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Securing Africa's Health Sovereignty

Why Investing in Science and Innovation Matters

Working Paper

August 2020

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About the Contributors

The contributors are Fellows and Affiliates of the African Academy of Sciences in response to the ongoing COVID-19 pandemic and as a contribution to the ongoing science prioritization work of the African Academy of Sciences in the area of global health security and epidemic preparedness. All authors have contributed equally to the development of the paper supported by staff at the African Academy of Sciences – Olivia Osula, Gladys Akinyi, Davies Mbela, and Grace Mwaura. The paper has also been reviewed by three external reviewers. The views expressed in this paper represent the views of the individual authors and not of the African Academy of Sciences.

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Executive Summary

The COVID-19 pandemic, caused by the SARS-2 coronavirus, is a systemic and transformative crisis that has irreversibly altered socio-economic and geopolitical structures around the world. It is a systemic crisis in the sense that it is causing widespread pervasive changes in social and economic as well as political structures around the world. It has disrupted food production, spiritual and cultural rituals, international transport and trade, and weakened national health systems. The pandemic may be an outcome of unsustainable economic and social practices, and largely a manifestation of weaknesses of/in national health systems. As such, it is both a cause and consequence of social and economic inequalities and related fragility of health systems around the world.

Nevertheless, COVID-19 is a transformative crisis that should not be wasted. The pandemic offers countries, particularly those on the African continent, unique and enormous opportunities to find pathways out of social, economic and health inequalities. Countries need to rethink and reframe their approaches to and agendas on development to position public health as a strategic core area of national security and sovereignty. Key to this is increasing national investment in health research and innovation (R&I) and related measures to strengthen health systems. Africa, like the rest of the world, should harness its rich and diverse knowledge and innovation capabilities to banish COVID-19 and related socio-economic as well as ecological ills. The continent's youthful population is already at the forefront, releasing its innovative powers by developing technologies for screening and tracing COVID-19 infections. African scientists and knowledge practitioners in various countries are actively engaged in building genomes of the virus in order to understand the disease and develop local treatments.

This working paper outlines issues for dialogue on how best to secure Africa's health sovereignty. It is premised on the view that Africa's health sovereignty—the collective social and political rights as well as economic integrity—is undermined by the continent's overdependence on foreign or external resources and knowledge to address development challenges such as COVID-19 and related health and socio-economic problems. The paper is one of the outcomes of an ongoing intense discourse among a multidisciplinary team of Fellows and Affiliates of the African Academy of Sciences (AAS) drawn from natural sciences, social sciences and humanities. Their focus has been to identify evidence-based strategic policy and institutional measures that African governments need to take in order to strengthen health systems, promote local production of diagnostic, medicines and other pharmaceuticals, and unlock the continent's scientific and technological capabilities to fight COVID-19 and other diseases.

Key issues and recommendations

Good health and wellbeing is a fundamental constitutional right, and source of economic productivity and security of individuals and communities in countries.

Yet, public health in general and health systems in particular receive meagre budgetary allocations and inadequate policy attention in Africa. In most African countries, health is considered or clustered with social sector goals such as sports and cultural programmes. Unlike infrastructure development and agriculture, health is not considered as a strategic economic security in most national development policy frameworks and plans. Huge contributions that health makes to national economic growth, competitiveness and prosperity are, often, not taken into account in national statistics and planning. It is critical that African countries ‘redefine’ or ‘reframe’ health and treat it as an economic and security sector and ensure that a significant percentage of national budgets is allocated to the health sector.

Research and innovation are critical to the attainment of good health and wellbeing (SDG3). They are sources of vaccines, diagnostics and other products and processes for improving health and wellbeing. Research in fields such as epidemiology and virology enhance society’s understanding of specific diseases such as COVID-19 and their causes, and so enables the development and deployment of treatments. Declarations such as the 2008 Algiers Declaration on Health Research, Bangkok Declaration on Health Research for Development, and the 2008 Bamako Communique of the Global Ministerial Forum on Research for Health emphasize the importance of countries investing in health research and development (R&D). Under these declarations and communiques, governments have committed to allocate at least 2 percent of their national health expenditure to health research and research capacity building.

However, most African countries spend less than 1 percent of their health budgets on R&D, and less than 1 percent of their Gross Domestic Product (GDP) on R&D in general. African governments underfund health research and innovation and fail to meet national constitutional and multilateral policy obligations. This is a governance issue, as government fails to meet their policy and constitutional obligations. ***To address the governance deficit, countries need strong legislative and civic oversight mechanisms, Ombudsmen for health, just like those for the administration of economic justice and environmental justice.*** National parliaments and the Pan African Parliament (PAP) should establish such mechanisms to monitor how governments implement constitutional provisions on the right to good health, national policies and legislation, and international commitments on health R&D. In order to ensure that health R&D and innovation activities are adequately funded, it is recommended that each country

should establish legal instruments for funding health R&D. The instruments should include tax credits for health R&D, tax exemption on importation of equipment for health research and clinical trials, venture capital and competitive research grants.

COVID-19 and related infectious disease epidemics such as Ebola virus, HIV and AIDS, tuberculosis (TB), and non-communicable diseases such as cancer and diabetes are vividly exposing structural and normative weaknesses in African health systems.¹ In most of Africa, health systems suffer from weak governance and accountability (weak implementation of policies and programmes); underfunded public health (hospitals with poor infrastructure health and lack medicines); shortage of skilled personnel (shortages of health workers such as nurses, doctors and technicians, and researchers), and other weaknesses. Ambiguous regulations for medicines, clinical trials and procurement systems of medical technologies and products are plagued by unreasonable pricing, irrational usage, fickle supply systems and variations in safety and quality. Under current COVID-19 conditions, many African countries are facing challenges to procure personal protective equipment (PPE), testing capacity, and intensive care personnel. This is further weakening their national health systems.

African countries need to take specific actions to strengthen their national health systems. The measures include designing and implementing bankable health systems plans, with measurable outcomes for expanding, mobilizing and utilizing domestic scientific and technological capabilities for health. Practical actions to train, resource and retain health workers, particularly doctors, nurses and technicians, and upgrade infrastructure will help to strengthen African national health systems. Strengthening African health systems should also involve to mobilizing and using the continent's engineering capabilities to design and manufacture medical equipment such as ventilators and essential protective gears. Thus, **connecting health with industrial policy, industrializing health (or industrialization for health) should be a strategic focus of governments' efforts to fight the current pandemic and reduce burden of disease.** Industrial policies to 're-purpose' private industrial activities will be necessary to leverage existing innovation capabilities to address COVID-19 and related manufacturing challenges. Private companies, particularly Small and Medium Enterprises (SMEs), need fiscal incentives to help produce on urgent basis Personal Protective Equipment (PPE).

A related issue pertains to the **huge costs of importing pharmaceuticals and medical equipment, overreliance on foreign companies for medicines and medical devices.** This is a concern recognized by African leaders. In the early 2000s, African leaders adopted the African Union (AU) Pharmaceutical Manufacturing Plan for Africa and related regional plans of the Regional Economic Communities (RECs). Unfortunately, not much has been done to implement the plans. This may be attributed to a range of factors

¹ Health systems comprise of socially and economically embedded institutions (in both public and private sectors) with infrastructures and resources, and related policies, laws and programmes that are organized to ensure that citizens have access to quality affordable health services, including health care and medicines.

including weak leadership and under-funding for implementation of the plans. Again, like with many African health plans, implementation deficits are always the stumbling blocks to the attainment of health goals, and hence barriers to Africa's health sovereignty. This is an issue of accountability, addressed by establishing watchdog mechanisms such as the health ombudsmen recommended in this paper. In addition, some legally binding mechanisms are required to help operationalize the pharmaceutical manufacturing plans. The African Continental Free Trade Agreement (AfCFTA) that will enter into force on 1 July 2020 offers some legally binding opportunity to the continent's countries to sharply focus on pharmaceutical manufacturing and 'industrialization of health. The AfCFTA is also an important instrument for helping African countries engage in pooled procurement of essential medicines and medical devices, particularly during the COVID-19 pandemic and epidemics such as Ebola and HIV/AIDS.

The continent is endowed with rich biological diversity and traditional knowledge that are critical in the search for medicines and other therapeutics for COVID-19 and other diseases. There are numerous R&I activities on traditional medicines and health products in Africa. For example, Ghana's Centre for Scientific Research into Plant Medicine, Nigeria's National Institute for Pharmaceutical Research and Development (NIPRD) and many other institutes across the continent are actively involved in research on the use of indigenous plants and knowledge to develop cures for COVID-19. These efforts need to be recognized and funded by African governments. ***Policy and regulatory measures that are inimical to the promotion and protection of African indigenous knowledge and biological diversity should be reviewed, and greater attention provided to strengthening institutions that safeguard the rights of local health knowledge holders and innovators.***

There are also many African Scientific R&I initiatives focused on the search for greater understanding of COVID-19 and its underlying causes as well as potential cures or treatments to help eliminate the pandemic. Research institutes and individual scientists across the continent are tirelessly working to find lasting solutions to the COVID-19 pandemic and related socio-economic crises. For example, scientists at the Kenya Medical Research Institute (KEMRI) and at several African universities are using molecular techniques to enable rapid mass testing to identify prospective COVID-19 cases or infections (Allam et al., 2020). There are also African efforts at sequencing coronavirus genomes. By mid-April 2020, coronavirus genome sequencing was taking place in at least ten African countries. Such efforts are scattered across the continent. Most are reliant on very limited project funding and individual scientists' efforts. There is need to urgently mobilize them through an African network for COVID-19 research and innovation. A special African fund, resourced by national governments, the AU, the African Development Bank (AfDB) and private companies, is required to get the networked efforts more strategically focused on finding scientific and technical solutions to the pandemic.

The COVID-19 crisis, like other epidemics and pandemics, shows that transdisciplinary multi-sectoral research that integrates issues or problems of health, climate change, food production, biodiversity and socio-economic change is key. A shift in funding research from disciplinary projects to transdisciplinary programmes is needed to give practical meaning to transdisciplinary and promote networking and synergies in African efforts. Related to this, is the need for the African Academy of Sciences (AAS) and national academies of sciences to play a more proactive role in helping African governments to establish appropriate multidisciplinary and transdisciplinary science advisory mechanisms. As such, ***Science academies have a critical role to play in strengthening Africa's health systems.*** By providing a rich pool of scientific expertise, they should inform investments in R&I, especially focusing on high quality and critical research gaps, building a critical mass of excellent researchers, and investing in the right infrastructure to support the researchers. The academies should provide leadership in helping systematic health priority-setting exercises, identify gaps in health research and innovation systems, and direct investments from governments and other funding partners to impactful research, delivers scalable interventions. Science academies should play a central role in translating scientific evidence into policy and practice and advising policy makers of the most cost-effective interventions to fight and eliminate COVID-19 and the disease burden in Africa.

Overall, the COVID-19 pandemic is a crisis that Africa should, strategically and innovatively, exploit to address long-standing challenges of weak national health systems, under-funding of health R&I, overreliance on foreign sources and imports of medicines and health products, and related deficits that help the persistence of the huge disease burden and acute vulnerability to the pandemic. Transformative political leadership is urgently required to implement constitutional and policy provisions on citizens' rights to good health and wellbeing by investing in research and innovation and building endogenous capacities to manufacture locally medicines and other health products. It is only through such measures that Africa will secure health sovereignty and become assertive in global geopolitics and competitive in the world economy. The paper provides some in-depth discussion on the current health situation, challenges, opportunities and recommendations to attaining health sovereignty in Africa.

Abstract



This paper aims at provoking broad-based dialogues and debates on ways and means of securing Africa's health sovereignty. It argues that health sovereignty is about the realization of specific national constitutional and policy objectives on citizens' access to and enjoyment of good health, resilient to COVID-19 and related disease pandemics. The paper also emphasizes the urgency of African countries fulfilling their commitments under global and regional declarations on health research. Investing in research, knowledge and innovation is critical to fight and win the war against COVID-19 and other diseases that undermine economic productivity and competitiveness of African countries. There is also a need for venture capitalists to demonstrate bankable ideas emanating from the science academies and funded by National Science Foundations. The base teachings at school level need to significantly invest in the "African philosophy" to create a shift in mind-set from the "grab and own without use mentality that is currently predominant on the continent. The paper recommends that executive, political and science leadership are needed to strengthen national health research and innovation systems through improved evidence-based policy implementation. With these thrusts working effectively together, rather than in silos, will afford the African continent to emerge victoriously in the combat against COVID-19 and other disease burdens.

1. Background: Health security and sovereignty of Africa

Health is fundamental to a nation's socio-economic security and political stability. It is critical to the preservation and assertion of the sovereignty of nations. Good health is a human right enshrined in constitutions of most countries around the world. There is a rich body of academic and policy studies demonstrating that the health of citizens determines economic progress, peace and political stability of countries. States have constitutional obligations to protect, promote and provide for the good health of their citizens.

In Africa, national constitutions of many countries contain explicit provisions on health as a human right to be protected and promoted by governments. For example, the Constitution of the Republic of Kenya 2010 in Section 43(1)(a) states: "Every person has the right to the highest attainable standard of health, which includes to health care services, including reproductive health care" (Republic of Kenya, 2010); Article 41 of the 2003 Constitution of the Republic of Rwanda provides that "all citizens have the right and duties relating to health. The State has the duty of mobilizing the population for activities aimed at promoting good health and to assist in the implementation of these activities"; (Republic of Rwanda, 2003); while Article 27(1a) of the 1996 Constitution of South Africa states that "Everyone has the right to have access to health care services, including health care" (Republic of South Africa, 1996).

There is a range of international conventions and declarations that treat health as a human right. Treaties such as the International Covenant on Civil and Political Rights (ICCPR) and the International Convention on Economic, Social and Cultural Rights (ICESCR), and the UN Declaration on the Right to Development have specific provisions articulating health as a fundamental human right. Governments of state parties to the treaties are required to institute measures that promote and protect citizens' health and access to healthcare.

Apart from being a human right issue, health is key to nation's economic growth and sustainability. As Bloom, et al (2003) assert: "health has a positive and statistically significant effect on economic growth... a one-year improvement in a population's life expectancy contributes to an increase of 4 percent in output... Thus improvements in health may increase output not only through labour productivity, but also through the accumulation of capital". Countries with high disease burdens and weak health systems tend to experience low labour productivity as resources such as time are expended away from economically useful work, nursing sickness (Bloom et al., 2003). During disease outbreaks, household incomes tend to divert from long-term investments to short-term health emergencies. In 2018, malaria costed sub-Saharan African countries about US\$12 billion exuberating economic insecurity and poverty of households in the region (UNICEF, 2019; WHO, 2018).

There is an intrinsic health value and health as a human right is indicative of a vigorous economic case for health investment. Being healthy is not just an outcome but also an underpinning for

development, so that one with good health can earn, save, invest, consume more, be more productive and work at greater length, encompassing a positive impact on the nations' gross domestic product (GDP). The financial burden placed by healthcare costs impact on families, communities, and the government. At the micro level, high financial healthcare costs often lead to people forgoing treatment, incurring debts, and facing severe poverty. At a macro level, healthy population can be beneficial to society as healthcare provision costs, lost productivity, unemployment benefits and high turnover rates reduce the overall costs to companies and government.

A “new international economic order” was called for by political leaders in 1978 at the primary healthcare in Alma Ata conference, indicating that social development and a sustained economy were only possible if people were healthy (WHO, 1978). It was also pointed out that investing in health is a representation of a successful and useful strategy to reduce poverty and investing in the improvement of population health will result in stronger and greater economic growth (WHO, 2001b). Investments in the African health systems provides an opportunity to heighten economic growth and development, contribute to life-long disability prevention and saving lives, as well as bringing countries closer to achieving the goals of national poverty reducing strategies.

Overall, there are demonstrable links between disease and political stability and sovereignty of nations. Studies such as (Stephenson, 2011) and (Heymann, 2006) show that infectious disease outbreaks and health emergencies in general often cause political tensions within and between countries. The tensions arise out of differences in political parties' or countries' policy measures, such as those pertaining restriction of political and economic activities, mandatory quarantining of citizens, and access to and competition for scarce medical resources. Health crises such COVID-19, Ebola virus, HIV and AIDS, cholera and other outbreaks cause tensions between global solidarity and national sovereignty. In this regard, health is a matter of political concern and national sovereignty. It preoccupies national governments and the international community in many ways. Governments through national and United Nations policy processes seek ways to reduce the health burden that falls disproportionately on low- and middle-income households and countries, in order to promote equitable and sustainable prosperity.

In 2015, African countries joined the rest of the world in adopting the United Nations Agenda 2030 Sustainable Development Goals (SDGs) and many of them have national Vision 2030 statements or plans. SDG3 is about good health and wellbeing, and national vision 2030 plans have set health goals such universal health coverage. The SDG3 and related health goals in national plans cannot be achieved without investments in R&I, and improved national health systems. Research and innovation are essential to develop diagnostics, improved drugs, medical devices, and to improve our knowledge or understanding of various diseases, their underlying causes and epidemiological trends.

The economic costs of epidemics such as Ebola are huge. As (CDC, 2013) noted, “aside from the devastating health effects, the Ebola epidemic also had a pronounced socio-economic impact in Guinea, Liberia, and Sierra Leone. According to 2014 projections from the World Bank, an

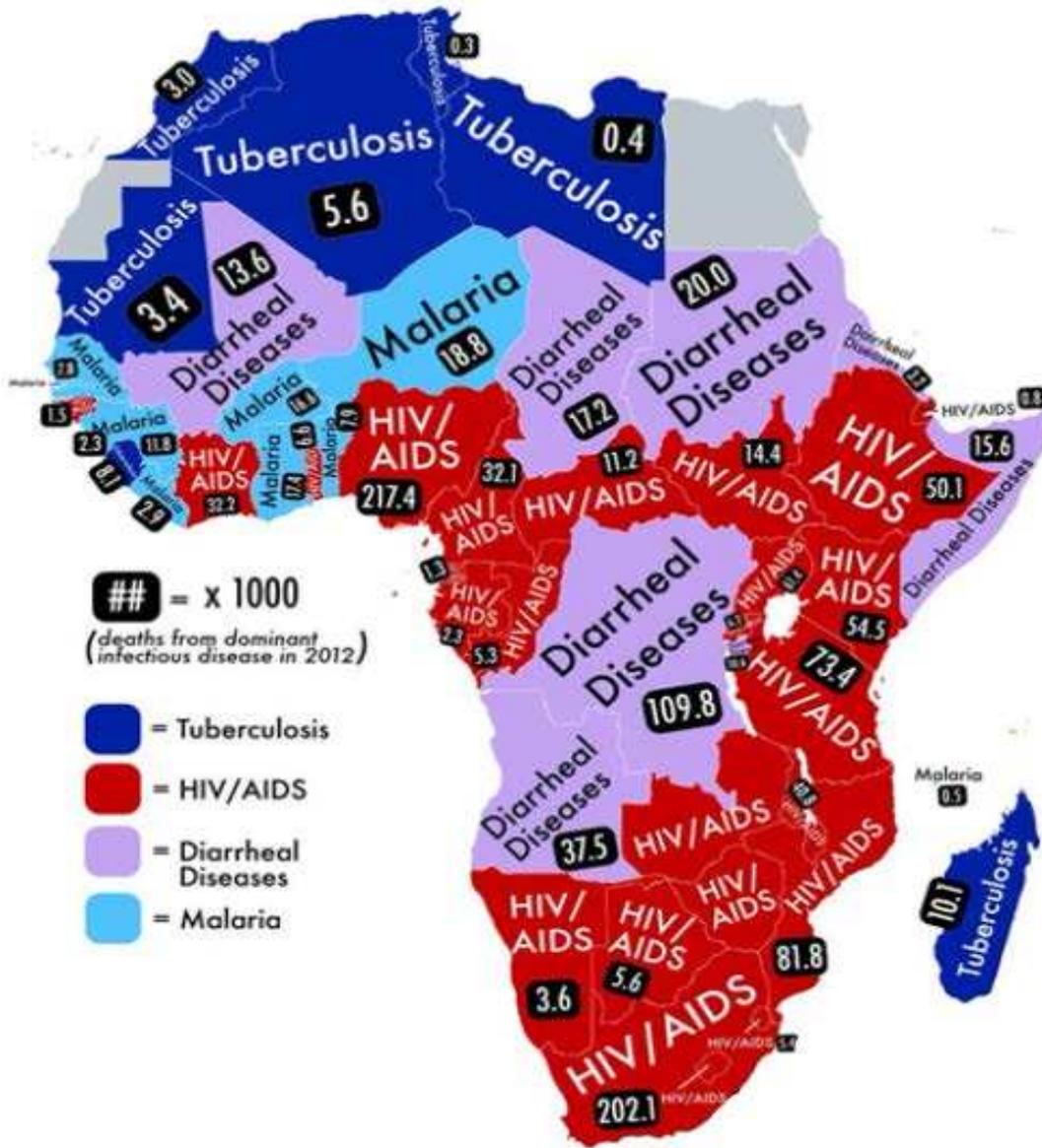
estimated \$2.2 billion was lost in 2015 in the gross domestic product (GDP) of the three countries” (CDC, 2016; World Bank, 2014). Similarly, in 2003, SARS led to an immediate economic loss of perhaps 2 percent of East Asian GDP, even though only about 800 people ultimately died. A global pandemic of (highly pathogenic avian influenza (HPAI) would have a more widespread effect.

It is in recognition of the critical importance of [R&I] in combating diseases that most African countries have formulated national policies for health research. They also have adopted declarations such as the 2004 Bangkok Declaration on Health Research for Development; the 2008 Bamako Communique of the Global Ministerial Forum on Research for Health; and 2004 Algiers Declaration of the Ministerial Conference on Research for Health in the African Region. Under the auspices of the African Union (AU), they have developed and adopted a continental plan for manufacturing pharmaceuticals and medical devices in order to reduce their excessive dependence on foreign high cost imports.

The ‘Pharmaceutical Manufacturing Plan for Africa’ was adopted in pursuance of the decision of the AU Abuja Summit in January 2005 mandating the AU Commission to develop a plan for the local production of generic medicines on the continent. The plan recognizes that the manufacture or production of pharmaceutical is knowledge and technology intensive. It requires scientific R&D capacity. In order to attain the plan’s goals, the “continent will have to invest in the production of different skilled scientists (biology, chemistry, process engineering, medical engineers, biochemistry, bio-computer science, physics, medical engineers, clinicians, pharmaceutical scientists, technicians etc.)” (African Union, 2006).

Despite the adoption African national and continental policies and plans for health R&I, the continent remains vulnerable to the high burden of disease. Weak health systems, high costs of importing medicines, drugs and medical devices, and over-reliance on external funding of health R&I undermine prospects of achieving SDG3 and most other SDGs as well as national vision 2030 aspirations in Africa.

According to the WHO, Africa carries 25 percent of the world's disease burden, but its share of global health expenditures is less than 1 percent. Moreover, Africa manufactures less than 2 percent—of the all medicines consumed on the continent. There is a need to relieve the overburden of health professionals in hospitals which are understaffed, or unable to handle the number of patients at one time, without enough PPE, appropriate equipment, and sufficient training (Badu et al., 2020; Finnan, 2020; Mugabe, 2015).



The COVID-19 pandemic will, at least in the short-term, weaken the continent's economic structures, and exacerbate socio-economic inequalities. For Africa, impacts of the disease spread pandemic will be more severe or magnified in view of high exposure and vulnerability to climate change and rapid population growth, a growing middle class, associated increased consumption and urbanization, and environmental degradation. According to the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES), “the health of ecosystems on which we and all other species depend is deteriorating more rapidly than ever. We are eroding the very foundations of our economies, livelihoods, food security, health and quality of life worldwide” (IPBES, 2019). However, it also offers African countries with opportunities to dedicate their scarce resources to strengthening health R&I and national health systems in general. The crisis is an opportunity to mobilize and use a wide range of policy instruments and political solidarity to harness the continent's scientific and technological capabilities for health and wellbeing of the African people.

2. Challenges: Africa's burden of disease and weak health systems

Africa has a relatively high burden of communicable (infectious) and non-communicable disease burden. It has many diseases with high prevalence and are almost exclusive to the continent, such as malaria, schistosomiasis, human African trypanosomiasis, and those disproportionately affecting the continent such as HIV/AIDS, tuberculosis, diarrhoeal diseases, meningitis, trachoma, lower respiratory infections and ascariasis. According to WHO, these diseases account for over 50 percent of the total disease burden in Africa (WHO, 1978) The economic impacts of the disease burden is quite high, accounting for 20 percent reduction in the continent GDP or \$200 billion annually (Kirigia & Mburugu, 2017; WHO, 2001a; WHO, 2001b).

During 2014-2016, the Ebola virus resulted in over 11 000 deaths, and lasted for approximately two and a half years. In comparison to COVID-19, the Ebola virus was a regional crisis, affecting countries in West Africa, while COVID-19 continues to affect over 213 countries and territories globally (UN, 2020b.) However, important lessons were learnt from the Ebola virus. In the Ebola virus aftermath, \$600 million was leveraged by the World Bank for the launch of the Regional Disease Surveillance Systems Enhancement (REDISSE) Project that aimed to strengthen the health systems and provided effective disease surveillance support to 16 Central and West African countries. This resulted in surveillance system strengthening of the Institut de Pasteur, whereby additional testing laboratory equipment that included bio-security equipment was procured to increase testing capacity and guarantee of the quality and safety protocols for testing. This has led to Institut de Pasteur becoming one of the first laboratories on the African continent to receive WHO accreditation for COVID-19 testing. To assist in the COVID-19 pandemic response, the World Bank has approved almost \$370 million for 10 African countries to complement the support to strengthen health systems and programs in Central and West Africa such as REDISSE and the new Africa Center for Disease Control and Prevention (Africa CDC) regional project. Together with other partners, the World Bank has approved a \$14 billion fast-track package that will assist African countries to rapidly detect, prevent and respond to the

COVID-19 spread, with the aim to strengthen health systems for public health preparedness (Worldbank, 2020).

The continent's main health challenges lie in preventable, infectious diseases. Tuberculosis, HIV/AIDS and malaria are the leading causing of morbidity and mortality in sub-Saharan Africa. Significant gains have been made in combating these diseases over the past decade and there is an increasing realization that non-communicable diseases, mostly cardiovascular diseases, cancers and metabolic disorders will soon overtake the communicable diseases in public health significance. However, the COVID-19 pandemic threatens to erode the gains made so far in the fight against the big killers on the continent. Africa's population remains largely rural and access to health infrastructure is poor at best- the current socioeconomic disruption occasioned by the COVID-19 pandemic is likely to exacerbate the situation with many prevention and treatment programmes on hold or operating sub-optimally. Furthermore, the COVID-19 situation is likely to see reallocation of funding, with further sharper decrease in funding for the longstanding infectious diseases to accommodate the new pandemic.

Despite the high burden of disease, pre-COVID-19 Africa experienced one of the fastest economic growth rates in the world. Africa also has the potential benefit of a demographic "dividend" with a population age structure dominated by young people who can contribute to its economic expansion if this advantage is properly harnessed. As stated earlier, for Africa to achieve its full socioeconomic potential, it must first address the health deficit and inequalities so that it can achieve a level of well-being that would form the basis for sustained economic growth and a productive workforce. Africa's resilience in the face of devastating infectious diseases cannot be underemphasized. Although the public health sector remains poorly resourced, Africa has in the past vanquished smallpox and made significant progress against polio, Ebola virus, Malaria and HIV/AIDS, with these diseases now largely in retreat.

Generally, these diseases are in retreat in sub-Saharan Africa (Vandormael et al., 2020). TB notification rates and TB-associated mortality are falling, mostly attributed to decreasing HIV incidence, treatment of HIV infection and progress in direct TB prevention and care (Vandormael et al., 2020). Malaria and Ebola are also have also seen a dramatic reduction in incidence (The Lancet, 2020).

Among the most successful strategies employed against these diseases have been mass mobilization with behavioural change at the heart of these strategies, not unlike the current campaigns for self-isolation, quarantine and social distancing in response to COVID-19. Large-scale testing of the population has also been a key pillar, accompanied by treatment or enhanced prevention strategies for HIV and AIDS, TB and Ebola virus. Finally, the bulwark of the successful smallpox eradication campaign was mass vaccination. It is important to note that none of these strategies would have been successful on its own without collaboration among communities and across countries. Collaboration of various institutions, and decisive actions of governments and legislatures have helped slow HIV and AIDS and eradicate smallpox in Africa.

The extent to which the continent will be able to fight COVID-19, future epidemics and effectively reduce the high burden of disease depends, to no small measure, on how well they strengthen their national health systems in general, their R&D and innovation capacities in particular. Most of the current R&D programmes for African diseases are funded by external donor organizations. Less than 10 percent of R&D funding at African public health research centres is local, with the rest coming directly or through collaborations from Europe, and the USA (Mugabe, 2015).

Strong national health systems are key to fighting COVID-19 and reducing the burden of disease. These systems comprise of institutions (in both public and private sectors) with infrastructures, and policies, laws and programmes that are organized or configured to ensure that citizens of a nation state have access to quality and affordable health services, including health care and medicines. These systems are supposed to be ‘socially and nationally embedded’ in the sense that they must be suited to social, physical and economic conditions of individual countries. National health systems are also knowledge intensive and dependent on social, technological and organizational innovations to respond to changing disease burdens and health emergencies in general. Thus, research and innovation are the main foundations of dynamic or effective national health systems.

African national health systems face an array of interrelated challenges. Recent studies (such as Dalal et al, 2011 and Gouda et al., 2019) have identified and analysed the challenges. Among the key challenges are:

- 1) **Weak governance and accountability** — Governance of health systems is about processes, practices, and institutions (both normative and organizations) for making decisions pertaining to equitable and fair access to healthcare, allocation and distribution of resources to health, setting of health R&D priorities, and regulatory mechanisms for procuring and testing medicines and other health innovations. It also refers to the “making, changing, monitoring and enforcing the rules that govern the demand and supply of health services” (Abimbola et al., 2017). Institutions—both state and non-state—involved in governance of health systems include ministries (and/or departments) of government, legislatures (or parliaments), civil society, private sector and international donor agencies. Interactions among these institutions influence the quality and effectiveness of decisions or policies for health. In most African countries, institutional arrangements and policy processes for health are generally weak, characterized by poor coordination. Often, there are mismatches between priority setting and budget allocation, and between executive policy decisions and legislative agendas. There are deficits in health policy effectiveness due to weak oversight, particularly from legislatures and civil society. Health policies in general, and health R&D policies in particular, are often designed with inadequate engagement of civil society and communities. Many health R&D policies and plans are not effectively implemented, and goals are unmet (Mugabe, 2015). Weak governance of health systems is a barrier to the attainment of constitutional rights to health and undermines social and economic stability of communities and countries.

2) **Underfunded budgets for public health**—Public health systems in general and R&D for public health in particular are under resourced in most of Africa. Sub-Saharan Africa’s public expenditure on health was estimated to be just about 5 percent of GDP in 2017 compared with an average of 10 percent of GDP for Asian countries (Worldbank, 2020). According to the United Nations Economic Commission for Africa (UNECA), “[t]otal spending on healthcare in Africa has remained within a narrow band of five to six percent of GDP in 2000 to 2015, on average, though in per capita terms it has almost doubled from US \$150 to US \$292 (in constant PPP dollars). Scarce public resources and unpredictable donor aid have resulted in high private out-of-pocket expenditure that have pushed many people into poverty. Therefore, health spending in Africa remains largely inadequate to meet the growing health financing needs and the rising healthcare demands creating a huge financing gap of US \$66 billion per year” (Worldbank, 2014). Most African countries’ health systems are reliant on sporadic external donor funding. This tends to undermine their efforts to realize constitutional and policy objectives of the citizens’ right to health.

Table 1 Trends in total health expenditure per capita in current US Dollars (Source: WHO/AFRO, 2013)

Year	Less than US\$ 20	US\$ 20–US\$ 44	More than US\$ 44
2001	Benin, Burkina Faso, Burundi, Central Africa Republic, Chad, Comoros, DRC, Eritrea, Ethiopia, Gambia, Ghana, Guinea Bissau, Kenya, Liberia, Madagascar, Malawi, Mali, Mozambique, Niger, Nigeria, Rwanda, Togo, Uganda, Tanzania (24 countries)	Angola, Cameroon, Congo, Côte d’Ivoire, Guinea, Lesotho, Mauritania, Senegal, Sierra Leone, Zambia (10 countries)	Algeria, Botswana, Cape Verde, Equatorial Guinea, Gabon, Mauritius, Namibia, Sao Tome and Principe, Seychelles, South Africa, Swaziland (11 countries)
2005	Burundi, Central African Republic, DRC, Eritrea, Ethiopia, Gambia, Guinea, Liberia, Madagascar, Malawi, Mozambique, Niger, Rwanda, Tanzania (14 countries)	Angola, Benin, Burkina Faso, Chad, Comoros, Congo, Côte d’Ivoire, Ghana, Guinea Bissau, Kenya, Lesotho, Mali, Mauritania, Senegal, Sierra Leone, Togo, Uganda, Zambia (18 countries)	Algeria, Botswana, Cameroon, Cape Verde, Equatorial Guinea, Gabon, Mauritius, Namibia, Nigeria, Sao Tome and Principe, Seychelles, South Africa, Swaziland (13 countries)
2010	Central African Republic, DRC, Eritrea,	Benin, Burkina Faso, Burundi, Chad, Comoros,	Algeria, Angola, Botswana, Cameroon, Cape Verde,

Ethiopia, Madagascar, Niger (6 countries)	Gambia, Guinea, Kenya, Liberia, Malawi, Mali, Mauritania, Mozambique, Sierra Leone, Togo, Tanzania (16 countries)	Congo, Côte d'Ivoire, Equatorial Guinea, Gabon, Ghana, Guinea-Bissau, Lesotho, Mauritius, Namibia, Nigeria, Rwanda, Sao Tome and Principe, Senegal, Seychelles, South Africa, Swaziland, Uganda, Zambia (23 countries)
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3) **Under-resourced health R&D**—although data are scanty, various studies and reports show that health R&D in Africa is underfunded and largely dependent on external donors. According to Simpkin et al, (2019), “[h]ealth science research, funding and research capacity are insufficient to address Africa’s current unmet health needs, and there are ambitious country-set targets and frameworks for progress still to be met over the coming decade”. Because of underfunding of R&D, Africa imports many health products (particularly medicines and medical devices) and its scientific productivity in health is relatively low (Mugabe, 2015).

4) **Shortage of skilled personnel**—Africa’s health security and sovereignty are undermined by shortages of personnel in various areas including R&D, planning and practice. Most African countries have shortages of health workers such as nurses, doctors and technicians, and researchers in such fields as epidemiology, virology, health genomics, and health policy and planning (Dalal et al., 2011; Gouda et al., 2019). Enrolment in health sciences is relatively low at African universities and colleges, and brain drain spurs human skill shortages as trained personnel (nurses, doctors, researchers and technicians) leave the continent in search of well-paying jobs or better research infrastructure abroad. Health workers density (nurses, doctors, laboratorians and technicians) in Africa was 2.3 per 1000 patients, compared with 4.3 in South East Asia, 18.9 in Europe and 24.8 in America, the global average was 9.3 per 1000 (WHO, 2006).

The shortage of health researchers and healthcare workers exacerbated by workforce distribution inequalities and compromised public health intervention delivery, especially in remote areas. This was occasioned by emigration, movements from public to private health settings, movements to NGOs and development organizations as well as those caused by HIV-related illness (WHO, 2014). There are already fewer health professionals per 100 000 people than the recommended 10 in Africa. A death of one doctor is a loss of healthcare to more than 10 000 people (World Economic Forum, 2020).

Adverse social health determinants and underdeveloped infrastructure—In many countries within sub-Saharan Africa, health resources (e.g. hospitals, information and medicines) are not easily accessible to poor income households. Even, clean water and sanitation are not easily

available a large portion of the continent's population. In many countries' health facilities are socially dislocated in the sense that they are designed to meet the needs of communities and special groups such as persons with disabilities. This is because the facilities are designed based on foreign specifications with foreign donor funding. There is limited community participation in health service design, monitoring and management; insufficient health related legislation and enforcement; fallible national research and health information systems and inept allocation and utilization of resources.

5) ***Lack of aid alignment and harmonization***—health service delivery and aid are often fragmented, due to program implementation in silos and varied coordination in public and private sectors, donors and non-governmental organizations.

6) ***Regulatory barriers to health innovation***—in many countries ambiguous regulations for medicines, clinical trials and procurement systems of medical technologies and products are plagued by unreasonable pricing, irrational usage, fickle supply systems and variations in safety and quality. Under current conditions with COVID19, many African countries are facing challenges to procure personal protective equipment (PPE), testing capacity, and intensive care personnel.

3. Opportunities: Africa's scientific and technological opportunities

COVID-19 offers African countries rare opportunities to mobilize and use their existing scientific and technological capabilities to address health challenges, reduce the burden of disease and assert their sovereignty. The pandemic has stimulated various scientific and technological as well as social innovations on the continent. Numerous cases of innovations for COVID-19 testing, tracing and treatment are frequently reported in media in Africa and internationally.

Most African countries have established various containment strategies and research activities on the pandemic. They are using their research capabilities—personnel, infrastructure and institutions to fight the pandemic. For example, in Kenya COVID19 testing is performed locally with the Kenya Medical Research Institute (KEMRI) taking the lead in diagnosis. KEMRI has capacity to test up to 10,000 samples a day through its satellite campuses that are all over the country. KEMRI has also commenced the development of a Point of Care Diagnostics, whole genome sequencing and identification of COVID-19 vaccine candidates.

In Senegal, Pasteur Institute located in Dakar is demonstrating scientific leadership in developing point of care testing and for COVID-19. The Institute is also developing ventilators using low cost 3D printing. There similar efforts at universities in Kenya, South Africa, Nigeria and other countries to use 3D printing to develop ventilators, face masks and other medical devices.

Some African countries are also harnessing bioinformatics and genomics to fight the COVID19 pandemic. They are using molecular techniques to enable rapid mass testing to identify prospective COVID19 cases (Allam et al, 2020). There are also African efforts at sequencing coronavirus genomes. For example, by mid-April 2020, genome sequencing was taking place in

the Democratic Republic of Congo (25 viral genomes), Kenya (22 viral genomes), Senegal (20 viral genomes), Ghana (15 viral genomes), South Africa (6 viral genomes), Algeria (3 viral sequences), and Nigeria (1 viral genome). These scientific efforts are aimed at building an understanding of genetic variations associated with disease transmission and severity. The genetic variations present in each of these genomes when compared to a repertoire of those from others collected across the globe, can be used to track transmission of particular strains and provide critical information on the appropriate public health interventions (Allam et al., 2020).

The sequencing of the virus genomes is an important lead in the development of vaccines to treat COVID-19. Data generated from COVID-19 samples collected from all corners of the vast geographically diverse African continent will aid the continent's own vaccine development programmes, key to ensuring vaccines that offer broad protection to all ethnically distinct African populations are available. This will reduce the continent's reliance on vaccines developed elsewhere and avoid its exclusion in the ongoing global vaccine development. Some of the vaccines developed abroad, without the involvement of African countries have been unsuitable for local African populations. Examples include the rotavirus and pneumococcal vaccines. These vaccines were developed primarily using strains or pathogen components predominantly found in Europe and North America, and as such they are less efficacious in protecting African populations due to the presence of different disease strains in circulation (Cunliffe et al., 2012).

Africa has a number of ongoing vaccine development initiatives that can be 'repurposed' to help COVID-19. Initiatives such as the South Africa AIDS Vaccine Initiative (SAAVI) have helped build domestic scientific and technological capabilities for vaccine development. SAAVI has focused on vaccine development, vaccine clinical trials and testing, and outreach and ethics of HIV vaccine. It has also supported the development infrastructure for R&D in a number of universities. Specific activities supported by SAAVI include candidate vaccine development at the University of Cape Town and vaccine evaluation and immunology at the National Institute for Virology. Clinical trials of a number of candidate vaccines have been conducted. These include of a candidate vaccine against HIV/AIDS based on the biologically active HIV-1 Tat protein and developed by the National AIDS Centre (CNAIDS) of the Italian Istituto Superiore di Sanità (ISS). With the funding from the Italian Ministry of Foreign Affairs, a facility for vaccine product development is being set up at the Biovac Institute (TBI) in Cape Town.

Africa's rich biodiversity and related traditional knowledge are critical in the fight against the COVID-19 pandemic and the burden of disease in general. The continent's forest biomes are a huge repository of plant medicines, the bedrock of many phytochemicals for pharmaceuticals around the world. The traditional knowledge resources that emerged from ancient societies like Africa's ancient Khmet, Egypt, Ethiopia, Persia and China have often combined philosophies, values, ethics and wisdom that have passed the test of time. These knowledge approaches that imbed culture, values, ethics, principles, caring, sharing, nostalgia, emotion and all other variables that enrich the quality of being and the ontological density of life have been rendered shallow by the intellectual dominance of a very instrumental, positivist, externalising, and separating

knowledge production approach where the observer and the observed are seen to occupy different positions in the knowledge creation processes.

There are many African initiatives or programmes aimed at harnessing the phytochemical potential of biodiversity and indigenous knowledge to develop health products in Africa. For example, Ghana's Centre for Scientific Research into Plant Medicine is a recognized centre of excellence in research on phytochemicals and traditional medicine. Recognized by the WHO since 1981 as a WHO collaborating Centre for Traditional Medicine, the Centre produces herbal products as well as operates an out-patient clinic, in excess of 16,000 patients every single month. The mission of the Center is to "develop herbal products that meet the exacting needs of both patients and industry, through innovative scientific research and productive partnerships" (Owusu-Ansah, 2014).

Similar centres and programmes for phytochemical research and traditional medicines exist in other African countries. In Nigeria, the National Institute for Pharmaceutical Research and Development (NIPRD) developed 'Niprisan' a cocktail drug, with phyto-pharmaceutical composition of four traditional plants extracted in a proprietary process. Currently the drug has been patented in 46 countries and is jointly owned by NIPRD and the traditional health practitioner. The drug has been licensed to XECHEM Inc., to enable local production. Additional pharmacological research by NIPRD led to the standardization of Niprisan into capsule dosage formulation. The current formulation has been approved, with the name NICOSAN™/Hemoxin, which has subsequently received recognition by the US FDA (2003) and EU (2005) (Kalua et al., 2009).

The University of Botswana's Centre for the Study of HIV and AIDS researches on various aspects of HIV/AIDS, particularly clinical trials. The University's Centre for Scientific Research, Indigenous Knowledge and Innovation (CESRIKI) is conducting research on the use of indigenous knowledge and local genetic resources in order to develop health products.

The number of clinical trials is another measure of scientific capability and productivity of countries. Although there is scant data, there has been increase in the number of clinical trials conducted in African countries over the past decade or so. Most African countries have had clinical trials focusing vaccines for HIV/AIDS, TB and malaria. However, the cost of conducting clinical trials in these countries is relatively high when compared to India for example. It is estimated that it costs between US\$40,000 to US\$80,000 to conduct trials in Kenya, and US\$50,000 to US\$120,000 in South Africa while it costs about US\$35,000 in India (Mugabe, 2015). These African countries are growing their capacities for clinical trials approval and regulation. With the support of institutions such as the European and Developing Countries Clinical Trials Partnership (EDCTP), scientists have been trained, guidelines developed and laboratory infrastructure has been upgraded in the six countries.

In addition to the scientific endeavours, there are many local low-cost innovations in that are contributing significantly to COVID-19 responses in Africa. They include innovations in the supply

of clean water, design and development of ventilators and face masks. African institutions—including informal ones—are at the forefront of these efforts. For example, there are low-cost ventilators and IgG/IgM rapid diagnostic tests from Kwame Nkrumah University of Science and Technology, and or solar powered auto hand washing machines from high school students in Ghana. Such innovations can be equally innovative as technological advancements and should be encouraged. Local regulatory and policy frameworks that support such bottom up efforts should be fast-tracked, including through capacity building.

The continent's scientific and technological capabilities, in both modern and traditional health, are scattered across countries and regions. They are underfunded and underutilized. Various institutional, policy, regulatory and socio-political barriers are in the way, blocking Africa from harnessing and using its own capabilities. There are weak links between R&D institutes and industry. Most of the health R&D activities are not directly linked to pharmaceutical companies' investments and innovation needs. Even in countries such as Kenya, Nigeria and South Africa where there is a significant presence of international pharmaceutical companies, there are few public-private R&D initiatives and few cases of private sector financing health R&D in public institutes. The weak links between public institutes and industry deny the countries opportunities to turning R&D into health innovations. Existing national health R&D policies and programmes do not foster public-private sector links.

Weak links between public health R&D and private industry have denied African countries opportunities to turn research into health products and become less reliant on foreign sources of medicines, diagnostics and other health products. Numerous cases illustrate this issue. One case is that of KEMRI's efforts to produce and commercialize affordable diagnostics and medicines. In 1990, KEMRI developed Hepcell RPHA kit for detecting Hepatitis B virus (HBV) that is the cause of the most serious type of viral hepatitis. Up to 2003, it was producing and supplying Hepcell RPHA kits free of charge to national health institutions in Kenya. To sustain or even increase production levels, KEMRI started charging US\$1 per test. Due to weak links to private sector and limited support from government, this technological potential remains stunted (Simiyu et al., 2010).

Another barrier to the exploitation of Africa's scientific and technological opportunities is weak regulatory mechanisms for clinical trials. A study by the Academy of Sciences of South Africa (ASSAf) identified some of the barriers to clinical research in South Africa to be: poor coordination among many players (including funders), inadequate public awareness of the importance of clinical research and thus weak public engagement, weak regulatory capacity of the Medicines Control Council (MCC), and limited local funding. Policy and institutional measures are needed to address these challenges. Below are some specific recommendations for action (Assaf, 2009).

4. Recommendations: Fighting COVID-19 is Africa's renewed call to action

COVID-19 is a transformative crisis that African countries should not waste. The pandemic is forcing countries all over the world to engage in various ways of self-discovery, to identify and exploit their existing or endogenous scientific and technological capabilities. Industrialized and economically advanced nations are coming to the harsh realities and recognition of how weak their health systems are, and how vulnerable their socio-economic structures are to an invisible virus, the SARS-CoV-2 (coronavirus). African economies and health systems are even more vulnerable. Fighting the COVID-19 pandemic is a matter of national security and sovereignty. Countries are unleashing all kinds of defense tools in their war against the virus. Economic stimuli measures are being used to ensure that national economies recovery and military institutions to keep citizens under lockdown to stop the spread of the virus. These measures are largely short-term and only address manifestations of the problem—the pandemic and the huge burden of disease that the continent is faced with.

Long-term measures to fight COVID-19, reduce the burden of diseases such as malaria, TB and HIV/AIDS and future global public health crises should focus on mobilizing, building and utilizing Africa's scientific and technological capabilities. This should not be news to African leaders, policymakers and politicians. Over the years, they have adopted policies and declarations on strengthening national and continental science and innovation in order to fight diseases and secure public health and wellbeing. As stated in the first section of this paper, African countries have adopted declarations such as the Algiers Declaration on Health Research, Bangkok Declaration on Health Research for Development; and the 2008 Bamako Communique of the Global Ministerial Forum on Research for Health. The challenge now is to implement provisions of these declarations and their own national policy frameworks.

There are five clusters of concrete or practical actions that African countries must take to address current and future health crises. The first is to **redefine health**. Currently, countries define health as a social need or service and focus on provision health services within a social sector. Health is often treated as if it is an add-on to national economic priorities of growth, competitiveness and sustainability. 'Treating health' this way has led governments to under-budget for it, compared for example to physical infrastructure such as rail and roads. This is despite the huge contributions of health to economic growth, competitiveness and prosperity of nations. The way forward is to define health as an economic and defence sector of national life, critical to security and sovereignty. This would lead to reconfiguration of institutional arrangements for health in the scheme of governance. Health ministries and related departments should be in the security and economic clusters, and health considerations embedded in whole-of-government.

The second category of policy actions is to **establish or strengthen mechanisms for accountability for health governance** with emphasis on implementation of constitutional obligations on the right to health and policies for health research and innovation. No African

country has attained the target of 2 percent of its national health budget on R&D as set in international and regional declarations because there is no mechanism for tracking national health R&D expenditure and weak advocacy for health R&D financing. As stated earlier, investing in research and innovation is key to the realization of national constitutional and policy goals on health as well as the global SDG3 (health and wellbeing). Yet, African governments underfund research and innovation and fail to meet constitutional obligations. To address this governance deficit, legislative and civic oversight institutional arrangements should be established within countries and the AU. Ombudsmen for health, just like those for the administration of economic justice and environmental justice, should be created within national parliaments and the Pan African Parliament (PAP) to monitor how governments implement constitutional provision, national policies and legislation, and international commitments on health, including commitments to increased funding for research and innovation for public health.

Civil society in general and NGOs in particular can play an important role of policy advocacy in the African countries. Leadership and public constituencies for health R&D are relatively weak in the six countries. As stated earlier, parliamentary committees on health, and science and technology rarely address health R&D policy and financing issues. There are also few NGOs dedicated to health R&D policy advocacy in the countries.

To strengthen political and legislative leadership, workshops on promoting health R&D policy be organized for parliamentary committees on health, science and technology, finance and planning in each of the countries. Existing health-sector NGOs' capacities need strengthening to integrate health R&D policy advocacy into their programmes. To strengthen political and legislative leadership, workshops on promoting health R&D policy should be organized for parliamentary committees on health, science and technology, finance and planning, etc. in each of the countries.

The third practical actions relate to **strengthening regulatory mechanisms for health research and innovation**. As already observed, regulatory mechanisms and frameworks for health R&D in general and clinical trials in particular are weak in most African countries. Costs—time and money—of clinical trials are relatively high in some countries. Institutional arrangements for regulating— including approval—health R&D and clinical trials in particular—are weak. Multiple agencies and ambiguous procedures make it cumbersome to get approvals for health R&D as well as clinical trials. This may undermine the continent's efforts to participate in global vaccine initiatives and related R&D. It is acts as a disincentive for private industry to engage with public health R&D and clinical trials.

Africa's lack of representation in clinical trials have been noted in the WHO multi-country, multi-arm clinical trial, with only South Africa as part of the 10 countries that have signed up for participation. The US National Institutes of Health online platform has only three trials registered in Egypt. It is imperative that more African countries participate in clinical trials, especially during the COVID-19 pandemic, so that data collected will not be generalized to large populations but rather a more accurate genetic representation of the continent.

There is need to conduct a rapid assessment of the status, trends, barriers and economics of clinical trials in Africa. The assessment would identify specific capacity needs and suggest measures for reform of national regulatory frameworks in order to enlarge the economic potential of clinical trials in Africa. Each country should also quickly review and reform its institutional arrangements—including procedures—to ensure that they provide incentives and are cost effective for health R&D.

African Governments should collectively engage the global pharmaceutical industry with COVID-19 candidates for inclusion. They should fast-track diligent ethical approval processes to ensure the continent's participation and inclusion in vaccine development. As stated earlier, the COVID-19 pandemic has laid bare gaping weaknesses in health systems worldwide. In these times, even competitive corporate pharmaceutical giants, GSK and Sanofi, announced that they would be joining forces to develop an "affordable to the public" vaccine to stop the spread of COVID-19 (GSK, 2020) African countries need to engage actively in such private sector led initiatives.

In addition, industrial policies that will help re-purposes private industrial activities will be necessary to leverage existing innovation capabilities to address COVID-19 and related manufacturing challenges. Private companies, particularly Small and Medium Enterprises (SMEs), should be given fiscal incentives to help produce on urgent basis Personal Protective Equipment (PPE) creating revenue streams and jobs during the current crisis while contributing to strengthening of local health systems. Identifying rapid funding mechanisms to scale these efforts are needed to meet local demands in the face of disruption of global value chains.

Access to essential medicines in Africa can be aided by promoting continental poles of production that harness the new African Continental Free Trade Agreement. Pooled procurement in medicines, industrial production of medical devices can help establish price controls that ensure that governments can afford drugs while also subsidizing R&I helps grow the pharmaceutical landscape (Shaikh & Gandjour, 2019). Strengthening the African Center for Disease Control, the African Vaccine Regulatory Forum (AVAREF), African Medicines Regulatory Harmonisation (AMRH) as well as national healthcare regulatory authorities would accelerate review of products and services offered by African SMEs in pharmaceuticals and medical devices manufacturing (Shaikh & Gandjour, 2019).

African domestic markets are small and fragmented and therefore regional integration is vital if African pharmaceutical companies want to achieve large-scale economies and compete at an international level. Poor adherence by manufacturers to maintaining good manufacturing practice (GMP) and weak regulatory authorities have resulted in low pharmaceutical production in Africa, and of non-assured quality. In countries relying on donor funding for healthcare, local manufacturers face difficulty in meeting international procurement and tender agencies.

The fourth cluster or category of actions are on **mobilizing, using and building the continent's scientific and technological capabilities**. As demonstrated in the previous section, there is a wide range of health R&D and related innovation activities undertaken by African scientists,

institutions and networks. Many of these efforts are dependent on external agencies for funding, are largely isolated and locked in national institutions. In addition, current R&D and innovation efforts are undertaken by relatively small cohorts of researchers or scientists largely driven by personal commitment. To boost these efforts there is an urgent need for African countries to, individually and collectively, design ways and means of mobilizing the scattered scientific efforts by creating more networks of R&D excellence, targeting funding at existing or current initiatives instead of spreading scarce resources thinly across many similar programmes.

Key to harnessing powerful African collaborations is the establishment and support of research groups and networks, so that laboratories become cohesive networks that complement one another functionally and technically to develop innovative novel tools to address diseases in Africa. This will result in local ownership and promote the African health research agendas, cooperating with one another to advance scientific interests locally. Therefore, a system governed by Africans is essential to provide a funding mechanism that is sustainable and also encourage African researchers to collaborate in harmony on health issues, share expertise, provide capacity building, that can lead to positive impacts on the economy of the African countries, and the African continent as a whole (Simpkin et al., 2019).

African governments should focus on increasing the research capacity of at least another million scientists, with currently only 198 researchers per million people, compared to a global average of 1,150/million, and 4,500/million in the UK and US (ADB, 2020). There is also a need to focus on the informal sector, so that skilled a person will be capable of turning challenges into a profitable business enterprise (Munang, 2020). To this end, more local opportunities for scientists need to be made to avoid the loss of 20,000 professionals to high-income countries every year (Kariuki & Kay, 2017). We need to ensure medical research does not only respond to the agenda of funding agencies, and more patents are locally generated, in view of the fact that the continent is home to 17 percent of the world's population but owns only 0.1 percent of the world's patents. Political backing is needed to support this funding for these developments, as currently, while since 2006 targets for AU nations to spend 1 percent of their GDP on R&D, in 2017 only three countries—South Africa, Malawi and Uganda—reached this goal.

In order to ensure that health R&D and innovation activities are adequately funded, it is recommended that each country should legally set specific funding instruments. The instruments should include tax credits for health R&D, tax exemption on importation of equipment for health research and clinical trials, venture capital and competitive research grants. Clear and monitorable targets for meeting the 2 percent of health budgets allocation for research should also be integrated in the legal instruments establishing national research and innovation funds.

The fifth category of policy actions is ***building scientific advisory capacities and sharpening or enhancing African political and policy-makers' attention to complex linkages between COVID-19, climate change, food security and economic resilience***. Research is critical to building understanding of the linkages and science is key to informing policymaking on COVID-19, its underlying systemic and complex ecological, social, economic and technological causes

as well as consequences. The science linking pandemics to deforestation, zoonotic disease and biodiversity loss need to be studied more systematically on the continent. These diseases that are transmitted from animals to humans represent 60 percent of all infectious diseases in humans and 75 percent of all emerging infectious diseases. In this regard, African governments need to invest in science for policy or the production of evidence for policy (Whitmee et al., 2015).

The COVID-19 crisis, like other epidemics and pandemics, shows that transdisciplinary multi-sectoral research that integrates issues or problems of health, climate change, food production, biodiversity and socio-economic change is key. There is a need in shift or re-organization of funding for research to give practical meaning to transdisciplinary and promote greater institutional articulation. Bringing the different scattered disciplinary scientific efforts together should be a major pre-occupation of science policymakers and funders.

The African Academy of Sciences (AAS) and national academies of sciences will need to play a more proactive role in helping African governments to establish appropriate multidisciplinary and transdisciplinary science advisory mechanisms. Science academies have a critical role to play in strengthening Africa's health systems. By providing a rich pool of scientific expertise, they should inform investments in research and innovation, especially focusing on high quality and critical research gaps, building a critical mass of excellent researchers, and investing in the right infrastructure to support the researchers. Firstly, they need to lead in systematic priority-setting exercises that identify pertinent gaps in health research and innovation systems, and the interlinkages to other sectors as environment and social services, hence directing investments from governments and other funding partners to the right research. Secondly, they have a duty to implement high quality research that not only includes all relevant stakeholders, but also delivers scalable interventions. Thirdly, being at the centre of knowledge production, academies must also play a central role in translating the same evidence into policy and practice, informing and advising policy makers of the most cost-effective interventions relevant to each country and community.

Science academies should use their capacities to help link evidence to action and also in strengthening the science environments to enable the training of a critical mass of rising research leaders and innovators that will continue supporting Africa's health system. By 2030, artificial intelligence (AI) will add \$15.7 trillion to the global GDP, with \$6.6 trillion projected to be from increased productivity and \$9.1 trillion from consumption effects (Travaly & Muvunyi, 2020). How Africa harnesses AI to scale health R&I could be transformative economically, promoting and preserving Africa's health sovereignty (Youssef & Muvunyi, 2020) Science academies play a critical role to national governments' emergency response teams, as well as in other specialized committees such as the African Union' Specialized Committee on Education Science and Technology.

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