth in private, digital health insurance products targeted at the poor. Neumark's research has focused instead on Tanzanian researchers, scientists and 'scientist-entrepreneurs' (Shapin, 2008) as they design and pilot digital health technologies.[3] These, they hope, will help to improve diagnostic capacity in and outside the public healthcare system, thus forming their own contribution towards efforts to make healthcare accessible to all. Yet in Tanzania too, actors enter into formal circuits of investor and philanthropic capital as they seek to fund and sustain their technological innovations.

On-going experimental and increasingly financialised efforts to digitalise healthcare in East Africa build upon, and may intensify, a projectified, individualised and fragmented terrain of healthcare. Our examples from Kenya, exploring the *downstream* deployment of digital financial technologies in healthcare, demonstrates this well. These may be detracting from alternative and crucial ways through which to reach UHC and achieve health for all. Yet we also recognise the possibilities opened up by digital technologies, and a range of technologies more generally, for improving healthcare systems. While we are cognisant of the political economic constraints, we are also interested in openings that may help produce more appropriate technologies, as we show in our material from Tanzania concerning the *upstream* design of digital diagnostics. Here, a variety of national actors, in their endeavours to design these more appropriate healthcare technologies and infrastructures, are seeking to wrestle epistemological authority away, if never in unmediated forms, from foreign experts. Such efforts and achievements, which are nonetheless fragile and uncertain, may represent a form of what Haraway (2016, p. 3) has called 'situated technical projects' in contrast to universalistic, capitalist techno-fixes.

1. Terrains of experimentation: East African digital health futures

Digital health in East Africa is a dynamic and multifarious phenomenon. While it increasingly includes what might be called the informal uses of digital technologies around healthcare and healthy living, for instance, the use of a mobile phone by a patient or healthcare worker (Hampshire et al., 2021), it has more typically been understood as the formal, digital projects or systems in healthcare. A recent review in Kenya has pointed to the rising number of digital health projects since 2010 (Njoroge et al., 2017). These include national digital health information systems, such as the widely deployed open-source platform DHIS2, as well as a variety of different forms of electronic patient records. However, continuing an emphasis set by the early *mhealth* movement, much of digital health focuses on particular diseases (such as HIV/AIDS and malaria) or issues (such as mother-and-child health). They include, for example, projects that use text messages to send information to influence patient or user behaviour (such as reminding HIV-positive people to take their medication, or reminding pregnant women of their antenatal care visits). Other pilot projects seek to create sustainable livelihoods for community health workers through apps that allow them to order commodities online and sell them to their communities. Meanwhile, microinsurance apps and 'health wallets' that seek to encourage people to save for healthcare via their mobile phones have mushroomed in popularity. In recent years there has also been a turn to digitalise older forms of telemedicine, by connecting patients both to human health workers (for example MedAfrica app, described as a 'pocket clinic') and to models trained with data through new artificial intelligence techniques.

The promise of the digital often lies in its capacity to directly and more cost-effectively connect patients ('through their mobile phones') with systems (such as healthcare facilities or community health workers, or health financing systems like health insurances, or even automated diagnosis). It also lies in the capacity of digital platforms to collect data 'in real time' (about how people use health systems, for example, or the distribution of malaria tests), thus enabling greater efficiency and transparency. Health system interventions, it is often argued, founder on a lack of data coupled with a lack of transparency concerning how money invested produces outcomes. Digital health technologies promise to collect data, providing 'results-based' interventions and 'transparency' for their donors and investors. It is this convergence of donors and investors that is shaping digital health, and global health more generally, in countries like Kenya and Tanzania.

In 21st century East Africa, the dominance of donors, NGOs and other charitable actors in healthcare is giving way to institutions more encouraging of the market, such as the philanthropic Gates Foundation, and foreign and local for-profit private sector actors. The funding landscape behind digital health projects reflects these larger shifts in development and healthcare funding in the Global South, towards a dominant model of private-public partnerships, philanthropic capital, and corporate investments offering 'catalytic capital' to kickstart new healthcare projects, producing a financialisation of global health (Hunter and Murray, 2019; Mawdsley, 2018; McGoey, 2012; Stein and Sridhar, 2018; Storm, 2018). In this new funding environment, NGOs are developing novel features; as they seek resources from corporate investors with promises to make profits and expand health markets, they present themselves as 'entrepreneurial organisations', which seek to create social goods (such as expanding access to healthcare) while making profits for their investors. Partnerships are developing between fintech, corporate investors, the Gates Foundation, NGOs, and governments to develop and deliver digital platforms.

Why has East Africa become a hub of experimentation in digital health? East African governments are actively seeking corporate investment into health care services and products, amidst continuous reduction in donor funding since the financial crisis of 2008. Healthcare is presented as an investment opportunity, for the development and expansion of new markets. The high density of mobile phone ownership/use and relatively good national internet coverage in Kenya and Tanzania offers an expansive territory for digital health pilots, with the possibility of scaling-up. Therefore, while digital health in the region stretches back to at least the late 1980s, when the national hospitals began to investigate possible ways to digitise patient records, it was only with the proliferation of mobile phones from the late 1990s that dreams of leapfrogging in health initiated what has come to be called *mhealth*. The landfall of undersea fibre telecommunication cables on the shores of East Africa around 2009, and the subsequent growth of 4G internet across the region, has nourished new hopes, connecting to dreams concerning health that have much longer histories (see also Geissler and Tousignant, 2020).

In Kenya, the success of the telecommunications company Safaricom and its mobile money product M-PESA, and the growth of digital fintech firms in what is known as 'Silicon Savannah', is encouraging experimentation with digital health products, driven by collaborations with Silicon Valley firms.[4] Mobile money platforms like M-PESA offer expanding access to financial services through mobile phones, creating huge profits for shareholders while encouraging indebtedness among ordinary Kenyans (Donovan and Park, 2019; Lyon, 2017; Malingha, 2019). The financial inclusion agenda offers an attractive model for investors, with the expansion of health insurance markets through digital platforms recognised as an emerging frontier. Similarly, impact and venture capital investors, faced with an increasingly saturated fintech market in East Africa, have begun looking for markets in other domains, including agriculture, energy and health. Meanwhile, the lack of data regulation creates a space for experimentation – while also generating concerns about data ownership and data protection (Adams, 2016). Kenya has only very recently introduced specific personal data protection laws but there are currently no signs of Tanzania doing the same (Marari, 2020). There are also fears that the laws, where they are in place, might be inadequate. In Kenya, there are concerns that the Data Protection Act 2019 does not properly protect citizens' data and was rushed through to assuage citizens' fears concerning the collection of their data in *Huduma Namba*, the government's ambitious national registration programme (Warah, 2019). These concerns speak to issues around privacy (Webster, 2019b) and sovereignty - that is, around the ownership, use and transfer of data across borders.

2. Downstream – expanding health insurance markets using digital platforms in Kenya

According to the Centre for Health Market Innovations, a non-profit organisation that organises a database of 'innovative health enterprises in low-and-middle income countries that are making quality health care affordable and access for the poor', Kenya 'has become a vibrant testing ground for health innovations' (Bazaz Smith, 2014). While there is a vast range of digital products, here we explore the 'mobile money for health' platforms that use digital technologies to reach 'mass markets', encouraging people to save money for health or subscribe to health insurances (Haas et al., 2013). These have typically worked with novel financial infrastructures offered by Safaricom's M-PESA platform, which by 2019 had reached 22 million users (see Malingha, 2019). The rise of the UHC agenda in Kenya, with its focus on improving access to affordable health care, has encouraged and legitimised a proliferation of health insurance and microinsurance schemes alongside 'mobile health wallets'. These enterprises are typical of the new ecologies of social enterprise solutions for healthcare coverage that have appeared during the past 10 years, as they seek to combine a 'social good' – enabling and expanding access to financial protection for health among the poor – with the pursuit of profit. Established by both Kenyan and foreign

entrepreneurs, often with seed funding from the Gates Foundation, bilateral donors, or the World Banks's International Finance Corporation, with a mandate to seek out corporate investment into new markets, they morph into for-profit social enterprises supported by venture capital. They thus provide an example of the increasingly intimate marriage between development and financial capitalism (Hunter and Murray, 2019), and of an investment in market solutions, which is particularly visible in Kenya. However, it is worth noting that these enterprises are, like the Tanzanian examples we discuss, often driven by or in collaboration with Kenya entrepreneurs who have an understanding of the challenges that most Kenyans face in paying for and accessing the healthcare they need. We briefly describe two of these projects as they have emerged over the past years, drawing out some salient features.

The first example is Changamka Microhealth, an integrated health financing company set up by a Kenyan entrepreneur, that utilises an electronic platform, accessible by mobile phones, to 'facilitate the financing of healthcare services for the working poor in Kenya'.[5] Changamka's mission is 'to innovatively use technology to create mechanisms for delivery of easily accessible, affordable, quality healthcare' (In Kiswahili, *changamka* means *get excited*). Its products include a health savings account, e-vouchers, and a microinsurance scheme. Founded in 2008 as a for-profit organisation, it launched a phone-based health insurance product together with Safaricom and British American Insurance Kenya Limited (BRITAM; Haas et al., 2013). By 2014, according to its website, its products had reached 80,000 customers.[6] It offered 'smart cards' for maternal health care and family health care, where 'customers can use M-PESA to transfer money into a savings account and use this account to pay for health care where needed'. Another product called Linda Jamii (*protect the community/society* in Kiswahili) offered what it called 'comprehensive health insurance' for the price of US$140 per family per year (more than twice the cost of that offered by the government's National Health Insurance Fund and far beyond the reach of most families). Much hyped when launched in 2014, Linda Jamii folded after less than two years, reportedly due to 'failure to gain traction in the market ... sending about 80,000 users of the product into confusion', when their health insurance cover was not renewed (Omondi, 2015).

Changamka's initial products failed to gain, in its language of business, 'market traction'. Initially aimed at the bottom-of-the-pyramid, these products operated on the idea, shared by many entrepreneurs and managers in this field, that most Kenyans are not too poor to pay for healthcare, but rather do not have the proper mechanisms for saving. However, efforts to convert low-income Kenyans into savers foundered. This produced a refocusing of products on middle-class markets, and Linda Jamii, which was reintroduced into the market, is now a service used mainly by higher-income earners in Kenya. Changamka is still active, currently offering products covering telemedicine, *mhealth*, health management, and mobile health wallets for maternal health and family health. It is currently seeking funding to move into new markets, for instance, financing chronic disease treatment by using mobile phones for 'innovative' crowdfunding 'demand generation', as well as for registration, payments, servicing and claims payments.[7]

A second example is the M-TIBA health wallet, a digital platform accessible through a mobile phone, which originally sought to enable healthcare savings for Kenyans on low-incomes. M-TIBA is not a form of insurance; it is a closed loop where funds saved can only be used for healthcare costs at selected (mostly private sector) providers, and there is no pooling of funds. It was produced through a partnership between PharmAccess (a Dutch-based entrepreneurial organisation and NGO financed by the Dutch government and the Global Fund, among others) and CarePay, a digital technology company (with a Dutch CEO) that received investment from Safaricom and M-PESA. PharmAccess' mission is to 'improve health care in Africa through technology and mobile innovations' and to 'make healthcare markets work through digital innovations'.[8] Lauded by the then-CEO of Safaricom as having the capacity to 'transform Kenya's healthcare sector', since M-TIBA's launch in 2016, the PharmAccess/CarePay partnership has embarked on an ambitious project to register Kenyans with this health wallet and connect consumers to (mostly selected private) health care providers using CarePay's digital platform. According to a blurb on its website, written soon after its launch in 2016, M-TIBA:

> is a first step in creating new digital solidarity mechanisms where people start paying for each other ... The strength of M-TIBA is that ... it allows us, with help from Safaricom, to identify vulnerable groups such as pregnant women living with HIV/AIDS in the slums, and place the financial support directly in the power of their hands, on their mobile phone.[9]

According to its designers, M-TIBA builds on existing solidarity mechanisms that are popular in Kenyan communities, like the *chama* savings-groups (neighbourhood savings groups, where mostly women meet and pool funds) or the *harambee* local fundraising events (Mbithi and Rasmusson, 1977; Rodima-Taylor, 2014; Shipton, 2010). In doing so, it seeks to replicate Safaricom's success with its M-PESA product, which reportedly was designed upon knowledge of local-level needs and habits (Donovan and Park, 2019).

Like Changamka, M-TIBA aims to activate what its designers see as an existing economy of savers, one based in existing solidarity mechanisms, redirecting their saving practices towards healthcare. Initially offering users or customers incentives to save, such as a 50 Kenyan shillings (ca US 50 cents) top-up on the first 100 shillings (ca US$1) saved, it too has foundered on the capacity and willingness of ordinary Kenyans to save specifically for healthcare costs, when they have many other pressing needs for money-in-hand. While by 2020, 140,000 people had registered on M-TIBA and 301 healthcare providers had signed up to the system, it is unclear how many of those registered are active users. For many Kenyans, saving for healthcare is difficult when

there are other pressing everyday needs. As one of its managers explained:

> The M-TIBA product was meant for the mass market, to target the poor, people in need to access to healthcare. But although we've enrolled many people country-wide, few of them are saving. I don't know what it is, but us Kenyans don't like saving. We don't save. Even where we have initiated an incentive scheme, where we are paying into people's M-TIBA savings, they don't do it, they drop out. There is no interest in savings. Kenyans like getting credit instead, they like loans. So people tell us, why am I saving but there is no loan?[10]

The M-TIBA users interviewed by Prince also explained their frustrations at a system in which their money was locked into a digital system that gave them access to a particular health care clinic and not to others. They also pointed out that this form of saving offered neither interest nor access to credit: 'It just stays there'.

By 2019, these problems had led to a shift in M-TIBA's target population from Kenyans on low, often sporadic, incomes to those earning higher and more regular incomes (i.e. middle-class Kenyans), who formed, according to one manager, 'a more sustainable market'. By focusing on higher income-earners, M-TIBA can still present itself as a product that expands access to financial protection for health. However, those working on M-TIBA observed these transformations with considerable ambiguity, and it was with considerable disappointment that they shifted their efforts away from what they regarded as offering forms of financial inclusion to low-income Kenyans, towards middle-class insurance markets.

Products like M-TIBA collect data on every transaction, which is fed back to particular healthcare providers in the private healthcare sector, providing 'timely and accurate data'. Since its launch, M-TIBA has also expanded into other applications, focusing on building an infrastructure of what employees described as 'data transparency'. For example, it provides an opportunity for private health insurers, to allow them to monitor customer use of health services; it was contracted to provide the digital registration platform for the parastatal National Hospital Insurance Fund and it offers healthcare providers a system of combining digital payments with 'real time' medical and financial data. These applications and products allow M-TIBA to present itself as 'the leading health financing technology platform for consumers, insurers, healthcare providers and governments'.[11]

Three features are common to the examples of M-TIBA and Changamka discussed above. First, these enterprises represent a shift towards new combinations of funding, which include donors and philanthropic foundations such as the Gates Foundation, as well as corporate investors. The mobile money-related digital health sector particularly attracts corporate investment because these services are more likely to make a profit for investors (compared to, for example, health information services).[12] While they may have begun as not-for profit enterprises, they often move towards for-profit models. The Kenyan state has encouraged these experiments with health insurance and healthcare savings, reflecting a global consensus (led by the World Bank) that UHC can be achieved in part through fostering markets for healthcare products, including health insurance.

Second, these products all seek to create an awareness and appreciation of the 'value' of health insurance and insurance-like products. The M-TIBA mobile health wallet, for example, seeks to create a savings culture around healthcare by engendering particular economic subjects, individuals who are able to prioritise health saving as an investment into a future. However, these aspirations have often foundered upon the economic realities of ordinary people's lives, where few have regular salaries, and people prefer flexibility in accessing savings.

Third, these efforts to reach and expand insurance markets have varying success, especially among low-income groups. Once donor-funded incentives to save money are removed, it is difficult to encourage saving. People in low-income brackets may prefer older and more trusted neighbourhood, church or work-based social savings groups that many (particularly women) are part of (Rodima-Taylor and Bähre, 2014).

The initial disappearance of Changamka's product Linda Jamii and its subsequent revival as a product for middle-class consumers, forms part of a litany of failed digital health technologies and fintech innovations, suggesting that efforts to foster particular economic subjects flounder in the economic realities of low-income livelihoods, where rarely is there extra money available for savings. Instead, people strive to borrow money. Safaricom's expansion of credit services (which enable people to gain credit more easily through their M-PESA accounts) feeds into these needs, while also creating much debt-related anxieties. M-TIBA has meanwhile refocused its efforts towards recruiting and maintaining middle-class markets. Such developments challenge expectations that such enterprises can achieve, or even aim to achieve, their stated aims of promoting health equity and universal access.

The Kenyan parastatal National Health Insurance Fund (NHIF), was set up in 1964 for civil servants and later expanded to include all those who are formally employed. Despite having the most widespread coverage in Kenya, NHIF still only covers about 20 per cent of the working population, although in spite of years spent trying to expand coverage among low-income and informally employed people. Its minimum premium of 500 Kenyan shillings (ca US$5) per month remains too high for most families. As the government aims to achieve UHC nationally by the year 2022, it has refocused efforts on expanding NHIF coverage among low-income groups, with donor-and World Bank-funded subsidy programmes for vulnerable families who are unable to pay for health insurance. PharmAccess and CarePay have recently developed partnerships with the NHIF to operate its M-TIBA digital platform alongside technical support, and are supporting selected county governments with funds to subsidise the enrolment of selected poor households into NHIF schemes. Thus, there appears to be a recent move away

from experiments with microinsurances and health wallet towards public-private partnerships between government, parastatals like the NHIF, NGOs like PharmAccess, and digital technology companies, and towards encouraging investments in national health insurance funds and structures – perhaps because these are well-known institutions that have a national presence and more potential for scaling up and reaching new markets (with government support) (Prince, 2020).

3. Upstream – digital health from Tanzania

Kenya's, and particularly Nairobi's, reputation as a digital innovation hub in Africa has made it a particularly attractive recipient for foreign investment and expertise, but Tanzania has not been entirely excluded from these flows. Major global off-grid solar energy companies, for instance, were founded in the country, and have found new, increasingly middle-class, markets through traditional radio, TV and internet marketing, a network of precariously employed sales agents, the widespread mobile money system, and sophisticated predictive analytics. Like many low and middle income countries, Tanzania's public healthcare system also depends on the open-source DHIS2 platform, developed by the University of Oslo, Norway. Furthermore, foreign health-tech companies, such as Ada Health and Macro-Eyes, have sought to integrate their digital technologies into the healthcare system, often relying on support from donors such as the Gates Foundation and the UN. Some of these digital health technologies fall into what have been described as frugal innovation, or famously in India as *jugaad*; forms of engineering that resembles the appropriate technology movement of the 1970s (Rai, 2019). In fact, PATH, which has acted as a facilitator for the Tanzanian government's digital health strategy, was established in the 1970s as the Programme for Appropriate Technology in Health. Yet today, the dramatic increase in availability of smartphones and the internet in Tanzania means that what is considered appropriate by some often also means something close to the cutting-edge of technology.

Tapping into these technologies, as well as global flows of money and knowledge, are tech-savvy young Tanzanians designing digital health technologies for their *own* country and its citizens. This small but growing population forms part of a wider phenomenon of digital innovation and entrepreneurship that has emerged across the African continent over the last decade, producing, among other things, mapping apps, wind power, electric cars, computer games, and more recently, robotic prosthetics and ventilators for Covid-19 patients (see also Friederici et al., 2020; Mavhunga, 2017; Poggiali, 2016).

One area that some Tanzanians are turning their data science expertise towards is the design of digital diagnostic devices that they see as addressing the deficit and unequal distribution of healthcare professionals. Primary healthcare facilities in Tanzania regularly lack functioning laboratories – these include deficiencies in basic infrastructure, such as water and electricity, equipment such as microscopes, slides

and reagents, and human expertise. To circumnavigate the inadequacies of basic healthcare infrastructures in Tanzania, antigen-based and antibody rapid diagnostic tests (RDTs), developed from the 1980s onwards, have now become widely available in the public healthcare system. Yet, these RDTs often make compromises, as is the case with available malaria RDTs, which produce only a qualitative rather than quantitative diagnosis of the disease. Recognising such compromises, and how their own public health system diverges from the WHO gold standard of quantitative microscopy diagnoses of malaria, a team of young Tanzanian computer-cum-data science students and staff at the University of Dodoma, decided to apply their own growing data skills to the problem. Acknowledging the problems in availability of laboratory technicians, particularly in rural primary health facilities, the team's aim was to create a diagnostic device that combined the image-capturing functionality and computational capacity of the smartphone, computational power in the cloud, and the standard laboratory microscope. Drawing on publicly available image data sets of magnified malaria-infected blood smears, and later their own collected data, they were able to train convolutional neural networks to begin recognising the malaria parasites, *plasmodium falciparum*.[13] The team, self-taught in these new data science techniques, were able to travel to some of the largest academic artificial intelligence conferences in the world, such as NeurIPS, and pan-African ones such as Deep Learning Indaba. Through these sorts of events, they were also able to make connections with researchers from around the world, developing collaborations that enabled funding and further study opportunities.

These and other Tanzanian digital health technologists present an interesting counterpoint to the foreign entrepreneurs, companies and institutions working in East Africa who are better resourced and networked. One important question to ask then is what digital health looks like when it is designed by those *from* Africa rather than by others *for* it? What might, for instance, a Tanzanian-led digital health sector look like?

On the one hand, these Tanzanian technologists are part of, must engage with, and potentially reproduce some of the drawbacks of the wider world of digital health. One particularly important aspect is financing. Many of them are looking to finance the on-going design, piloting and scale-up of their technologies. With often minimal support from the government, the technologists must wrestle with how to finance their technologies while remaining true to their aspirations to improve public healthcare infrastructures for marginal populations. To sustain their activities, they seek other sources of finance, including donors, investors, and individual users. When they turn to donors they risk contributing to the experimental, short-term and piecemeal, rather than scaled-up, landscape not only of digital health (Huang et al., 2017) but also of the heavily donor-funded, NGOised health systems across much of Africa. But when they turn to investors and individual users, they risk turning towards those mostly middle-class users who are more likely to generate better financial returns. Such exigencies place

Tanzanian technologists into global business movements around social enterprise or the bottom of the pyramid (Ely-achar, 2012) that have been widely shown to extend capitalism in ways that are detrimental to the poor.

Furthermore, if we are to understand the very valorisation of novelty in the drive for innovation as a social and historical particularity, we might also see its effects, for instance, how it might divert funds away from the more basic and essential, but not necessarily only analogue, infrastructures (Erikson, 2018). Or how it might create an avalanche of innovation that distracts and overburdens, rather than supports and relieves, often overstretched healthcare workers. Such a drive for innovation in digital health may also have the effect of perpetuating problems of a digital divide, rather than this divide merely hampering digital health. For instance, to take advantage of the latest developments in neural network predictive analytics in order to achieve higher diagnosis accuracy, the malaria project team soon realised they needed to abandon Android phones in favour of iPhones because of the consistency this Apple product offered in image capture. Yet, in doing so, they also had to move away from the affordability and wide availability of generic Android phones in Tanzania. The drive by digital health actors to incorporate the latest data analytical techniques, which Neumark observed in a number of instances, may risk making the best innovations available only to those who can afford them, for instance, urban private healthcare facilities, thus further exacerbating digital divides.

On the other hand, while it cannot be assumed that urban-based Tanzanian technologists instinctively know the needs of the poorer and marginalised populations in their own country, they often seem to have better ways of producing technologies that are more situated and less abstracted from a particular place, people or problem. Their long-term investment in, and desire to help, their own country means an engagement in it that is far deeper and more sustained than many foreign companies and researchers. While Tanzanian technologists experience satisfaction in perfecting code and solving technical problems, they also spend much of their time meeting face-to-face with fellow Tanzanian healthcare workers, health researchers, and government leaders. They see the necessity of advocating for their technologies and what can be done with their advanced data analytic skills while at the same time learning 'domain' knowledge from others. One data scientist who was designing a diagnostic device for urinary tract infections, a disease common in Tanzania, told Neumark, 'I need to know about urine, they need to know about artificial intelligence'.[14] In practice, 'knowing urine', meant understanding *Tanzanian* urinary based disease, but this still meant the more objective aspects of its aetiology and treatment in the country. Yet, at times the data scientists find themselves confronted by, and wrestling with, new forms of more situated knowledge that challenge and shape the very solutions they are developing. For instance, when a Tanzanian healthtech start-up piloted their Bayesian-based diagnostic app in a rural health facility, they carried out their own research, observing the existing largely analogue paper-based diagnostic knowledge infrastructures contained within books in boxes and on shelves. From this, they began wondering if what was also needed in their app was the inclusion of these in a simple, digitalised version. While not immune to dreams of the universal techno-fix that could be scaled-up with enough Big Data, the Tanzanian data scientists were constantly being pulled back into the situatedness of action.

While Tanzanian data scientists sought to make more situated, better technologies, they also sought to mount a political challenge to long-standing narratives that have reproduced the idea of their country as the recipient in transfers of technology developed elsewhere or as a site of experimentation by foreigners. In this way, they generate new forms of hope for their own national and even pan-African community of technologists. Their hopefulness is different to that of outsiders. Whereas many companies and institutions coming from outside tend to see Tanzania as a generic African country whose poor infrastructures can be addressed by new, cutting-edge technology, the hope of Tanzanian data scientists embodies a sense of sovereignty and self-actualisation that moves beyond the production of better or more appropriate technologies. Instead, producing better health technologies are about producing better futures for Tanzania, as well as Africa as a continent. Technologists draw on past state failures, for instance of training and retaining enough healthcare workers, as indicative of future realities that could ensue in the absence of the new technological solutions they themselves are developing. Yet, they also recognise their relative minority status in the technology world. Foreign companies, with more substantial resources, have historically been favoured and trusted by the Tanzanian government over 'home-grown' Tanzanian innovators. Moreover, deficiencies in national digital and data regulation have meant that such companies can also continue to carve out new markets for their digital apps, even from afar, often with little scrutiny.

4. Conclusion

The physician and anthropologist Farmer (2012), speaking from his experience in Haiti, argued that healthcare systems need what he calls 'infrastructures of transparency', which include 'electricity, modern bookkeeping, accountants [and] computers', to reassure donors that money is being accounted for. In East Africa, the recent proliferation of small-scale off-grid solar, mobile phones and 4G telecommunication infrastructures might help provide what Farmer is arguing healthcare systems need. But it is becoming increasingly apparent that digital technologies are offering more. A recent study in Africa has pointed to the variety of ways healthcare workers are using mobile phones, from googling symptoms to using the camera for medical procedures, suggesting that this informal digital health constitutes 'a large-scale emergent health system' in itself (Hampshire et al., 2021, p. 21). The authors argue this is taking place independently of the formal digital health projects that have proliferated across Africa.

Digital health projects often operate on much smaller scales, particularly as many never move beyond the piloting stage owing to issues of financing and regulation. Instead, they may contribute to the fragmentation that continues to characterise African health systems, even as governments make moves towards UHC, aiming to scale-up national healthcare systems to 'reach everyone'; that is, national populations and all citizens. Although digital health projects often share a language of 'scaling-up', 'reaching everyone', and 'universality' with the UHC agenda, it is important to note the slippage between the ways 'universal' may be imagined. Digital health projects like those involving the M-TIBA platform imagine scaling up towards new *international* markets rather than *national* healthcare systems or national populations. Such digital health applications are tried out in one country and scaled up in others. For example, PharmAccess' products and platforms designed by CarePay are being scaled up in Nigeria, Tanzania, Uganda and Ghana. Such imaginations illustrate Achille Mbembe's point that capitalism and its technological solutions do not need to absorb everything in their path; when they hit resistance, for instance, when the poor do not save for their own healthcare, they can, in Ferguson's (2005) terms, 'hop' to other places or other populations, like the middle-classes, even across a national border. As Mbembe (2017, p. 255) says, one way to solve these sorts of local problems is by 'mutations onto larger and larger scales'. The concept of universal, then, points towards different destinations: on the one hand, towards expanding markets for profit-driven innovations, and on the other, towards reaching national populations through improving healthcare access and healthcare systems. While project designers may argue that the two destinations converge, there is no evidence that market innovations always improve healthcare access for poor people.

As we have seen, the Tanzanian digital health innovators' imaginations and hopes concerning their designs currently tend to be more focused on the national healthcare systems and populations. This is not a stable state of affairs, however. For a fringe minority in the digital innovation space in Tanzania, it represents a *failure* of imagination – Tanzanian technologists should be thinking more universally, beyond apparently out-dated ideas of the nation-state. But for many more, focusing on their own country, and working with the government to scale in the public healthcare system, is a matter of being able to design better, more appropriate, technologies. In doing so, they have been pulled into the world of the government as it seeks to coordinate different digital health stakeholders and move away from the more piecemeal and short-term projects through its National Digital Health Strategy. We believe more research is needed to understand the often painstakingly slow and politically charged work in which governments seek to connect digital health technologies to what already exists while coordinating the work of stakeholders. While innovation remains crucial, what is perhaps needed, then, is for it to be joined by more talk of coordination, regulation, interoperability and standards. Integration may be more important than innovation, if digital health is to strengthen national healthcare systems and help achieve goals of health for all. Such integration would need to consider not only formal digital health projects, but also how, or even if, to include the proliferating informal uses of digital technologies in healthcare systems in Africa (Hampshire et al., 2021).

Such work also draws attention to the potential dangers of innovation itself. East African populations and bodies have long been subjected to forms of experimentation in the name of scientific and technological innovation. Yet such innovation risks drawing resources and attention away from persistent problems that already have older, even if still digital, solutions. The Covid-19 pandemic response in the Global North has also revealed this in stark terms, characterised as it was by initial hopes for novel, untried, digital technologies, such as for tracking and tracing infections, and then their subsequent failures (Erikson, 2020). The current Covid-19 response has drawn attention to the dependence upon older, more established digital solutions, for example, mobile phones through which people potentially infected by the virus are contacted, teleconferencing between doctors and vulnerable patients who cannot attend clinics in person, WhatsApp messaging to distribute vital public health information, and payroll software that has ensured healthcare workers are paid. In East Africa too, as our interlocutors often reminded us, more work is needed to build the basics of a digital health system appropriate to and supportive of its countries' public healthcare systems.

Notes

1. Our research is part of a larger project on Universal Health Coverage and the Public Good in Africa, funded by the European Research Council ('UNIVERSAL HEALTH', ERC-STG, nr.759820). Prince thanks Professor Charles Owuor Olungah and the Institute of Anthropology, Gender and African Studies at the University of Nairobi, as well as Biddy Odindo and the staff of DVBD for their support. Neumark thanks Dr Vendelin Simon at the University of Dar es Salaam for his encouragement and advice, and is grateful to all his interlocutors in Tanzania for sharing their time and expertise.https://www.who.int/news-room/fact-sheets/detail/universal-health-coverage-(uhc).
2. Prince's research took place in Kenya during three periods in 2018, 2019 and 2020, focusing on health insurance and state-led experiments with universal healthcare and universal health coverage. Research for this article included interviews with MTIBA users and managers, conducted in 2018 and 2019, follow-up cases with users, and with regional NHIF managers, hospital managers, health workers and county health officials in 2019 and 2020. The research received ethics approval from Kenyatta National Hospital-University of Nairobi Ethics Review Committee (P48/01/2019) and NACOSTI (Research Licenses NACOSTI/P/19/262280/28533 and NACOSTI/P/20/4186). Our research is part of a larger project on Universal Health Coverage and the Public Good in Africa, funded by the European Research Council ('UNIVERSAL HEALTH', ERC-STG, nr.759820).
3. Neumark's research, that began in 2019, focuses on the design, piloting and deployment of digital technologies in the domain of health and healthcare in East Africa, and their role in the Universal Health Coverage agenda. The data for this article was gathered in Tanzania between 2019 and 2020, through ethnographic fieldwork with data and computer scientists, health researchers, nurses, clinical officers and clinicians. Ethics approval was granted by Tanzania's

National Institute for Medical Research (NIMR/HQ/vol. IX/3186) and research approval by the Tanzania Commission for Science and Technology (2019-389 NA 2019 – 177).

4. Kenya's success in expanding mobile and digital financial services, and the density of fintech firms that have since developed in its Silicon Savannah, often through partnerships with Silicon Valley firms (which provide capital and technical expertise/advice).

5. http://changamka.co.ke/, accessed 18 August 2020.

6. https://www.innovationsinhealthcare.org/Changamka%20Profile.pdf, accessed 18 August 2020.

7. See https://www.changemakers.com/makingmorehealth/entries/changamka-microhealth-0

8. According to its website, 'PharmAccess helps build stronger health markets that make smart use of funds and give power to the individual'. https://www.pharmaccess.org/update/global-fund-partners-with-pharmaccess-to-accelerate-universal-health-coverage-in-africa/, accessed 1 November 2019.

9. M-TIBA, accessed 17 August 2020.

10. Interview with Prince in July 2019.

11. M-TIBA, accessed 17August 2020.

12. Thus, there are efforts to combine health interventions, such as health information service with mobile money products. A recent USAID report even suggests levering community health workers to act as mobile money agents in hard-to-reach areas, extending the reach of both health services and mobile money (Haas et al., 2013).

13. See https://ai4d.ai/malaria-diagnosis/.

14. Quote from informal conversation during participant-observation by Neumark on 21 September 2019.

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