Building a Global Power of Experience in Diagnostic Imaging – Lessons from Africa's COVID-19 Response

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Nigeria's experience with Ebola shows us how having trained experts in place can make the difference when confronting unexpected health threats.

The U.S. Centers for Disease Control and Prevention (CDC), 2016

As we collectively resume our daily life in the post-pandemic 'new normal' and reflect on the varying trials and tribulations brought on by the COVID-19 pandemic, some have argued that what we lived through in the past two years was a 'syndemic' – the aggregation of the acute infectious SARS-CoV-2 and chronic noncommunicable diseases (NCDs), with their interaction increasing disease susceptibility and worsening health outcomes [1, 2]. In all likelihood, the poor management of the growing prevalence of NCDs, due primarily to a fragmented global public health policy, created the perfect storm for a COVID-19 syndemic [1]. Nonetheless, as the number of COVID-19 cases worldwide continue to trend downwards, the growing burden of NCDs, especially in low resourced areas, remains a threat to post-pandemic recovery and to the sustainability of health systems worldwide [3].

The pandemic highlighted the need for "medicine without borders", including development of accurate and easily implementable diagnostic tools. Here, we focus on high value diagnostic imaging, particularly CT and MRI services, as the global demand has risen over the past two decades as the technological innovations of these services become rapidly adopted as standard of care to manage the growing burden of NCDs. Thirteen of the twenty leading causes of deaths worldwide are NCDs, with cardiovascular diseases, cancers, respiratory diseases, and dementia leading the way (Fig. 1) [4, 5]. A staggering majority (70–80%) of these deaths occur in low-to-middle income countries (LMICs) [4]. Even in Sub-Saharan Africa, premature mortality from NCDs is on track to outpace the combined deaths from communicable, maternal, neonatal, and nutritional diseases by 2030 [4]. Not surprising, deaths from heart disease and cancer in 2019 (the latest global numbers available) were far greater than the total number of deaths attributed to COVID-19 from January 2020 to September 2022 (Fig. 1) [6].

What's even more surprising is that Africa seems to have fared relatively well with the COVID-19 pandemic, or syndemic, with a fewer number of COVID-19 cases and deaths compared to other regions of the world [6, 7], despite having the lowest vaccination rate in the world [7]. This is quite remarkable given early predictions of worse outcomes considering Africa's notoriously weak healthcare systems and its perennial lack of health infrastructure and skilled workforce [8–10]. Although the jury is still out as to why Africa seemingly weathered the COVID-19 storm, wave after wave, there is a general understanding that the region's level of preparedness from lessons of decades of battling epidemic infectious diseases may have conferred the *Power of Experience* to manage COVID-19 relatively well [7–12].

Are there lessons from Africa's COVID-19 experience that can be gleaned to inform pragmatic strategies that will strengthen diagnostic imaging services to address global threats from NCDs? Given that 80% of the world's population who largely resides in low-resourced areas is the most vulnerable but do not have access to adequate diagnostic imaging and must contend with poorly maintained equipment sporadically centralized in major cities in centers that are understaffed and lack skilled personnel, it is crucial that any wins in one health sector in LMICs is unweariedly and efficiently adapted to other sectors.

COVID-19 lessons from Africa: Think Omicron!

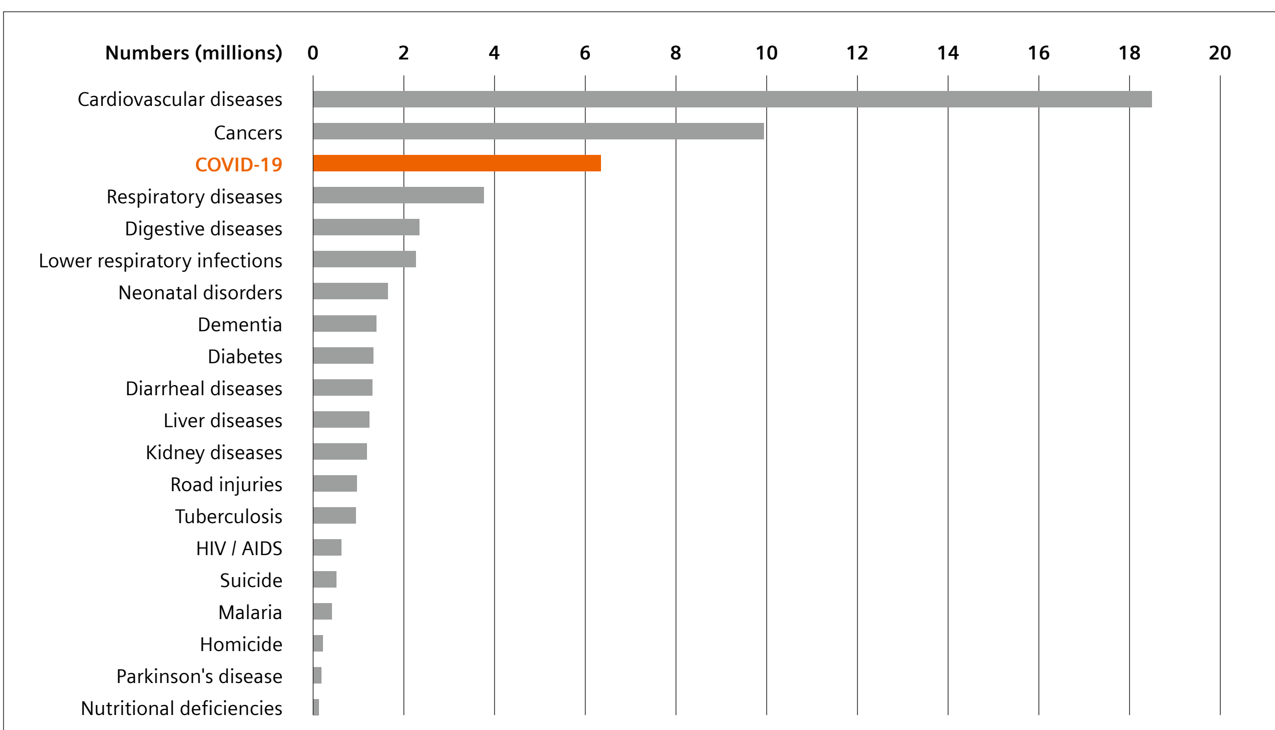
Precisely one year before COVID-19 took the world by storm, Nature ran a news feature on February 20, 2019, with the following headline, “This Nigerian doctor might just prevent the next deadly pandemic” [13]. The author, Amy Maxmen, was writing about Dr. Chikwe Ihekweazu, the first Director General of Nigeria Centre for Disease Control (NCDC), who completed his medical training at the University of Nigeria in Nsukka, Nigeria, prior to receiving his Master’s in Public Health from Heinrich Heine University of Düsseldorf, Germany, and subsequent stints as a Medical Epidemiologists in Germany and the UK. The article described the ‘step change’ in Nigeria’s pandemic preparedness with the arrival of Dr Ihekweazu as head of the fledging NCDC in 2016, during the 2014–16 Ebola crisis [13]. Armed with a measly $4 million budget in 2018 (0.036% of the US CDC’s annual budget in the same year) and lessons from several epidemics (2016 Polio, 2016–17 Meningitis, 2018 Yellow fever, Lassa fever and Cholera), as well as a healthy political will from the Nigerian Government to support the NCDC and their leadership, Dr Ihekweazu did what Africans generally do – do much with little. The good doctor at the outset made “careful choices” [13] with his scarce resources and created a power of experience in COVID-19 management by:

I. Forming “real partnerships not a master-servant relationship” with US CDC [14] and other international public health institutions [15] to **train** epidemiologists and biologists in place at the NCDC and use his sheer dedication to attract Nigerians abroad to join the NCDC – “an experiment in brain gain” [13].

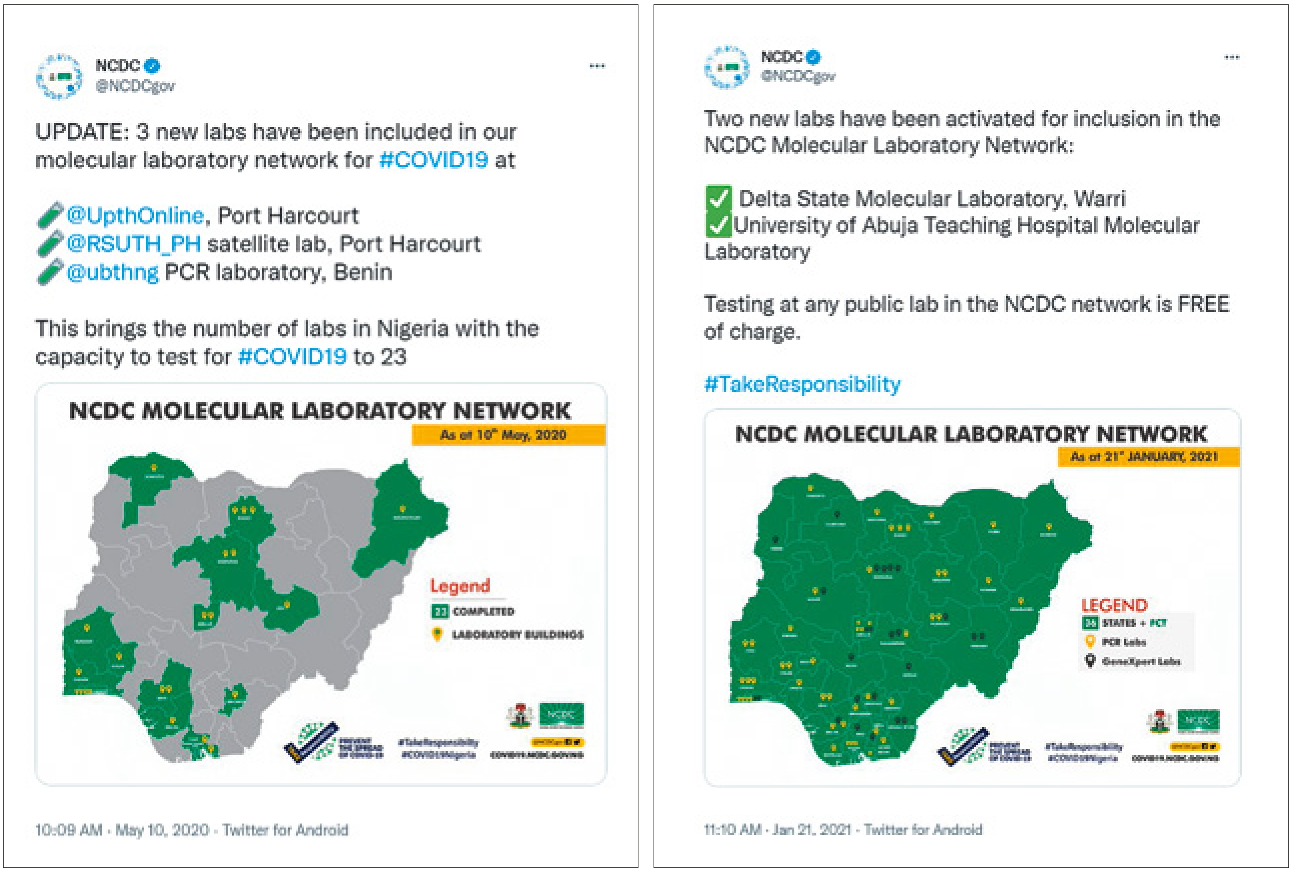
II. Building a regional **network** of molecular labs with the capacity to monitor pathogens and surveillance offices in each state in Nigeria linked to the national NCDC headquarter in the nation’s capital, Abuja to prevent and respond to infectious disease outbreaks in a coordinated manner.

III. Strategically equipping regional labs with **infrastructure** for high quality diagnostics capacity including Polymerase Chain Reaction (PCR) machines, rapid antibody sensitivity diagnostic systems, and genomic sequencing and immunological testing systems.

When COVID-19 hit Nigeria in March of 2020, the NCDC had 6 molecular labs judiciously distributed across the country with capacity for PCR COVID-19 testing and other 6 in the process of being completed [16]. By May 2020, the test capacity had jumped to 23 labs across the country and, within 10 months, in January 2021, all 36 states in the country had molecular labs equipped with skilled



1 2019 worldwide number of deaths by cause [5].



2 Strategically equipping regional labs with infrastructure for high quality diagnostics capacity.

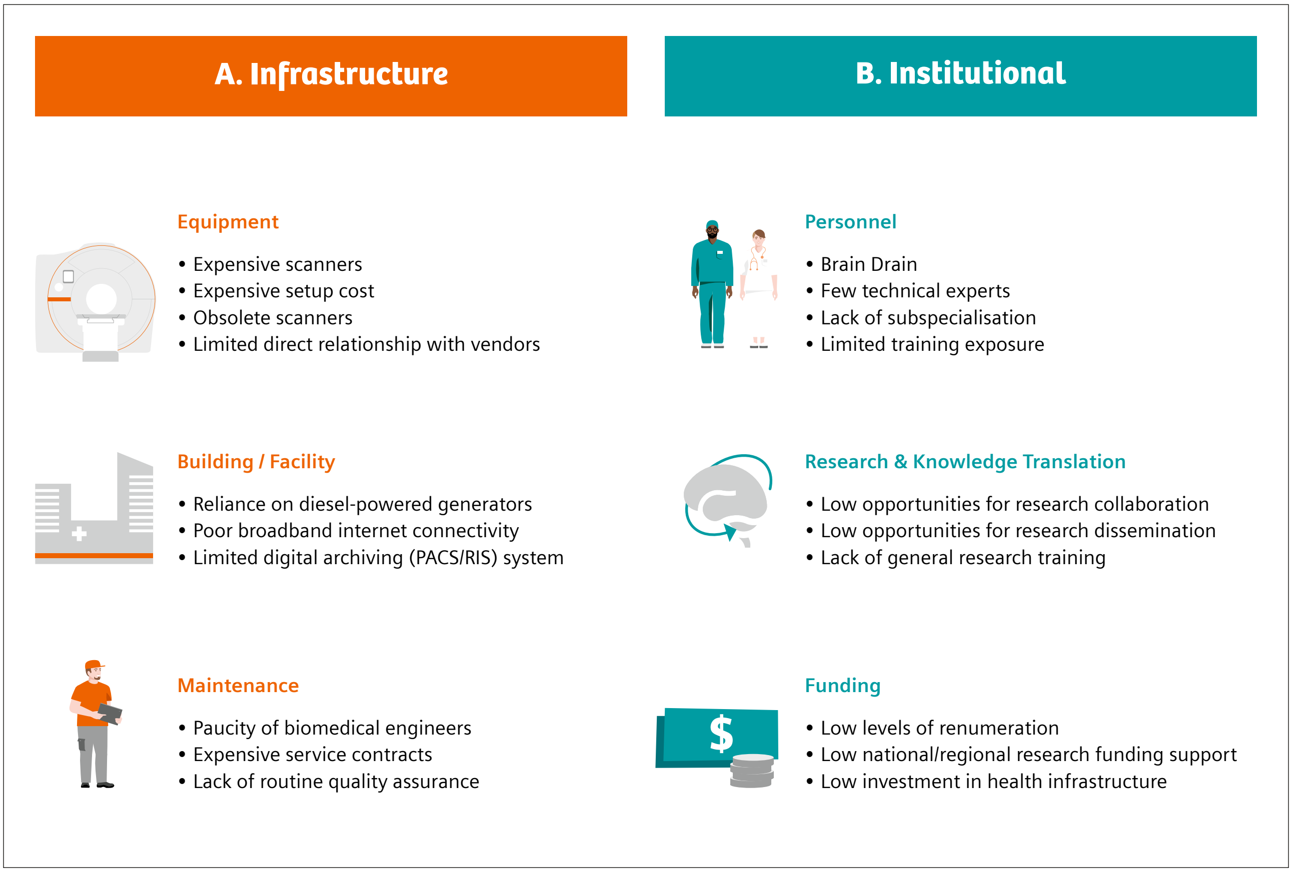
personnel, infrastructure for COVID-19 testing, and linkage to rapid viral genome sequencing centers (Fig. 2). These resources were rapidly deployed to detect and track the emerging COVID-19 threat [16].

While Dr Ihekweazu and his team at NCDC were preparing Nigeria to address COVID-19, the Africa Center for Disease Control and Prevention (Africa CDC), formed in 2017, following the Ebola crisis, leaped into action in February 2020, days after the 1st case of COVID-19 was reported in Egypt [7], to form a Joint Continental Strategy with national public health institutions across the region. This continent-wide collaboration, still in place, provided the coordinated platform to share resources, work together in a pan-regional network, and communicate efforts, including implementation of lockdowns and restrictions [5]. More importantly, this continent-wide network, supported by scaled-up local capacity in surveillance and genomics, resulted in rapid discovery of several COVID-19 variants across Africa, including the now infamous Omicron variant, sampled in Botswana, and sequenced by the Network for Genomic Surveillance in South Africa [7, 17].

Now, imagine if Africa had the standard global support – the mismatched donated low-cost and low-resolution health technology, in this case, rapid kits or PCR with limited and isolated capacity for viral genome sequencing – if that were the case, the world would not have benefited from the African discovery of Omicron. Generally speaking, if low-resourced settings around the world were not empowered to develop and sustain their own local public health systems, the COVID-19 pandemic/syndemic may have had a more dire outlook. Therefore, we must lose no time to adopt this winning strategy to other healthcare sectors in LMICs.

Closing global gaps in diagnostic imaging

What Africa got right [7] with COVID-19 and a global lesson with clear relevance to diagnostic imaging is the need to work together as a global community to create the power of experience, the rich local expertise and capacity that will enable each country and each region to meet their pertinent and unique health care challenges.



3 Drivers of limited access to MRI in Africa. *Figure adapted from [19].*

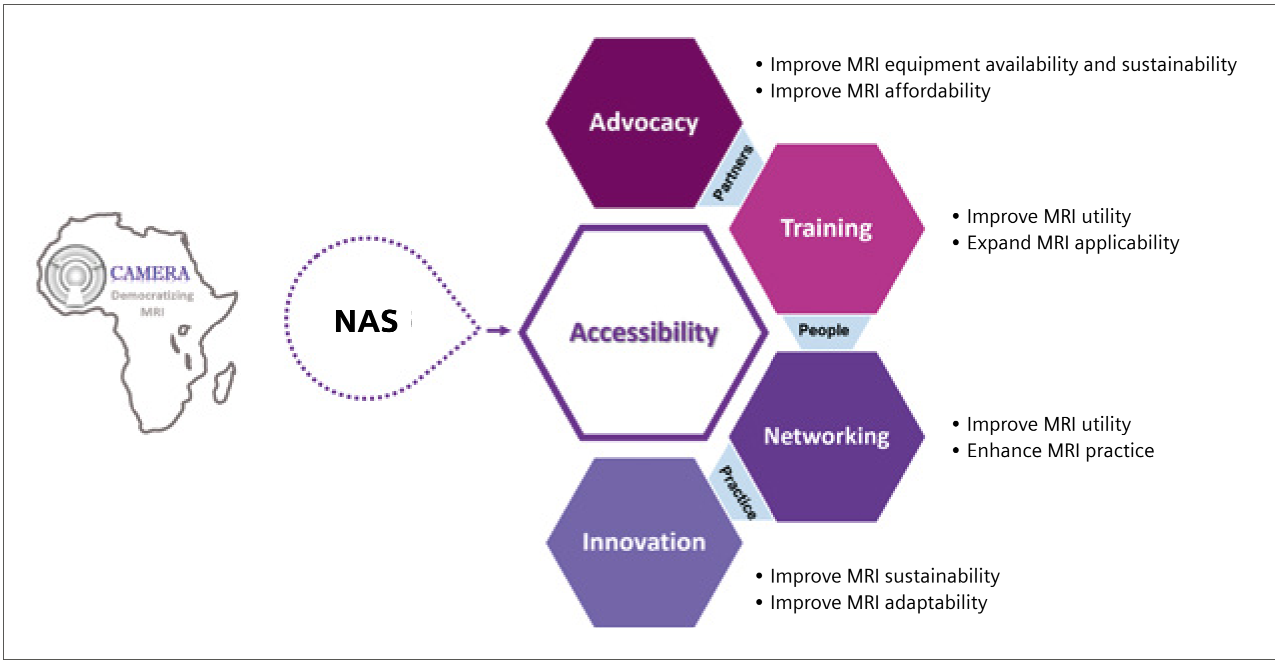
The question then is: How do we, as a global imaging community, work with those from the least-resourced areas to close longstanding inequities and enable our colleagues in Africa to address their overlapping complex imaging barriers (Fig. 3) so that the region's poor are provided with adequate access to clinically valuable diagnostic imaging?

In October 2019, we set out to do just that. We formed the Consortium for Advancement of MRI Education and Research in Africa (CAMERA), as a working group of the European Society of Magnetic Resonance in Medicine and Biology (ESMRMB), to address challenges to MRI access in Africa by strengthening local capacity for clinical use of MRI and expediting research translation of local MRI innovations. Since then, we have grown to become a global network of MRI experts from all disciplines (radiology, radiography, physics, biomedical engineering) and emerging fields (computational imaging and artificial intelligence) with a clear vision [18] and strategy, gleaning from Africa's COVID-19 lessons, to create the unbroken chain of resources and expertise in MRI across Africa [19]. In 2020 and 2021, we leveraged the general slowdown in radiology services during the COVID-19 lockdowns to conduct a Needs Assessment Study (NAS) to identify MRI capacity gaps and understand the general landscape of MRI in the region [19]. Our NAS captured needs as well as opportunities along four central priorities:

1) availability and access,
2) personnel training and education,
3) research translation, and
4) sustainable technology [19].

Based on the NAS findings, we formulated a framework (Fig. 4) to address these four priorities and the intricate barriers that accompany them (Fig. 3) [19].

We discovered that overall, the percentage of high field 1.5T MRI in Sub-Saharan Africa is growing and predominantly installed and operated at private clinics [19]. Furthermore, these scanners are severely (92%) underutilized, scanning less than 15 patients per day, per scanner, a far cry from the potential capacity of MRI, especially for clinics that service relatively large geographical areas [19]. Our study found that one of the major contributors to the under-utilization of MRI in the region is the perpetual and persistent lack of trained expertise to scan (radiographers), interpret (radiologists), develop,



4 The CAMERA conceptual framework. *Figure adapted from [19].*

or optimize protocols, as well as process high quality images (physicists) and maintain (engineers) the scanners [19]. To address these issues, we are leveraging the existing MRI infrastructure in the region to develop local training and continuing education programs and create regional networking opportunities to provide our African colleagues with the power of experience in MRI diagnostics [19].

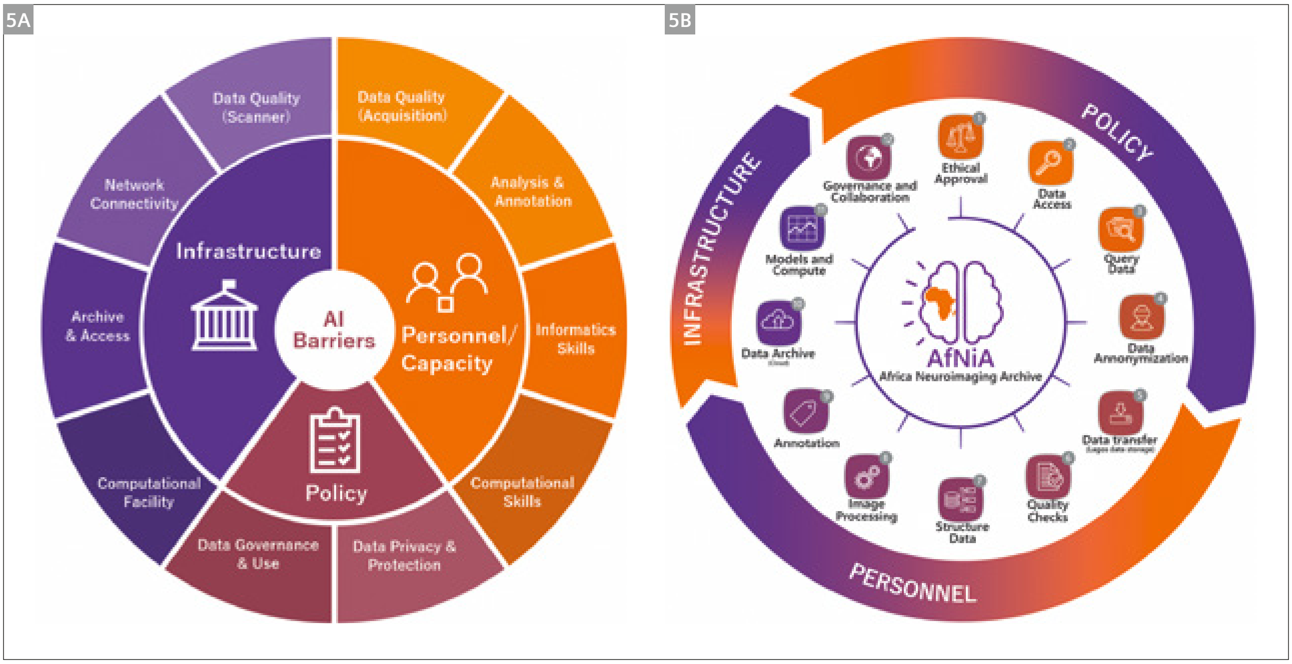
Training game changers and creating catalysts for MRI innovation in Africa

In October 2022 at the Association of Radiologists in Nigeria (ARIN) annual meeting, we launched the Africa Neuroimaging Archive (AfNiA), one of the key initiatives at CAMERA and funded by the Lacuna Fund [20], with the overarching aim of providing the power of experience in artificial intelligence (AI) applications in MRI diagnostics in low-resourced settings [21]. Specifically, AfNiA is a collaborative framework to enable ethical data share and aggregation of fragmented expertise, disciplines, resources, and pipelines required to effectively apply AI imaging solutions to transform diagnostic imaging care in the African setting (Fig. 5).

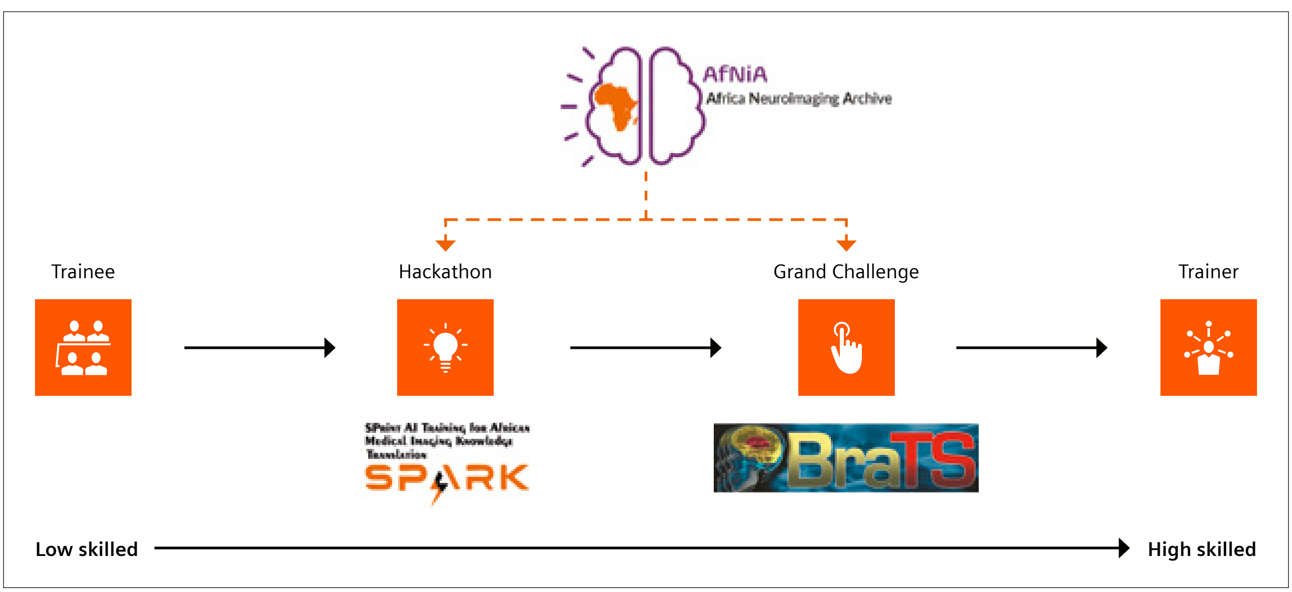
We have created the AfNiA ecosystem using glioma MRI diagnostics as an optimal use case and catalyst for the design, implementation, and validation of its 12 nodes (Fig. 5B). We chose glioma diagnostics to leverage the decade-long collaborative global efforts in glioma AI imaging applications by the computational imaging community through the RSNA/ACR/MICCAI Brain Tumor Segmentation (BraTS) challenge [22]. Although the BraTS challenge has provided several promising models, some segmenting tumors with precision comparable to manual expert reads [23], it is unclear if these models can be applied to African populations who need AI-assisted diagnosis the most [22]. Starting with data, we are aggregating retrospective brain MRI scans from clinics across Africa, including clinics that do not have access to PACS to curate, annotate, and archive the data for public use in the upcoming BraTS challenge.

Moreover, to address the lack of region-specific data governance provisions, policies for ethical use are being developed to govern access to curated data and ensure that AI solutions created using AfNiA will directly benefit the local communities who own and provide the data. This effort is crucial in Africa, where medical data is overwhelmingly provided from out-of-pocket patient expenses, and as such require direct benefit considerations [19]. Using the data governance mechanism, we will link local clinics to the wider imaging community and among themselves to enable co-creation of AI solutions in a global peer-to-peer collaborative network.

Lastly, to meaningfully create a rich local experience in AI imaging capacity, as part of AfNiA, we have developed the SPARK (Sprint AI Training for African Medical Imaging Knowledge Translation) program as a train-the-trainer workshop and hackathon (Fig. 6) to rapidly establish game changers that will drive AI imaging innovations locally.



5 **(5A)** AI challenges in healthcare. **(5B)** The AfNiA ecosystem.



6 Train-the-trainer concepts to meaningfully create a rich local experience in AI imaging capacity.

The SPARK training program, which is planned to run for the first time in Summer 2023, will use RAD-AID's *Teach-Try-Use* [24] approach to train a multi-disciplinary team on data collection, AI model development, and clinical evaluation. The aim is to equip the trainees with competent skills to participate in the next 2023 BraTS challenge with models that have a clear chance of winning the challenge.

SPARK and AfNiA will operate out the Medical Artificial Intelligence (MAI) lab, strategically situated within Crestview Radiology Ltd, Lagos, Nigeria – a local clinic not affiliated with an academic institution, to ensure that AI models being developed can be swiftly and directly deployed to clinic (i.e., rapid model-to-clinic or bench-to-bedside).

Democratizing diagnostic imaging to advance global health

As novel innovations in mobile and low-cost imaging technology such as the 0.55T MRI system MAGNETOM Free.Max (Siemens Healthcare, Erlangen, Germany) continue to make their way into clinics, especially those in low-resourced settings, imaging communities such as the Radiological Society of North America, can partner with vendors who are starting to break barriers with these systems, to provide local communities around the world with the power of experience to address their global health challenges using high value diagnostic imaging. Considering how crucial low field MRI is to the democratization of diagnostic imaging and the surge of research and development in this field, collaborative multi-national and multi-institutional efforts should be strongly encouraged, especially those aimed at open sharing of resources, to readily include low-resourced settings. One such exemplary effort is the recent in situ assembly of a low field MRI system [25] at Dr Johnes Obungoloch's MRI lab at the Mbarara University of Science and Technology (MUST), Uganda (Fig. 7). The MRI system was developed at Leiden University Medical Center, the Netherlands, by Professor Andrew Webb and constructed at MUST by a team of international MRI scientists (Fig. 7) supported by Professor Steven Schiff's group at Yale University, New Haven, CT, USA. This first MRI system collaboratively built in Africa under a resource-limited setting and the accompanying MRI training provided to local scientists is the power of experience that will catalyze research projects pertinent to increasing MRI capacity to meet the region's healthcare needs and ambitions.

If COVID-19 has taught us anything, it is that we must now practice 'medicine without borders', to Think Globally while Acting Locally, to now go further together, so we can as Professor Daniel K Sodickson, former President of ISMRM eloquently stated at the ISMRM-ESMRMB 2018 Mansfield Lecture, marshal all our disruptive innovative forces to continue to create new ways of seeing [26].

7 Assembly of a low field MRI system at Mbarara University of Science and Technology (MUST), Uganda, Africa.

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