Digital contact-tracing and pandemics: Institutional and technological preparedness in Africa

Abstract

Several countries in Africa have either deployed or considering using digital contact-tracing (DCT) as part of their Covid-19 containment strategy, amidst calls for the use of technology to improve the efficiency of traditional contact-tracing. In this research note, we discuss some of the complexities entailed in using in DCT in Africa. Adopting a socio-technical perspective, we argue that if DCT design and deployment is not well thought out, it can lead to unintended consequences, particularly in a continent like Africa with disproportionate levels of digital divides and other structural inequalities. We suggest that any adoption of DCT by African countries must take account of their compatibility with local resources, values, social structure and domestic political factors. Accordingly, we argue that the unproblematic *transfer* of DCT to African countries can result in the marginalisation of people who suffer a varying degree of digital divides and other structural inequalities. Instead, we propose a process of *translation* whereby DCT adaptation is made to accommodate the unique institutional and technological characteristics of African countries by leveraging local practices learned from previous pandemics like Ebola to develop a *blended epidemiolocal approach* to (digital) contact-tracing.

Keywords: Africa; Contact-tracing; Covid-19; Institutions, Pandemic; Socio-technical perspective

Introduction

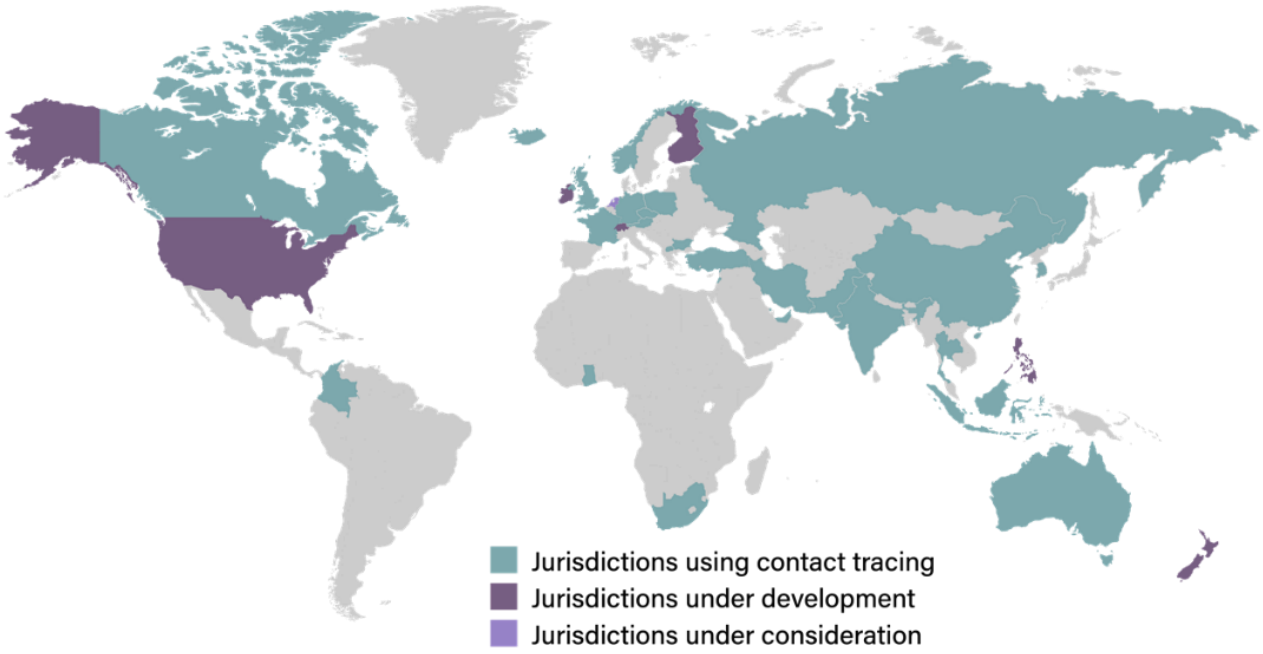
From the first reported Covid-19 case in Egypt on 14 February 2020, Africa has recorded around 130,000 positive cases as of May 29, 2020 (Worldometers, 2020). In order to contain the initial spread of the pandemic, African governments imposed various control measures and restrictions including social distancing to ensure that they were able to reduce the reproduction rate ("R_t") and avoid overwhelming their health services. These measures have had substantial impacts on economic and social life across Africa. It is increasingly clear that in order to resume economic activities, contact-tracing needs to be implemented (WHO Regional Office for Africa, 2020).

Contact-tracing- the identification and follow up of persons who may have had contact with a confirmed Covid-19 patient- is an important part of any epidemiologic investigation and active surveillance. This is also critical for any de-confinement strategy of gradually easing lockdowns. The Africa CDC (2020) guidelines on contact tracing has advised member states to use "the characteristics of the epidemic in their country to decide when and how to do contact tracing". Some African countries have learned best practices for contact-tracing from previous infectious diseases such as Ebola virus ("EVD") (Largent, 2016). These experiences have made it clear that there are logistical and governance challenges in the implementation of traditional/manual contact-tracing (Greiner, Sobanski, & Bock, 2015). The recognition of these challenges among other things, has resulted in the call for the use of digital contact-tracing (DCT) to improve the efficiency of traditional contact-tracing (Africa CDC, 2020; Bode et al., 2020; Ferretti et al., 2020; Gbenga, 2020).

As of 31st of May 2020, 28 countries have already adopted DCT, including China, Australia, South Korea and Taiwan with many other countries considering their implementation (see Figure 1). Thus far, our country analysis indicates Rwanda and Egypt have implemented GSP enabled DCT with mobile app and cellphone tower data respectively in

Africa. The South African government has partnered with the University of Cape Town to develop GSP enabled DCT with mobile app. WHO AFRO is piloting a project with the Republic of Congo to repurpose the Polio GIS platform previously developed for EVD, into Covid-19 DCT. Furthermore, WHO is also developing a global app for checking symptoms and tracing contacts, that should support African and other developing countries in their fight against Covid-19 (Dave, 2020).

Figure 1: Contact Tracing Global Snapshot as of May 29, 2020



Source: Norton Rose Fulbright (2020)

Until now the discourse on the suitability and effectiveness of DCT has primarily focused on privacy issues (Bamford et al., 2020; Ferretti et al., 2020; Privacy International, 2020). This discourse often takes a techno-centric perspective with a focus on how to address data security and privacy concerns through technical solutions (Yasaka, Lehrich, & Sahyouni, 2020). While privacy issues are important, we argue in this research note that if DCT design and deployment is not well thought out, it can lead to unintended consequences, particularly in

a continent like Africa with disproportionate levels of digital divides[1] and other structural inequalities (Arakpogun, Wanjiru, & Whalley, 2017; GSMA, 2020).

Adopting a socio-technical perspective, we argue that inscribed in DCT design is certain "vision of (or prediction about) the world" (Akrich, 1992, p. 208) - that is, assumptions about the world of the users and how they are going to use the technology. For example, inscribed in the DCT design are assumptions that citizens are willing to share their data, they possess smartphones, they have the skills to use the application, and that the country's institutional and technological infrastructure is supportive of DCT deployment. However, we argue in this research note that the national institutional framework affects the deployment of public health systems such as DCT by stipulating the governing rules and shaping social interactions, including what is fair and reasonable under certain circumstances (Miller, Toffolutti, & Reeves, 2018). The range of national institutions that will have implications for the adoption of DCT as part of a public health strategy are complex in any context. This raises the research question of *what epidemiological contact-tracing approach should African governments adopt in dealing with a pandemic?*

In this research note, we take a brief look at some of the complexities of the interactions between DCT and the national institutional frameworks in African countries. We suggest that any adoption of DCT by African countries must take account of their compatibility with local resources, values, social structure and domestic political factors. Accordingly, we argue that the unproblematic *transfer* of DCT to African countries can result in the marginalisation of people who suffer a varying degree of digital divides and other structural inequalities. Instead, we propose a process of *translation* whereby DCT adaptation is made to accommodate the unique institutional and technological characteristics of African countries by leveraging local

[1] Digital divides here include the lack of access to telecoms network, mobile devices and digital literacy.

practices learned from previous pandemics like EVD to develop a *blended epidemiolocal approach* to (digital) contact-tracing.

Our article is organised as follows: we first provide a brief overview of the differences between a techno-centric vs a socio-technical perspective on technology. We then discuss the difficulties entailed in transferring technologies across contexts with a particular focus on the deployment of DCT in the African context. Finally, we end this research note by discussing possible policies and actions to overcome the shortcomings of using DCT in Africa.

Techno-centric vs socio-technical perspectives

A technocentric view of DCT would conceptualise it as "isolated technical artefacts, the collection of hardware and software" (Heeks, 2005, p. 25) which entails using a smartphone app to identify and trace contact persons. This techno-centric view is often criticized for its relative neglect of the interplay between technology and its societal context of deployment by focusing on the techno-economic benefits of a given technology (Avgerou, 2008; Walsham, 2017). The limit of such view is that it portrays technological artefacts as neutral material objects, and thus conceals "how institutions influence the design, use, and consequences of technologies" (Orlikowski & Barley, 2001: 153). In contrast, socio-technical perspectives emphasise the interplay between technology and its context of design, implementation and use (Avgerou, 2008; Gebre-Mariam & Bygstad, 2019; Hatakka et al., 2019). According to this perspective, technologies are inherently political since they involve decisions about their designs which cater to certain users' interests and exclude others (Bijker, 1995; Joerges & Czarniawska, 1998; Spicer, 2005).

Therefore, technologies inscribe the social beliefs and assumptions of the creators and stakeholders involved in its design (Akrich, 1992). The concept of inscription from actor network theory (Joerges & Czarniawska, 1998; Latour, 1992) is central in this view to capture

the idea that technology producers inscribe into a technology "a series of technical norms that specify the standard uses of that technology and how the technology itself is to behave" (Spicer, 2005, p. 869). These inscriptions reflect the designers' assumptions about the potential user, their skills, and the contexts in which the technology will be used (Linderoth & Pellegrino, 2005). For example, in the context of DCT, designers would have assumed that users possess smart phones and have the needed digital skills to use the mobile applications. Furthermore, they would have assumed that the context of use is supportive of using DCT in terms of the availability of digital infrastructure and the required institutions to deploy and manage the app throughout the nation.

Designers' assumptions are shaped by the context in which they are embedded and therefore their own cultural values and views are inscribed in the technology (Heeks, 2005). The realisation of the social embeddedness of technology design, implementation and use, have led scholars to bring attention to the difficulties involved in transferring technologies across contexts (De' & Ratan, 2009; Heeks, 2005). In particular, scholars in the field of ICT4D have challenged the idea that ICT can be deployed unproblematically in developing countries to achieve socioeconomic development goals, rather they pointed out that such endeavours often fail due to differences between the design and implementation contexts (Avgerou, 2008; De' et al., 2017; Heeks, 2005) and/or lead to unintended consequences by marginalising vulnerable[2] groups whose circumstances are not considered by technology producers (De' & Ratan, 2009).

Transferring technologies across contexts

Prior studies on the diffusion and adoption of e-government systems and applications in the public sector can provide us with important insights into the use of DCT in developing countries. As the literature on e-government has shown, the diffusion and adoption of these

[2] People most affected by existing structural inequality

systems are uneven globally with developing countries lagging behind (Cavalheiro & Joia, 2014; Heeks, 2005; Zhang et al., 2014). The characteristics of the institutional and political environments in various countries can enable or constrain technology adoption (Zhang et al., 2014). For example, the lack of infrastructure for information and communication technologies (ICT) such as broadband internet can inhibit the adoption of e-government applications (Faniran & Olaniyan, 2009). Macro environmental factors such as formal institutions (Quast, 2007) and cultural and societal norms and values (Al-Hadidi & Rezgui, 2010) impact the successful deployment of technologies in a certain context (Zhang et al., 2014). Besides, the capabilities, skills, and resources of the relevant governmental agencies and stakeholders determine the suitability of the technology in a given context (Al-Busaidy & Weerakkody, 2009; Moon & Norris, 2005).

A unifying theme across these studies is the idea of a "contextual mismatch" (Heeks, 2005) between the original context in which the technology was designed and the context to which it is transferred. The cultural, institutional and technological differences across countries complexify the technology transfer process and its successful deployment. Heeks (2002) points out this is especially the case when a certain technology is developed by designers from a developed country for developed country users and then subsequently transferred and adopted by a developing country. The literature is bound with examples of failed transfers and/or cases where substantial modifications to the technology were needed.

Of relevance to our discussion are the unintended consequences on vulnerable people's circumstances that might result from the unproblematic transfer of technologies across contexts. For example, Prakash and De' (2007) show how introducing a computerized land records system in India has marginalised small and landless farmers. As Heeks (2005) points out, in these situations, this mismatch is a result of a design-reality gap as designers fail to take into consideration the local conditions of the context in which the technology is deployed. As

pointed out earlier, a technology contains inscriptions (Latour, 1992) which are assumptions or expectations about the user's context and how they will use the technology. These assumptions are "perceptions of the designer about the world of the user, so they are drawn from the world of the designer" (Heeks, 2005, p.56), and therefore they are shaped by the cultural and institutional environments in which the technology emerged.

Therefore, it is vital to uncover the assumptions inscribed into the architecture and design of DCT. Prior studies have identified different design dimensions that captures the contextual elements inscribed in a design (Heeks et al., 1999; Heeks, 2005). These inscriptions involve assumptions about: the *information* to be handled by the application; the *technology* needed by the application; *processes* through which the application will function; implicit *cultural values* that the users hold; the *skills* needed by both the staff managing the application and the users; *management systems and structures* needed to deploy and manage the application; and finally *other resources* needed to deploy and maintain the application (Heeks et al., 1999; Heeks, 2005).

We apply the framework proposed by Heeks et al. (1999) to uncover the inherent assumptions in DCT design and examine their suitability in the African context. As shown in Table 1, some dimensions like information and technology requirements are explicit. For example, for DCT to be successful, it requires users to possess smartphones and that individuals' information are easily retrieved through a central government repository. Conversely, dimensions such as objectives and values are more implicit. For example, how do users perceive pandemics and their stance towards contact-tracing. Overall, Table 1 shows that while the designers of a technology like DCT may inscribe their assumptions into the design under the various dimensions proposed by Heeks et al., (1999), the suitability of DCT would unravel when the technology is transferred without considering exiting institutional and technological factors in a given context. Therefore, the need to contextualise inscribed

assumptions into the design of technology is critical to avoid creating a “contextual collision” (Heeks, 2005) which could lead to the failure of new technologies like DCT and inhibit the containment of Covid-19 pandemic.

Table 1: Contextualising technology design dimensions in Africa

Dimensions	Explicit or Implicit Requirements	Inscribed Assumptions	Challenges	Consequences
Information	Explicit	Individual agrees to sharing their information Individuals' information can be easily retrieved Accuracy of information	▪ Weak or non-existent privacy legislation ▪ Absence of non-digital system of national IDs like driver's license and birth certification ▪ Difficult to trace contacts when patients have used public transport or have been in busy public spaces ▪ Some individuals leave little or no digital trace ▪ Some rural areas do not have/use house address	▪ Individuals reluctant to use the system – concerns about personal information being used for purposes outside the realm of public health services ▪ Identification of Covid-19 contacts is difficult using DCT – delays in notification, possible spread of contagion ▪ Staff intensive to track and trace contacts ▪ When individuals rely on daily income and must travel long distances to earn a living – risk of multiple community spreads ▪ Not all contacts may be notified to self-isolate
Technology	Explicit	The ubiquity of ICT infrastructure; That citizens have compatible mobile devices – smartphones with latest operating software	▪ Low mobile phone subscriber penetration North Africa – 68% (GSMA, 2019) Sub-Saharan Africa – 45% (GSMA, 2020) ▪ Low smartphone adoption North Africa – 52% (GSMA, 2019) Sub-Sahara Africa (SSA) – 45% (GSMA, 2020) ▪ Lack of connectivity in rural areas, for example over 5,000 villages in Nigeria lack internet connectivity. In 2018 an average 56% of total African populations reside in rural areas. In 2018 Burundi had highest percentage of rural population (89.97%); Gabon with the lowest rural	▪ Research ICT Africa (RIA) survey found that majority of adults in Rwanda and Tanzania only have access to basic phones ▪ DCT should be available and accessible irrespective of the technology needed or the level of digital literacy ▪ A lack of ICT and poor bandwidth connectivity in hospitals to enable smooth and timely information transfer ▪ Difficult to implement DCT in rural areas in many African countries. Lack of ready infrastructure to provide connectivity to mobile services. Large percentage of population residing in remote areas makes it difficult to reach these individuals with DCT ▪ Significant burden of maintaining phones through charge, credit and repair in rural areas

			population (10.63%) (World Bank, 2019) ▪ Individuals owning multiple SIMS from different providers (Arakpogun et al., 2017) ▪ Some people share their smartphones (for example, in 2013, 58 per cent of Kenyan's did not own a mobile phone but shared with someone else)	▪ Inaccurate information or duplicate contacts recorded for one person. Yet, DCT should not be limited by proprietary rights of service provider ▪ Inaccuracy of identification of contact. People may fall through the net and not be aware that they were in contact with a Covid-19 patient ▪ Sharing phones could be a barrier to the adoption of m-health applications (Mogoba et al., 2019)
Processes	Implicit	That there is tight digital integration between relevant government agencies and other sectors. For example, the integration between public health and the telecoms sector.	▪ Lack of digitalisation in many African government agencies. ▪ Inadequacy of fixed telecoms infrastructure requiring a heavy reliance on mobile networks ▪ Limited or inadequate legal and regulatory framework for data protection (*in 2018 only 19 African countries had enacted data protection and privacy laws*; 6 had laws in draft⁺; the remaining had no legislation or no data available (Consumer International, 2018)*	▪ Highlights a lack of institutional and technological preparedness for DCT ▪ Insufficient logistic support to coordinate and manage contact tracing between the telecoms platform and public health authorities ▪ Valuable time is lost as the system may not be able to analyse data in real-time
Objectives and values	Implicit	That citizens are going to use the app/platforms There is no stigmatism associated with the confirmation of a Covid-19 diagnosis	▪ Digital engagement varies by country in Africa, dependent on many factors and outcomes, including level of education, access and availability of technology, usage and skills. ▪ Existing structural inequalities result in restricted or absence of access to mobile technology coinciding with other forms of marginalisation. Social stratification could mean that there is a disparity in mobile	▪ Digital inequalities reinforce existing social/structural inequalities and can even exacerbate them as they carry over pre-existing differences in social networks ▪ Self-reporting is one of the primary requirements for an effective system of contact tracing. It all starts with an individual response and willingness to be tested then depends on an individual willing to reveal contacts. The social contexts in some African countries mean that there is a stigma attached to being identified as a positive Covid-19 case as accentuated by Greiner et al (2015, p. 54):

			adoption between age and gender. ▪ African countries have one of the highest rates of digital gender gap in the world with 82% of males having access to mobile phones compared to 69% of females in SSA ▪ Evidence from previous infectious diseases in, for example, Guinea, Mali and Sierra Leone, suggests that there is stigmatisation (Greiner et al., 2025)	*"Community misperceptions and fear of Ebola treatment units, as well as apprehension regarding isolation and quarantine, have also contributed to case-patient hesitancy to reveal names of contact-persons"* *"…naming a contact-person has been perceived as assigning a person to a death list"*
Staffing and skills	Implicit	That trained staff can deploy the app/platform and coordinate among the relevant stakeholders. That users can use the app/platform	▪ Evidence abounds of the lack of digital skills in various parts of Africa, which limits the ability of people to use mobile devices and optimally engage with the Internet. For example, data from the RIA survey indicates that 13% and 35% of 15-25 years old in Nigeria and Tanzania have not adopted mobile phones due to a lack of digital skills. ▪ Arakpogun et al (2017) has also identified stakeholder engagement as one of the problematic elements hindering digital inclusion in Africa.	▪ In 2018 almost 60% of Africa's population was under the age of 25. Africa is the world's youngest continent. It is likely that this will contribute to less take up of DCT by the population ▪ Current studies suggest that for DCT to contribute to the effective suppression of the spread of Covid-19, there needs to be at least 60% of a national population using the app/platform. ▪ May be difficult to coordinate among relevant stakeholders for DCT – highlighting the need for a coordinated collaboration between public and private agencies for the effective deployment of DCT. Not the least, to ensure that the service is affordable.
Management systems and structures	Implicit	A preconceived notion of the structure and state of the public healthcare system	▪ WHO's recommendation for a minimum of 23 core health workers (physicians, nurses and midwives) per 10,000 population – only Mauritius and South Africa meet this requirement. It is believed that around 20,000 ICU	▪ DCT is not a 'silver bullet' to address the suppression of Covid-19. It can only be effective if supported by adequate education and access to required medical services and medical surveillance. ▪ DCT should not be taken as an excuse to do away with any policy or system for the

			beds are available across Africa, which equates to about 1.7 ICU beds per 100,000 persons. Ventilators are also acute with an estimated 20,000 pieces across Africa compared to 160,000 across the US.	employment of more trained and specialist medical staff and acquiring required medical equipment and personal protective equipment.
Other resources	Explicit or implicit	That other supporting infrastructure, for example, electricity, transportation and road networks, testing kits, etc., are readily available	▪ One in three of the 1.2 billion odd people in Africa and over half of SSA lack access to stable electricity. ▪ Poor road networks and fixed line connectivity	▪ Mobile users may switch Bluetooth/GPS off to save battery power, which then makes it difficult to monitor the proximity of phones. Data could also be lost in transmission as a result of power cuts while diagnostic labs would not be able to function without generators. ▪ Poor infrastructure could limit access to identified contacts by health officials. Similarly, after identification there may be limited access to required health services.

Adapted by the authors from Heeks et al (1999) using data from a variety of secondary sources such as GSMA, Pew Research, Research ICT Africa and World Economic Forum, and primary sources from webinars participation, for example, the Internet Society and the Alliance for Affordable Internet (A4AI).

* Angola, Benin, Burkina Faso, Chad, Equatorial Guinea, Mali, Gabon, Ghana, Ivory Coast, Lesotho, Madagascar, Malawi, Morocco, Niger, Senegal, South Africa, Tunisia, Zambia; $^{+}$ Kenya, Nigeria, Togo, Tanzania, Uganda and Zimbabwe.

The way forward: From technology transfer to translation

While tracking contacts of positive cases and using technology may be effective in curbing the outbreak of Covid-19 pandemic, application without adaptations could put public health at odds with the reality of the structural inequalities across Africa. Any DCT should ideally be supported by initiatives that not only increase access to mobile technology, but that also develop the infrastructure required for its effective deployment and uptake. Rolling out an application without consideration of the wider social implications can be dangerous and costly. It cannot be ignored that some individuals in African countries leave little or no trace in the digital realm (Robinson et al., 2015). Accordingly, continued use of traditional manual contact-tracing should not be ignored. For example, evidence from our case analysis reveals that Rwanda is one of the few African countries that have followed in the steps of economies in Asia and the North to deploy DCT. The government argues that the reason for adopting DCT is to mitigate the inefficiencies of traditional tracing, particularly the unreliability of verbal information provided by Covid-19 patients. While this is understandable, such approach disregard the prevalence of digital divides in the country.

To mitigate the risks of contextual collision and mismatch in the design and deployment of DCT and the unintended consequences that follow, we propose a *blended epidemiological approach* to (digital) contact-tracing in Africa – a strategy that is underpinned by a process of *translation* whereby DCT is made to reflect the unique institutional and technological characteristics of African countries, through combining it with local initiatives learned from previous pandemics such as EVD. The idea of translation "refers to the process whereby ICT ideas are reinterpreted and implemented in particular organizational settings (Czarniawska & Joerges, 1996)" (Nielsen et al., 2014: 170). While the notion of diffusion implies that technologies are transferred unproblematically and without modification (Latour, 1986; Nielsen et al., 2014), the concept of translation emphasizes how technologies can be made

relevant as actors translate and adapt them to suit their local conditions. Such approach would involve developing a more inclusive containment strategy by relying and combining both DCT and bottom-up local initiatives to mitigate the unintended consequences that might arise from the sole reliance on DCT (see Table 2 for examples of local Covid-19 initiatives across Africa).

Table 2: Examples of Africa's local initiatives for tackling Covid-19

Countries	Local initiatives
Senegal	▪ Senegal has repurposed existing laboratories used for previous infectious diseases like Ebola and engineered a $1 Covid-19 testing kit to provide testing for all persons ▪ Given the acute availability of 50 ventilators for 15 million people, local engineers have resorted to the use of 3D technology in building $60 ventilators compared to the $16,000 imported machines
Sierra Leone	▪ Given the criticality of effective communication and information dissemination in tackling Covid-19, Sierra Leone has reactivated its 'Mammy Queens' - a group of local community female chiefs previously deployed during Ebola – to provide vital information and demonstrate hygiene practices like handwashing in local languages to local communities ▪ Mammy Queens are now being combined with traditional media like 'town criers' and religious leaders to provide Covid-19 information and updates
Chad	▪ Given the high levels of digital divides in Chad, the Chadian government has enlisted the service of town criers (troubadours) to disseminate Covid-19 information across the country, especially in rural areas where digital divides are rife with little or no access to traditional media like radio.
Ghana	▪ Given the lack of running tap water in Ghana, a dustbin-like plastic container called 'Veronica Bucket' has been repurposed with a tap and wastewater bowl by a local public health worker (Veronica Bekoe) to facilitate public handwashing as previously practiced during Ebola ▪ Ghana is also using Zipline drones to collect Covid-19 test samples from hard-to-reach rural areas for processing in major cities like Accra and Kumasi ▪ Ghana is also pioneering "pool testing" – a technique that involves testing multiple blood samples in a single batch – to then follow-up on positivity cases only to maximise testing capacity and healthcare resources.
Nigeria	▪ Given the limited testing capacity in the country, Flying Doctors (a group of local physicians) have created mobile and stationery "zero-contact" Covid-19 testing booths to help protect healthcare workers from contracting Covid-19 and ramp up testing in Nigeria ▪ Nigerian CDC has also repurposed existing throughput HIV machines to be able to process 3,000 test samples in one attempt
Kenya, Tanzania, Rwanda South Africa	▪ To tackle the lack of electricity and ventilators, local investors across the aforementioned four countries have collaborated with the Grand Challenges Canada (GCC) to build affordable solar-powered oxygen machines called "SP02" to support healthcare systems in rural areas
Kenya	▪ To mitigate the shortages of personal protective equipment (PPE), textile factories across Kenya have had to quickly repurpose their production lines to produce facemasks and other PPE for the country. Notably among them is Kitui County Textile Centre where a group of 400 female workers (half of whom are uneducated) produced 30,000 units of surgical facemasks a day following only one-week training
Rwanda	▪ Local innovators in Rwanda have collaborated with GCC to build a virtual care platform called "WelTel" to remotely support rural healthcare systems across the country in dealing with Covid-19, including the provision of home care for those under quarantine
Somalia	▪ A local inventor (Mohamad Adawe) has produced a homemade ventilator to support the effort of healthcare workers against Covid-19. Such an invention has proven to be critical in the face of ventilator shortages in the country with doctors previously replying on manual respiratory devices to support the breathing of critically ill Covid-19 patients.

Developed by the authors from a variety of sources such as African CDC, EurekAlert as well as international and local news on Africa

In addition to combining the existing local initiatives in Table 2 with DCT, African governments can further contextualise the process by using, for example, universal service fund[3] to help vulnerable people secure mobile phones as practiced in Taiwan. This will help close the *technology* dimension gap in Table 1. Furthermore, local initiatives like Mammy Queens, town criers (troubadours) and religious leaders (see Table 2) could be embedded with DCT to close the *information* dimension gap in Table 1. Prior research indicated that these community groups are a democratic method through which people can educate themselves on different topics (Bjerkaker, 2014; Wamala, 2012) The use of local inventions such as the Veronica Bucket could complement DCT and close the gap of *other resources* dimension in table 1. These proposed blended approaches will go a long way in helping to protect vulnerable groups, who are already disproportionately impacted by Covid-19 pandemic.

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[3] See Arakpogun et al. (2017)

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